CLEANSHIPPING INTERNATIONAL

WINTER 2019

MAKING WAVES
Japanese report boosts the case for scrubber use

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The membership journal of
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POWER TO THE PEOPLE

by Nick Savvides

People power is certainly a theme at the moment in Brexit Britain. But BB, aside power is an essential tool to the shipping industry and providing the energy source for that most noble activity, shipping, has become something of a journalists' playground ever since the International Maritime Organization (IMO) decided in the spring of 2018 to impose a 50% cut in carbon emissions by 2050.

While the focus of the industry is rightly on the first environmental deadline, the sulphur cap that will be introduced on 1 January 2020 — the so-called IMO 2020 regulation — the subsequent deadlines keep coming and are ever-more onerous in their nature.

By 2023, we expect to see the introduction of the IMO's Data Collection System, which will give rise to a more reliable measure of the level of carbon emissions from the shipping industry. That will lead to the introduction of a carbon levy – a tax or trading scheme that will impose a charge on vessels that pollute the atmosphere with greenhouse gases.

In London in early October, Dr Alexandra Ebbinghaus, the maritime strategic project lead for oil major Shell, made an extraordinary speech on alternative fuels at the home of the IMO. Ebbinghaus told the audience: "What we're looking for is a global greenhouse gas (GHG) emission framework that will provide the certainty that people are looking for and that will push the faster reduction of GHG. All the low-carbon solutions will be much more expensive than existing fossil fuel solutions, so we need to look at how we develop a level playing field."

In effect, one of the world's biggest carbon producers was calling for a tax on its own product. But the key to this speech had come earlier, when Ebbinghaus had displayed a picture of Shell's new proton exchange membrane electrolyser, used to produce hydrogen.

It was, perhaps, one of the first outward admissions from the oil industry that the momentum behind the environmental concerns from wider society had been heard and that at least one oil major was planning for the post-carbon era – a PC world.

Achieving that post-carbon goal will see a 40% reduction in GHG by 2030, before the 2050 goal of 50% is attained. But to reach those targets, Ebbinghaus argued: "What we really need to do is deploy existing technology as soon as possible, as well as using low-carbon fuels such as liquefied natural gas or biofuels. But that is not going to be enough — we will need zero carbon fuels as soon as possible."

Key to the success of this plan is that the industry must collaborate to develop the technology and we need the policy that enables this to happen. But to develop the business case, the industry needs the certainty of a regulatory framework, emphasised Ebbinghaus.

In this first *Clean Shipping International* magazine, the stories that readers will find will, hopefully, inform debate and add to the knowledge needed for the industry to make the transition to the brave new PC world. with news on how technology can help with the transformation, new vessel design technology and different views on the path to the transition to decarbonisation.

All in all, this first magazine has dipped into a dynamic industry driving forward to a cleaner tomorrow. Unlike the UK with its Brexit plans, the shipping industry is getting on with the job and offering clean power to the people.

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A LONG WAY IN A SHORT TIME

by Capt. Michael Kaczmarek, Vice-President, Carnival Corporation

Welcome to the first edition of *Clean Shipping International* magazine, which aims not only to provide information relating to the aims and objectives of the Clean Shipping Alliance 2020 (CSA 2020), but also to provide informed opinion on the wider developments taking place.

As an organisation, CSA 2020 aims to raise environmental issues and concerns, and explain what the global shipping industry is doing to meet the challenges faced to ensure seaborne transportation is environmentally sustainable – challenges that will affect us all.

CSA 2020 has come a long way in a short time since its foundation in September 2018. So allow me to take this opportunity to reflect on the events of the past 13 months.

On 27 September 2018, 25 shipping companies, all of whom had seen the environmental benefits of exhaust gas cleaning systems (EGCS), agreed to form CSA 2020 to provide information and research data to better inform not only the industry, but the wider public on the environmental performance and benefits of open- and closed-loop EGCS and associated air and water emissions.

In December, CSA 2020 appointed an association management company specialising in the maritime industry to help support our activities. By the end of 2018, membership had grown to 30.

As our membership has grown – now counting 37 prominent shipowner members — our attention has become firmly focused on providing technical/scientific input to the International Maritime Organization (IMO), flag state administrations, the trade press, and others.

During our first general meeting and technical seminar, which intentionally coincided with PPR 6 in February 2019, we were able to successfully engage with the IMO Secretariat and present the findings of the Carnival/DNVPS EGCS washwater analysis. PPR 6 was also the first presentation of a study carried out by the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT), which complimented the Carnival/ DNVPS study with its own independent findings.

The Japanese delegation was subsequently invited to our own technical seminar to present its findings to more than 100 shipowners, regulators, OEMs and members of the international press. The technical seminar immediately followed CSA 2020's first Annual General Meeting, where members agreed the by-laws of the alliance and elected the Executive Committee and a Communications Committee.

The influence we are having in the global emissions debate is evident not only from the release and distribution of data from credible, independent academic institutions and other research faculties, but also from our regular attendance at IMO.

At the 74th session of the Marine Environment Protection Committee, we saw further progress on the issues that had been discussed at PPR 6. The main development was the referral to GESAMP for a study into the effects of washwater in coastal waters.

The outcome of these and other sessions were explored in September during our general meeting and technical seminar in Singapore.

We now approach the end of our first full year having enjoyed an increase in membership and stature as a credible voice that provides much-needed balance to respond to the vocal minority of critics that have created a divisive emissions debate around exhaust gas cleaning systems.

All in all, it's been a very busy, but successful first year for CSA 2020, and we anticipate an even higher tempo in the second year as we approach the entry into force of the global sulphur cap in January, 2020.

Enjoy your first edition of *Clean Shipping International*.

"We now approach the end of our first full year having enjoyed an increase in membership and stature as a credible voice"

As shipping makes the shift into modernity, it challenges tradition with green principles

FACING THE FUTURE

by Andrea Morgante, Vice President, Strategy & Business Development, Wärtsilä Marine

Regulations and technological developments are set to transform the shipping sector from its classical roots into a modern, 21st-century industry. A significant change, given that many commentators argue that shipping has not changed in its essential operations for centuries.

End-to-end supply chains that are transparent and composed of transport and equipment that operate on clean energy, reducing emissions, increasing safety and improving the efficiency of the entire logistics system are expected to be developed over the next decade or so.

It has to be pointed out that until the 19th century, shipping used clean renewable energy and was not responsible for any climate degradation through atmospheric pollution. Modern requirements for fast and dependable cargo deliveries have driven the use of fossil fuels and while shipping may have to change fundamentally to reduce air and sea pollution, consumer demand and expectation will also need to undergo something of a transformation, too.

Wärtsilä itself has concentrated on the transformation of shipping that is expected to happen over the coming years. Expectations of substantial changes to the maritime sector in particular, but also to logistics services as a whole, have led the smart technology group to take a holistic approach to the conundrum of how to meet the targets set by the International Maritime Organization (IMO) and the challenges posed by new technology.

Some of these challenges are already being met with developing technology, as with the recent deployment of Swedish icebreaking tug, *Vilja*. This vessel has been fitted with Wärtsilä HY; a solution featuring operating characteristics that include "green mode", with zero emissions and no noise, a "power boost" that delivers a higher bollard pull, and "smokeless operation" whereby no smoke is produced even during start-up of the main engines.

In the first instance, however, the challenge set by the IMO is to reduce the

Vilja is the first vessel of its kind to operate with the Wärtsilä HY hybrid power module, designed by Robert Allan Ltd. ©Port of Luleå

sulphur content of vessel fuels, for ships operating outside of emission control areas (ECAs), from 3.5% to 0.5%. The new regulation governing this change will be enforced globally from 1 January 2020 and owners essentially have three choices on how they can comply with the regulation, also known as the sulphur cap. All of the options could pose problems for owners.

> *"To require a complex industry to make the step-changes needed to seriously address the sustainability targets set out by the United Nations is not an easy thing"*

SULPHUR CAP SOLUTIONS

Shipowners have largely decided to use low-sulphur fuel, now being made available by oil companies, perhaps because it is the simplest to adopt. But there are question marks, however, relating to cost and availability.

An alternative option is to continue using the same fuel oil as before, but with scrubbers fitted to clean the exhaust. The key technical component here is the reactor in the exhaust system that cleans the exhaust gases before they are released into the atmosphere. It is a practical solution, that is getting increasingly positive feedback from the owners who have adopted it — namely because the capital expenditure required for the installation may be offset by the reduced operating expenditure coming from the fuel cost spread. Any savings will depend on the price differential between low-sulphur fuel and heavy fuel oil (HFO).

The third choice, and one that is being increasingly adopted when building new ships, is to operate engines on liquefied natural gas (LNG). Wärtsilä experts point to global trends as an indication of how transformative gas can be in the near future. As LNG burns cleaner than distillate fuels, territories like the US, China and Europe are switching to gas as a fuel for heavy vehicles. This is creating the infrastructure that further elevates LNG as a viable bunkering fuel for seagoing vessels. Some market watchers foresee an imminent inflection point where demand for LNG will significantly increase.

And there is nothing that the internal combustion engine does with HFO that cannot be done with LNG. Dual-fuel engines capable of running on both regular fuel and LNG were introduced to the maritime sector a couple of decades ago by Wärtsilä, so this is a well-established and proven technology. LNG contains virtually no sulphur, thus making 2020 compliance easier.

None of the above solutions for compliance with the sulphur cap alone can address the IMO's next significant regulatory challenge set in April 2018 — to reduce greenhouse gas (GHG) emissions from the maritime sector to 50% of 2008 levels by 2050. A combination of some of these technologies can help to make significant headway, but to meet that challenge entirely new technologies and energy sources will need to be introduced as well.

For some, 2018 was viewed as a pivotal year for climate action when the

Wärtsilä believes that a modern approach to shipping will see collaboration between partners that will ultimately reduce greenhouse gas emissions by the industry and allow it to meet IMO targets.

world started demanding change. The global warming debate intensified when the Intergovernmental Panel on Climate Change (IPCC) reported that surpassing the 1.5 degrees rise in global temperature carries huge risks for humans and nature alike.

Global emissions need to be lowered dramatically and the maritime industry has a significant stake in making it happen. This is a call that rings true with Wärtsilä as the corporation's purpose is to enable sustainable societies with smart technology. Initiating "An Oceanic Awakening" in 2018, Wärtsilä set out to rally the maritime industry into action and to help accelerate the adoption of environmentally friendly marine technology.

As global cargo fleet capacity continues to grow on average 3% per year, the sea as a means of transportation retains its relevance in the future, but the growth also puts pressure on finding cleaner and more environmental solutions in maritime. This is a challenge that Wärtsilä is taking head on, together with its customers, partners and other stakeholders.

The ultimate aim, under the IMO's "levels of ambition", is to phase out shipping emissions entirely by 2100.

Along this route to the 2050 requirements and beyond, there are legislative milestones. And by 2030, GHG emissions from individual ships — meaning primarily CO_2 — must be cut by 40% on average compared to 2008 levels, for all vessels, new or existing.

To require a complex industry to make the step-changes needed to seriously address the sustainability targets set out by the United Nations, is not an easy thing. Nevertheless, the targets are there and the maritime industry is having to undergo a process of evaluation to establish the most realistic and cost-effective means of meeting them.

It must be said that, based on predicted demand for cargo transportation between now and 2050, the number of vessels will grow and emission reduction targets on a vessel level need to significantly surpass those on the fleet level. Around 70% reductions on the vessel level are needed to enable a 50% fleet level emission cut, which means the combined emissions of all ships in the fleet.

While being the most cost-effective and energy-efficient means of transportation, shipping still withstands a multitude of inefficiencies, waste, pollution, long waiting times in ports and abundant safety risks. For container shipping alone, global fleet-wide waste from inefficient fuel usage, owing to sub-optimal voyage planning and execution, is estimated to cost about €14.5bn annually. Some €220m is wasted on other inefficiencies, such as deployment of crew, maintenance, spares, oils and facilities issues.

Active vessels spend on average 35% of their time at anchorage, approach manoeuvring, berth and other port operations. This leads to an ever-growing need for this waste to be addressed alongside the environmental side effects.

Wärtsilä, through its Smart Marine vision, has determined to provide the market with low-CAPEX smart technologies that when combined can push vessel operations to become more cost-effective, fuel efficient and climate-friendly. The use of connectivity, real-time communication and data analytics in voyage optimisation, operation and energy management are crucial elements in the journey towards sustainable shipping. But choosing the right energy source is just as important on the journey towards a more sustainable maritime future.

FUTURE FUELS

After passing the first heavy duty milestone — sulphur compliance — the going gets far tougher. None of the solutions for compliance with the sulphur regulations alone will substantially affect CO_2 levels from shipping. To meet the IMO carbon emission target will require a combination of different solutions. This means that alternative clean-burning solutions must be found to power ships across the oceans of the world. This could require changes in an ordered and stepped way, meeting targets for 2030 first using a cleaner fuel before later switching to zero carbon fuels.

There are existing ways of propelling a ship with zero or almost zero emissions, battery power being the most obvious. But while current energy storage capacity is sufficient for short voyage sailing, further development is still required to make it technologically feasible, robust and cost-effective for larger vessels and it may be that it never becomes a viable option for ocean-going ships.

It is also necessary to consider emissions from well-to-wake when evaluating future fuels to complement energy solutions — bringing to attention the production of the fuel as well as the way it is transformed into mechanical energy.

There is speculation that fuel cells may one day emerge as technically and economically viable power solutions of the future, but Wärtsilä believes the internal combustion engine will continue to play a critical role at a time when the industry is faced with difficult questions on how to move forward.

Therefore, we recommend that shipping companies should look to using future-fuels compatible with existing combustion engine technology, but without the harmful emissions.

Put another way, in the run-up to the 2030 milestone, the most economically viable and reliable solution for ships being built from now on comprises a combustion engine running on LNG, as a bridging fuel, that is supported by the use of connectivity, real-time communication and data analytics in operation and energy management.

CAN SUPPLIES MEET DEMAND?

Wärtsilä, and other major industry providers, is investing heavily in research on possible alternative fuels. These include bio-LNG and synthetic LNG, ammonia and hydrogen fuel cells. There are considerable obstacles to overcome before their widespread use can be adopted, however. Let's not forget that the introduction of a new fuel — LNG — required a long period of testing and development of technologies covering the whole supply chain, which finally resulted in the adoption of the IGF code in 2015.

Apart from the potential suitability of these alternative fuels for meeting the legislation, other questions to which answers are needed include the likely costs involved, the existence or not of an adequate supply chain and futureproof infrastructure and whether there be enough to meet demand. Here, the flexibility of multi-fuel combustion engine technology comes to the fore.

As experience has shown, such engines can switch seamlessly between different fuels so if one is not available, others can be used.

A DIGITAL SEASCAPE BECKONS

Wärtsilä's Smart Marine vision is a forward-looking initiative that takes a big picture approach to reaching the IMO's targets and to improving sustainability in general. In a Smart Marine Ecosystem, vessels will be technologically smart, using cloud-based software and digital technology to substantially increase efficiencies that will optimise the use of energy, so that fuel consumption is minimised.

These ships will sail between smart ports that manage traffic flows extremely efficiently so that waste, such as ships waiting to dock in congested harbours, is eliminated. The vision also foresees new business models emerging whereby greater cooperation between shippers will ensure that ships sail with full cargo loads, enabling more cargo to flow using the optimal number of vessels.

Sub-optimal fuel operation is something that can be relatively easily rectified with the right digital tools. For instance, the typical drivers of excess energy consumption or energy waste on board single sea voyages are the route selection, sub-optimal route planning and execution, or schedule deviation owing to congestion or delays at ports.

For this reason, Wärtsilä, through our Voyage Solutions, is looking to improve efficiency and safety and to reduce the environmental impact of shipping by using data and connecting the vessel, the port and the fleet operation centre together in a common decision support environment.

This kind of ecosystem will certainly be a major component of the ultimate solution to 2050 compliance.

There will be all-electric vessels sailing short sea routes and new technologies will be developed between now and then. But essentially, it seems that the big change will be in the fuel mix used by engines. The fuel-flexible combustion engine, therefore, presents itself as a future-proof technology that will enable the industry to meet future targets as and when alternative and renewable fuels become available.

WHERE TO INVEST?

The world of shipping is being re-shaped and investments in sustainable production of bio and synthetic fuels are needed today if they are to become broadly available post 2030. Leveraging radical and transformative innovation is no doubt the way to tackle emissions.

Today, LNG presents itself as one of the best and most economical pathways to decarbonisation, owing to its cleaner burn, compatible pricing and established supply infrastructure — the same infrastructure that can be used for future fuels. And a Smart Marine Ecosystem will support the growing need to optimise operations.

The combustion engine will remain the stalwart of shipping because the reciprocating engine enables fuel flexibility, leaving the doors wide open for the future renewable liquid and gaseous fuels as and when they become compliant, market-ready and available.

PURETEQ – THE SCRUBBER MAKER

PureteQ is a Danish engineering company located in southern part of Denmark. PureteQ design, deliver and commission state of art, reliable and patented Exhaust Gas Cleaning Systems to the shipping industry across the globe. This includes superior quality and easy to install and operate water treatment systems. The open tower in-line scrubber system has no moving parts nor any obstructions such as a packaging layer. The simple construction requires less maintenance and it is very simple to operate for the crew. It features the lowest OPEX in the business, hence a very attractive business case.

The Scrubbers are delivered to shipyards and shipowners. We employ marine professionals who will support the client from signing of contract to final approval of the system by flag state. In most cases we even enter service contracts with clients to ensure optimal maintenance and calibration of systems and frequent refresher training of crews. In other cases, we just surveille the systems on behalf of the clients to ensure compliance and guide the crew when necessary.

Presently, PureteQ have 5 factories that supply scrubber towers. All these factories have undergone an extensive quality testing procedure to ensure that they deliver superior quality products. Once they have been qualified/ accepted by PureteQ, they may produce products under supervision of PureteQ Engineers. Customers are always welcome visit the production sites. We believe that a close collaboration with our suppliers lead to shared learning and flexible solutions on our maritime scrubber systems – a win-win.

According to a new study published by independent Norwegian research organization, SINTEF, scrubbers are the most environmentally beneficial means of meeting global greenhouse emissions targets. This report does not stand alone, as researchers from Denmark and Japan have reached the

same conclusion. We are extremely proud of being a part of this and intend to push the boundaries for what can be done to improve the environment every day. For this reason, we invest considerably time and capital into R&D. We focus on optimizing OPEX and CAPEX for our customers. PureteQ are currently testing the world's first filtration plant on one of our customer's vessel, using candlestick technology. To further assist our customers in complying with possible tighter legislation in the future, we also have R&D activities in reduction of CO_2.

SAFE AND EASY SCRUBBER-OPERATION

Is reliability and quality one and the same? Not quite, but at PureteQ we believe that they definitely go hand in hand! That is why our scrubber system is designed with extensive safety measures, on and beyond normal industry standards, to ensure continuous easy operations and to avoid malfunctioning. All scrubber towers have two drainpipes, each with a 100 % capacity.

This enables for wash water to flow freely, even if one drain is blocked. This is especially an advantage in rough seas. Each drainpipe is equipped with a hardwired sensor. These will promptly detect, if water does not flow freely in any of the drainpipes and hereafter shut down the scrubber pumps immediately for safety. The two-drainpipes setup also ensures redundant level switch functionality.

As an extra safety measure, a Water Catch System with level switch is installed. If, for any reason, water should run back towards the engine, the water will flow into a Water Catch System and activate a level switch. This will shut down the scrubber pumps. Once the system is in operation, the PureteQ scrubber system has remote access capabilities. Experienced PureteQ marine engineers as well as shipowner may access the system, analyze and provide guidance to the crew as well as monitor performance.

These are just a few of the many safety measures installed. For a comprehensive list, feel free to contact our CEO, Anders Skibdal, on the contact information provided. We always aim to guide not only our customers but all interested parties with an honest agenda.

GLOBAL IN-HOUSE SPECIALISTS

Currently, PureteQ employ more than 50 marine engineers who are specialized in development, design and management of the individual projects. Our in-house engineers design and customize every scrubber system to the individual vessel and our Project Managers are responsible for project execution. The Project Managers receive extensive training in chemistry, metallurgy, process technology and machinery as well as on-the-job training prior to taking on their own projects. They also receive training in navigating between all involved stakeholders, such as shipowner, Class Societies, Naval Architects, designers, sub-suppliers and yards. All of this to provide the best possible advice to the shipowner from the minute the contract is signed until approval of the system.

The increased lead time on yards sets even higher demands for our Project Manager to perform meticulous planning and eminent risk management. These capabilities are instrumental in on-time delivery of systems.

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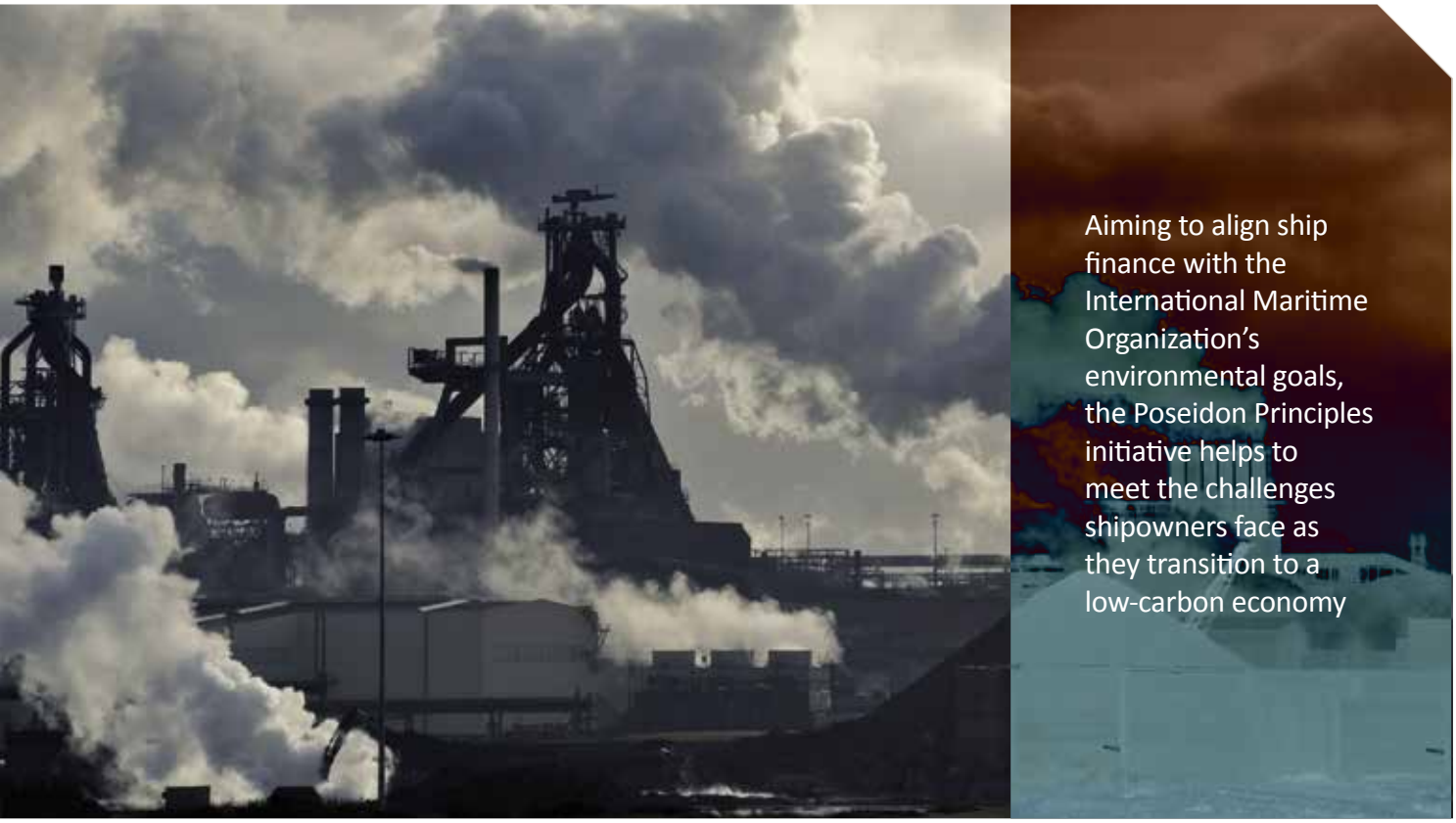

Aiming to align ship finance with the International Maritime Organization's environmental goals, the Poseidon Principles initiative helps to meet the challenges shipowners face as they transition to a low-carbon economy

A PRINCIPLED **APPROACH**

by Paul Stuart-Smith
Founder,
Zero Carbon Finance

Doubly dependent on fossil fuels, both for propulsion and as cargo, the shipping industry is more exposed to the risks of climate change than most other industrial sectors, not least from the very real possibility of assets becoming "stranded", as the International Maritime Organization (IMO) implements its greenhouse gas (GHG) strategy and the world economy decarbonises.

No surprise then, that climate change is a hot topic at shipping conferences these days. Along with zero emission vessels (ZEVs), it was a key theme at Nor-Shipping in June and again at London International Shipping Week in September. Industry bodies such as the Global Maritime Forum and the International Chamber of Shipping are also on the case, promoting the development of deep-sea ZEVs by 2030 and seeking engagement across supply chains to cut emissions.

Yet, recent research reports, such as *Carbon Carriers*, from Maritime Strategies International and *A Sea Change* from CDP (formerly the Carbon Disclosure Project) suggest few shipping companies have begun to assess the serious challenges they face from the transition to a low-carbon economy.

By contrast, central bankers, such as the Bank of England's Sarah Breeden, are extremely concerned about the risks of climate change, fearing that a sudden re-pricing of fossil fuel dependent assets could undermine the financial system. She describes the dangers as "foreseeable, far-reaching and for action today". Financial firms, they believe, have a pivotal role to play in mitigating climate risks by steering capital towards companies that are addressing the threats they face, and away from those that are not.

But to do this, investors, lenders, advisors and other financial firms, including index providers and ratings agencies, need to be able to integrate climate risk fully into their decision-making processes. And that can only be achieved through access to better quality data.

This is the ethos behind the Poseidon Principles, the initiative announced in June by 11 ship-finance banks and supported by Lloyd's Register, which commits the banks to measuring and disclosing the climate alignment of their ship-finance portfolios. And it is the basis for the major global corporate reporting framework published in 2017 by the Taskforce on Climate-related Financial Disclosures (TCFD) under the auspices of the G20's Financial Stability Board.

This framework, known as the TCFD recommendations, urges companies to identify the short- and longer-term risks and opportunities they face from climate change, gauge the resilience of their business strategy under at least two possible future climate and policy scenarios, and then use this information to make a set of 11 climate-related disclosures to investors in their mainstream reports.

Implementation of the TCFD recommendations has, so far, been optional, but this is changing as policy makers and institutional investors put pressure on companies to become fully TCFD-aligned. One of the major announcements in the UK government's Green Finance Strategy published in early July, for example, is the expectation that all listed companies and large asset owners will implement the TCFD recommendations by 2022. The government may introduce legislation if sufficient progress towards this goal has not been made by next year.

At the same time, governments from the UK, Norway and France to Fiji and the Marshall Islands are committing to complete decarbonisation of their economies by 2050 or sooner. The UK has also recently announced an ambitious Clean Maritime Plan, which calls for new vessels ordered for use in UK waters to have zero emission propulsion capability by 2025.

> *"Initiatives such as the Poseidon Principles will force shipowners and operators to focus on the need to reduce the carbon dependence of their operations or risk access to finance becoming scarcer than it already is"*

Climate change is thus shooting up the political and policy agenda. And with the physical impacts of climate change from extreme weather and rising sea levels also becoming increasingly evident, corporate procrastination is no longer an option.

The IMO's greenhouse gas (GHG) strategy requires the shipping industry's own emissions to be cut by at least 50% from 2008 levels by 2050, while achieving the goals of the Paris Agreement to keep mean global temperatures to less than 2°C above pre-industrial levels requires global energy-related emissions to peak by next year and worldwide demand for fossil fuels then to fall sharply.

According to the International Energy Agency's World Energy Outlook 2018 (in its Sustainable Development Scenario), this would mean primary energy demand for coal and oil dropping by almost 60% and 30% respectively by 2040.

In this type of scenario, the MSI report referred to earlier concludes that earnings and asset prices for carbon carriers such as Capesize bulkers and VLCCs, would be "hammered" and the risk of these assets becoming completely stranded would be considerable. But, according to MSI, "discussion of these potentially disastrous demand-side dynamics is almost totally absent from the shipping industry."

This seems to be borne out by the

CDP report, which found that only four shipping companies are official supporters of the TCFD and that "board level oversight of climate issues is very low compared to other sectors".

Yet, as the physical and policy risks increase, so do the climate-related fiduciary duties of company boards. Directors have a clear responsibility to ensure that climate change issues are being managed and that financially-material information is disclosed to investors. Failure to do so risks potential personal liability.

Legal cases, in which investors seek damages from companies for losses caused by failure to disclose climate-related risks, are already being heard in the courts (for example Abrahams v Commonwealth Bank of Australia). And climate change litigation is likely to expand dramatically as more climate-related laws come into force (now estimated to number around 1,500 world-wide) and as climate-related financial losses mount.

All of this points to the importance of company boards and management devoting far more time and resources to managing climate change risks. But another key reason to do so is availability of finance. Initiatives such as the Poseidon Principles will force shipowners and operators to focus on the need to reduce the carbon dependence of their operations or risk access to finance becoming scarcer than it already is.

Banks signing up to the Poseidon Principles commit to publishing carbon intensity figures for their shipping portfolios each year beginning in 2020. This will be measured as the average amount of CO_2 emitted (in grams per deadweight tonne-nautical mile) across the assets in the portfolio, using vessel emissions data that shipowners will report to the IMO Data Collection System (DCS) via Flag States beginning next March.

Some have questioned whether the Poseidon Principles are merely another example of "greenwashing". In fact, other things being equal, they should require the banks to reduce the carbon intensity of their portfolios each year and at a pace consistent with meeting the IMO's emissions target. They should therefore act as a ratchet, forcing the banks to channel new loans to ever lower-carbon shipping ventures.

Effects of climate change become more devastating.

The Secretariat of the Poseidon Principles will produce downward sloping "decarbonisation trajectories" showing the appropriate level of carbon intensity permitted for each year and for each ship type and size class needed to achieve the IMO's 2050 goal, taking into account the projected total transport demand for each sector.

If, as many expect, global sea-borne trade volumes double over the next 30 years, ships will, on average, need to become at least 75% more efficient than today, a far more onerous target than the IMO's secondary goal of a 70% improvement in efficiency from 2008 levels.

The Poseidon Principles should therefore help to align ship-finance with the IMO target. Shipowners could, of course, seek finance from lenders or investors not signed up to the Poseidon Principles. But if their business plans are not consistent with the IMO target, the risks to both shipowner and finance provider of a sharp drop in the value of the asset may prove unacceptably high.

Indeed, these risks may grow as the effects of climate change become more devastating, putting the IMO under pressure to strengthen its 2050 target and bring forward the goal of complete decarbonisation.

In the 1950's, philosopher, physician and Nobel Peace Prize winner Albert Schweitzer wrote: "Man has lost the capacity to foresee and forestall, he will end by destroying the world." His words were echoed, famously, by Rachel Carson in *Silent Spring*, her seminal 1962 book about the effects of pesticides on the environment.

Integrating the TCFD recommendations into corporate governance and business processes is an important first step for shipowners — and their investors — to take to show that, in the context of climate change, Schweitzer's fears will not be realised.

Zero Carbon Finance provides climate-related advice to companies in the shipping, oil and other industries, with a particular focus on implementation of the TCFD recommendations.

For many shipowners, scrubbers are a new technology that they have little experience of. Here, Poul Woodall of DFDS explains how the company took the first tentative steps to installing scrubbers 10 years ago and why it was a risk worth taking

WHY SCRUBBERS MAKE SENSE

Danish ro-ro ferry operator DFDS has been using scrubber technology on its vessels for 10 years. According to director Poul Woodall, the reason for its initial decision to go down this route was that, back in 2009, the company was exclusively a north European operator and was aware that the Sulphur Emission Control Area (SECA) would be imposed on 1 January 2015, so it was already looking for options to operate within the emissions control area.

Cost is crucial to the decision-making process to fit scrubbers and Woodall estimates the cost for DFDS has amounted to around €4-9m per vessel. "That is not only for the scrubber," says Woodall. "It includes all the service and the whole consequence of retrofitting a scrubber. On a newbuild, you don't have some of these costs — it is becoming cheaper."

The company decided to install a pilot unit on the *Ficaria Seaways* 10 years ago. "We operated that for three years as a learning experience," explains Woodall.

A NECESSARY LEARNING CURVE

In hindsight, it proved to be an expensive experiment, but it was money well spent because the company learned a lot about materials, handling and fine tuning the system, in close co-operation with Alfa Laval, the system manufacturer.

"Although scrubbing technology was nothing new, it was in the marine environment. There were things in the original installation that were not optimal, for example the piping — we had to change it to glass reinforced piping, which was probably the biggest change. It was more expensive, but it was necessary. Probably everyone is doing that today," says Woodall.

There is no doubt, according to Woodall, that fitting scrubbers was the right decision for DFDS; viewed with hindsight, the decision has made sense for reliability, financial and environmental points of view.

The company has also made a payback on its scrubbers through the difference between the cost of heavy fuel oil (HFO) compared to low sulphur diesel, with HFO prices having remained well below the price for its low-sulphur competition, and the company has had a better environmental footprint.

In total, DFDS will have 28 ships fitted with scrubbers by the end of this year and a further 10 in the pipeline, either in retrofits or newbuildings, out of a total fleet of around 50 ships. The criteria for fitting scrubbers to vessels is a combination of whether the vessel in question is owned, where it will trade so that the company can plan the refuelling and the cost of the scrubber unit.

FITTING SCRUBBERS ON A SEQUENTIAL BASIS

"Scrubbers are not suitable for all the ships in our fleet, so we still use compliant fuel in some vessels," says Woodall. "We have fitted scrubbers on a sequential basis where it makes most sense, but some ships don't have scrubbers for technical reasons."

The company operates a combination of ro-ro and ro-pax ships and "when it comes to installing a significant engineering addition," such as a scrubber on some ro-pax vessels the installation can be extremely complex", he says. "We have found it really difficult."

The world is a little more complex now than in 2013, when DFDS decided to expand its scrubber programme and the cost of 0.1% is slightly higher than 0.5% sulphur content fuels, but the calculations and risks will be similar, Woodall claims.

CLEAN MARINE: SET TO CUT SCRUBBER COSTS

Norwegian technology company Clean Marine is set to cut shipowners' investment and installation costs, plus scrubber operating expenditure, through its newly launched Open Deck Compact SOx Scrubber

The newly developed SOx Open Deck Scrubber reduces the total installed weight of infrastructure by more than two thirds, which means significant capex savings on the scrubber itself and no need to strengthen the ship structure prior to installation.

The simplified scrubber also reduces installation time from four-to-five weeks to three weeks, thereby cutting docking costs significantly, too. A pre-fabricated electric room is one of the solutions that enable significantly shorter installation time. All critical components on the open deck scrubber are protected from harsh sea conditions.

"Overall, our new scrubber application is significantly more competitive than other scrubber applications on the market and compared to the alternative of using low-sulphur fuels to meet the IMO2020 standards," says Nils Høy-Petersen, CEO of Clean Marine. "This development is in response to many shipowners who have requested both lower capex and opex levels for marine scrubbers while being able to satisfy the IMO 2020 emission level requirements."

The compact Open Deck scrubber is a hybrid scrubber than can run with both open and closed loop, thereby avoiding conflict with ports that have prohibited the use of open loop scrubbers. It can easily be inspected and maintained by the vessel crew in order to maximise operational uptime.

The scrubber is made of high-grade stainless-steel material and is easily incorporated with the ship's boilers. It comes with a proven zero-back-pressure construction that has already had more than 100,000 hours of operation with boilers the past few years. Favourable placement of electronics and simplified cable connections make it easy to install and maintain.

"The big shipowners with a clear sustainability profile and plan seem largely unaffected by recent industry discussions," adds Høy-Petersen. "However, we believe this next-generation scrubber application could make it easier for other smaller shipowning companies to opt for a scrubber solution."

Clean Marine's technology has become one of the most favoured solutions for shipowners in the maritime and shipping industries, where zero back-pressure and boiler connections have been in focus. As a result, the company's revenues trebled from 2016 to 2018. Furthermore, Clean Marine expects

The CleanSOx Open Deck scrubber can be easily integrated on deck and reduces weight and installation time significantly

2019 revenues to be six-to-seven times higher than in 2018.

"It is fair to say that the scrubber market has slowed down in recent months, but we have invested in production capacity worldwide that allows us to handle large orders and shorten delivery times," says Høy-Petersen.

"Our current order backlog requires us to deliver eight-10 exhaust gas systems per month in the run-up to IMO 2020. Instead of operating the vessels in the turmoil of January 2020, it could be beneficial to install a scrubber during that difficult time. We still have available production slots for shipowners that require scrubbers for delivery in early 2020."

BY SHIPOWNERS, FOR SHIPOWNERS

With the intention of creating scrubber-technology that would be the most future-proof solution for shipowners around the world, Clean Marine's research and development began in 2004 as part of the industry-leading shipowner, Thorvald Klaveness Group.

Its thorough knowledge of the maritime industry, coupled with Norwegian traditions for being an innovative and quality-driven maritime player and good engineering practice, have been incorporated into the design of our marine scrubbers.

Being one of the pioneers of the scrubber industry, Clean Marine has already had more than 100,000 running hours of its systems, proving its comprehensive engineering capabilities and best-in-class technology.

Clean Marine is staffed with highly skilled personnel from both the maritime and the process industries. With its headquarters in Oslo, Clean Marine also has offices in Singapore, Bulgaria and in Houston, US, plus service hubs in all major basins and sales representatives worldwide. A large team of technicians supports customers during both installation and operation of the scrubber. The company is dedicated to emission cleaning only and is recognised as a highly competitive supplier of marine exhaust gas scrubbers.

It has dedicated partners in all corners of the globe, bringing it closer to both shipowners and shipbuilders. Its global presence enables it to offer the expertise and equipment needed to install an EGCS on both new and existing ships.

Clean Marine has a strategic partnership with Høglund, a well-established and highly regarded marine solution company, delivering high-quality products and services to all types of marine installations worldwide. Pictured here is Clean Marines Head of Project Execution Øystein Brekke, following up with a customer during sea trials

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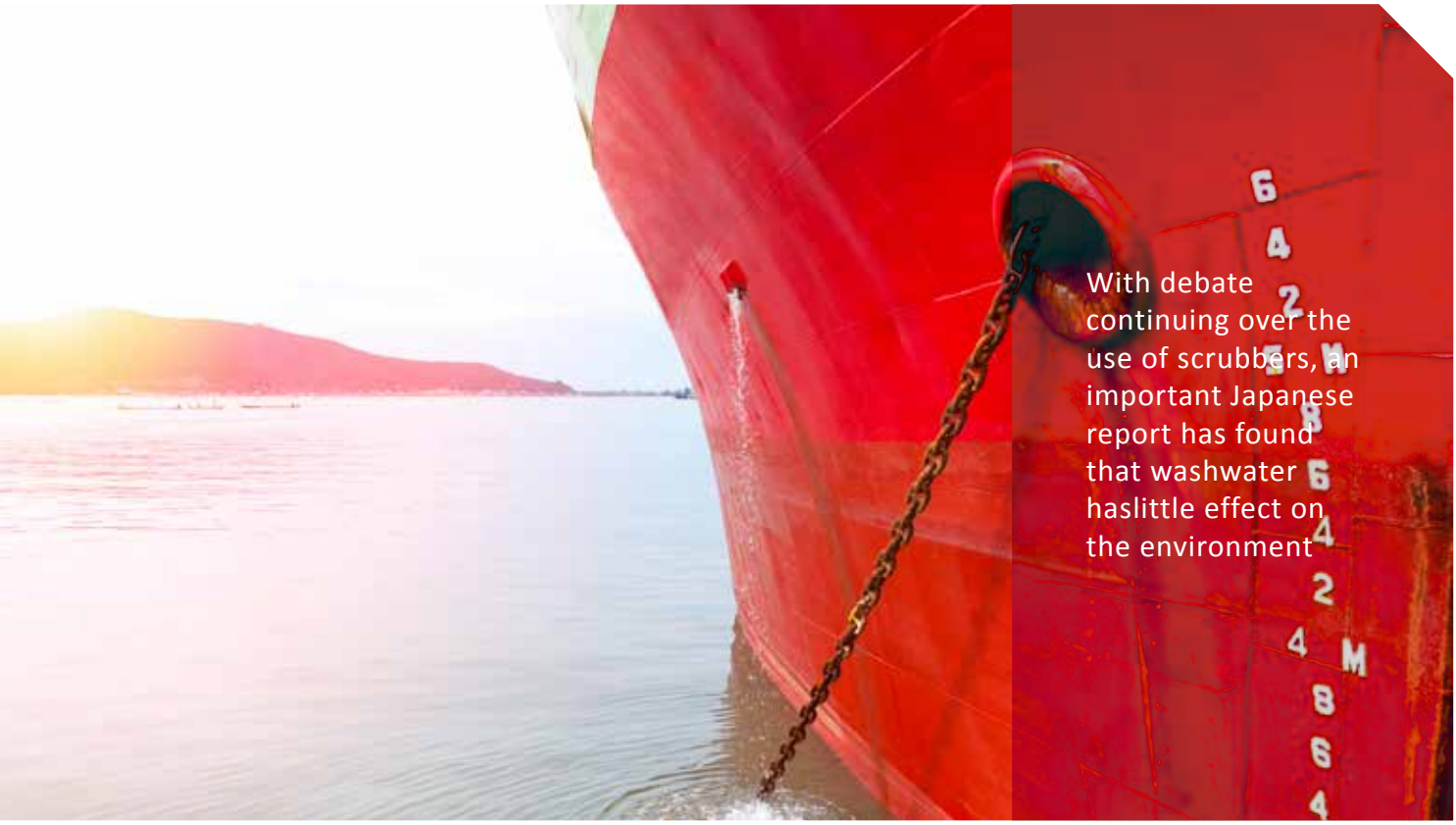
CLEAN MARINE



With debate continuing over the use of scrubbers, an important Japanese report has found that washwater haslittle effect on the environment

Naohide Saitoh, the MLIT report co-ordinator on EGCS washwater

REPORT CALMS THE WASHWATER DEBATE

Regulations governing the release of sulphur oxides, also known as SOx, into the atmosphere will become a reality on 1 January 2020 and most operators have opted to use low- sulphur fuel to comply with the new rules.

Around 5% of owners have, however, opted to use exhaust gas cleaning systems (EGCS), or scrubbers and the washwater from these systems is causing consternation among the regulators, with calls from a number of organisations for further regulation to curb the discharge of scrubber washwater from vessels fitted with open loop scrubbers.

Open loop scrubbers collect sulphur and other pollutants from the exhaust and the collected pollutants, rather than being discharged into the atmosphere are released into the ocean. Many scrubbers have a closed loop system where the collected pollutants are stored on board and dealt with at a port, while others have hybrid, closed and open loop systems. For some industry observers, the washwater from scrubber technology is seen as a possible new source of pollution and will require further regulation to prevent the pollution of the seas. This is because the washwater from onboard scrubbers will contain heavy metals such as cadmium and lead as well as other pollutants such as PAHs (Polycyclic aromatic hydrocarbons) anthracene, fluoranthene and naphthalene, among other chemicals.

At the most recent Marine Environment Protection Committee, (MEPC74), of the International Maritime Organization (IMO), the Japanese delegation presented a report based on expert research on washwater that logged the expected environmental impact of scrubbers on the oceans. That report concluded that there would be little effect on the marine environment.

That research conducted by experts commissioned by Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has concluded that there is no serious danger from the discharge of scrubber washwater into the oceans, not only in the

short-term, but over the long term and in the wider marine environment.

According to the report, which was published earlier this year, there is no "scientific justification to prohibit the use of open-looped (*sic*) scrubbers, as long as the IMO's discharge criteria were met".

Speaking exclusively to Clean Shipping International, the MLIT report co-ordinator Naohide Saitoh says: "The conclusions of the paper were that the heavy metal, PAHs and SOx in the washwater do not pose any serious harmful effects on the marine environment as the levels were quite low.

"We don't need to care about the amounts as the detection levels were too low to worry about."

In its washwater report, MLIT assumed that all ships were fitted with open-loop scrubbers and the researchers intentionally studied the comparatively enclosed areas of the Seto Sea, Ise and Tokyo Bay. Using details on washwater deposits from ships fitted with open-loop devices researchers were able to use AIS data to estimate the number of ships visiting the regions over a 10-year period and to calculate the accumulated concentrations of harmful substances.

Given that only around 5% of ships have currently been fitted with scrubbers, the calculations are considered to be substantial over-estimates of the actual deposits expected over a decade, explained Saitoh.

At MEPC74, Japan concluded that the risk of harmful concentrations of pollutants from washwater was "in the acceptable range of negligible", both in the long and short term and that based on this stud,y Japan will not apply restrictions on open-loop scrubbers in its waters.

Results from Japan's research project are very similar to the initial conclusions drawn by consultants CE Delft and Deltares in their study of exhaust gas cleaning systems (EGCSs) called *The Impacts Of EGCS Washwater Discharges On Water Quality*, which was also submitted to this year's MEPC74 in May. This report is aimed at assessing the impact of washwater discharges at the berth, with a focus on the Baltic and North Seas.

According to the initial findings of the CE Delft/Deltares report, the impact of washwater from EGCSs would "increase the equilibrium concentration in the port by no more than 0.025% of the annual average 2021 environmental quality standard in the EU."

Annual average harbour accumulated concentrations are calculated as a percentage of future expected averages, in 2021, and the allowable concentrations laid down in the EU Directive 2013/39/EU, concerning pollutants in surface waters, both inland and in the wider seas and oceans.

Initial results from the European consultants will be followed by further research into two more generic ports in the North Sea and Baltic regions, comparing a range of potentially hazardous compounds against the IMO criteria for washwater from EGCSs as well as comparing concentrations in river and sea water.

Meanwhile, a third study conducted by cruise ship operator Carnival Corporation is an ongoing analysis of washwater from 23 cruise vessels testing for 54 separate parameters, including PAHs and heavy metals. Samples are taken from three points, the EGCS inlet, the tower and the outlet.

Carnival said that an expanded data base included samples from 11 vessels that were fitted with washwater filtration systems, samples were also taken from the point immediately before the water entered the filter.

However, the researchers pointed out that the positive results from the vessels fitted with filtration systems particularly for certain compounds, such as anthracene, benzo(a) anthracene, benzo(b)fluoranthene, arsenic, copper and many other substances, the number of ships in the study with filters was just 11 and as such there would need to be further tests, including operational trials, to determine the effectiveness of filtration.

Nevertheless, the company concluded that washwater concentrations were below the emission limits for land-based industry. However, the report cautioned: "This is not evidence of compliance with these standards (which are intended for a different regime and include other controls and limits for compliance). The comparison does, however, establish a point of reference to understand the quality of the EGCS washwater relative to other industrial discharges."

Even so,the report also pointed out that the washwater concentrations measured from the cruise ships also compared favourably with tougher environmental regulations such as the EU Surface Water Standards for inland waters. The analysis again pointed out that these EU rules were designed for a very different application, but said "they provide a useful quantitative reference" in understanding the washwater concentrations, particularly for compounds such as PAHs where "there is a lack of more suitable standards".

Results also pointed to low concentrations of certain compounds such as arsenic, cadmium, lead, mercury, selenium and thallium.

While useful, the Carnival study does have some acknowledged limitations. These include the statistics provided are averages of all the vessels in the study rather than individual results for each ship.

In addition, Carnival points out that the study only offers an insight into washwater quality as a basis for a more informed, industry-wide debate. It does not assess the cumulative effects of washwater discharges and neither does the research offer an insight into the wider environmental impacts of those discharges.

Results from the Carnival and CE Delft/Deltares research projects, while inconclusive, offer an insight into the levels of concentrations that could be emitted from vessels using scrubber technology to meet new IMO 2020 regulations. The broader study by MLIT shows that the wider effects of washwater discharges are unlikely to pollute the oceans significantly.

Whether Japan and other countries can use this evidence to successfully argue this case at an IMO that is keeping one eye on the wider population and its opinion remains open to question.

DATALINK INSTRUMENTS: KEEPING A WATCH ON WATER

Datalink Instruments (DTLI) has been designing and manufacturing high-reliability, low-maintenance and cost-effective online water monitoring solutions since 1989.

Offering a wide range of online water analysers and probes that use the latest technologies, it provides monitoring for:

- Polycyclic aromatic hydrocarbons (PAH);
- BOD (biochemical oxygen demand), COD (chemical oxygen demand) and TOD (total oxygen demand) using SAC254 correlation;
- Nitrate
- Nitrite
- Ammonium ions
- Sulphide
- Phosphate
- Chlorophyll A
- Fluorescent tracers
- Chromium VI
- Formaldehyde
- Heavy metals (nickel, zinc, manganese, aluminium, etc)
- pH
- ORP (oxidation reduction potential)
- Conductivity
- Temperature
- Dissolved oxygen
- Turbidity
- TSS (total suspended solids)
- Colour

DTLI offers a wide range of online water analysers and probes that use the very latest technology

APPLICATIONS

DTLI water analysers and probes are suitable for a number of applications:

- Scrubbers' washwater quality monitoring
- Drinking water
- Waste water and ground water monitoring (treatment plants, alert stations)
- Environmental monitoring
- Refineries
- Petrochemical industry,
- Industrial effluents
- Process monitoring.

With its highly skilled team, DTLI has been offering complete tailored solutions for monitoring water quality all over the world for the past 30 years. With a large-scale distribution network, it provides technical support and after-sales service all around the world.

Based on its extensive experience and know-how, DTLI's Research and Development department continues to create new products while working on the improvement of existing ones, according to both the requirements of the applications and the wants of the customers.

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Shipowners cannot be expected to delay their compliance plans, therefore it is essential that vessel operators have reliable and comprehensive washwater monitoring systems that use failsafe methodology

MONITORING FOR SCRUBBER COMPLIANCE: **AN UNCERTAIN CERTAINTY**

by Paul Griffiths, Head of Sales and Marketing, Chelsea Technologies

The identification of harmful contaminants in washwater ahead of discharge enables preventative action to be taken that will avoid financial penalties and damage to the marine environment. When it comes to washwater monitoring, the International Maritime Organization (IMO) has made some headway in providing clear guidelines. However, the methodology behind monitoring for polycyclic aromatic hydrocarbons (PAHs) has yet to be agreed through regulatory compliance.

It has been argued that PAH discharge is most crucial when it comes to the prevention of harmful discharge and accurate measurement of PAH levels in washwater is a mandatory aspect for compliance.

The lack of an agreed methodology in this instance is particularly challenging. For shipowners investing significant capital in scrubber installations, it becomes difficult to accurately weigh up the pros and cons of the technology currently available to them. Equally, scrubber manufacturers need to ensure that they employ a reliable, consistent monitoring solution that can accurately assess the efficacy of their systems, in order to offer stakeholder reassurance that the systems are operating in-line with manufacturer specifications.

Furthermore, the industry anticipates that it is only a matter of time before IMO washwater monitoring guidelines will be mandated. The likelihood of this happening ahead of 1 January is slim, which means that some shipowners will have already made significant investments in scrubber systems and washwater monitoring equipment. Safeguarding investment against these future regulations must be a priority, in order to ensure owners are not short-changed.

Alongside this, monitoring technologies need to have the capacity to accurately measure all parameters of wash water based on a well-researched, proven and future-proof methodology if they are to stand up to rigorous requirements.

Owners looking for monitoring systems should ensure that their system of choice performs the full regulatory analysis, as required by the IMO, including PAH, pH, turbidity (to ISO 7027: 1999) and temperature. The science behind these parameters is robust and has been type approved by DNV GL while having an accredited methodology to MEPC 259(68), courtesy of ClassNK and DNV GL.

The technology to accurately measure and monitor all aspects of scrubber washwater is already available. One such system, among others, is Chelsea Technologies, which has used its more than 50 years of experience in monitoring technology to develop Sea Sentry, a fully autonomous washwater monitoring system that monitors both the water inlet and outlet of wet exhaust gas scrubber systems.

Despite the current uncertainties and complexities in the market, it is vital that owners and operators who are choosing the scrubber route to compliance, take steps now in order to safeguard their investments. One of the first actions to protect equipment will be selecting partners who are able to advise, plan, and support with safeguarding by ensuring that they are prepared for all regulatory eventualities.

Combined with its technical experience, Chelsea has worked closely with leading global scrubber manufacturers with a view to offering owners and operators a collaboration that should increase their confidence in the system. This includes ongoing research and development and an in-depth knowledge of the stringent standards imposed by regulators.

DIVISIVE EFFECT

It goes without saying that the scrubber route to compliance with Marpol Annex VI has had a divisive effect throughout the industry. The conversations have been centred around environmental impact, specifically when discussing the washwater effluents from wet scrubbers and whether there is a way of understanding, or even predicting, the long-term effects on marine infrastructure. However, time is running out and, as we hurtle towards the implementation date for the 2020 sulphur cap, owners and operators cannot be expected to delay their compliance plans.

WHERE IT ALL BEGAN

In 2015, the German Federal Environment Agency (FEA) opened up the floor for scrubber discussion with its report on the impact of scrubbers on port and coastal waters. This report factored in the environmental stressors specific to German coastal waters, along-side the unknown impacts of scrubber washwater. It is this concept of the unknown that presents the crux of the argument for both sides of the debate, and it is for this reason that the upshot of the German report was a call to the IMO for a multilateral approach to safeguarding coastlines; for the German FEA, mitigating the risk for potential damage to the nation's marine environment is tangential to long-term sustainability efforts.

More recently, the trepidation of the unknown has led to highly publicised moves from significant shipping nations. Singapore, China and Fujairah in the UAE have banned the use of open loop scrubbers in their waters. China, with its notable maritime influence, has cemented its position further by announcing an extension of the ban from designated emissions control zones (ECZ), including all Chinese territorial waters out to 12 nautical miles, by imposing an HFO carriage ban.

SCRUBBER SURGE

However, not all parties agree. The market saw a surge in uptake for scrubbers in 2018 and 2019, and the market opened up to bulk carriers, tankers and container vessels, alongside early adopters in cruise and ferry.

The Exhaust Gas Cleaning Systems Association (EGCSA) estimates there will be as many as 4,000 vessels with units in operation by 1 January 2020, and operators who have installed and used scrubber systems have reported that, on the whole, they anticipate to experience financial benefits from continuing to burn heavy fuel oil (HFO).

Economically speaking, the case for scrubbers appears to hold water, particularly for owners and operators, with certain trading streams suggesting that investment in scrubber technology could be the difference between a viable shipping service or switching to road.

MEPC 74 was the seat of some interesting updates in favour of scrubber technology. A translation of a range of studies on the effects of scrubber washwater were submitted to the committee by CE Delft and the Japanese Transport Ministry.

In light of this, the EU has called for scientifically informed global policy harmonisation in attempts to streamline state-level positioning and empower the IMO to align all signatory states in a single policy approach.

However, there is little to indicate how long it will take to gather enough data on washwater effluent impacts in order to unify its position. The potential for it to take a number of years is a real possibility.

Chelsea Technologies Sea Sentry washwater monitoring system

Carbon is coming under far greater scrutiny — as is the ability of owners and charterers to manage it. With the help of a vessel's digital twin, it is possible to extract information, monitor performance and conduct more precise planning of operations, leading to a more accurate report on carbon emissions — and the steps that can be taken to cut them

TWO-PRONGED APPROACH

by Dr Teemu Manderbacka, Senior R&D Engineer at NAPA Shipping Solutions.

The debate over the mechanisms that will be used to achieve a reduction in carbon emissions will probably go down as one of the defining conversations within shipping during 2019 — and if the current state of readiness for the IMO 2020 sulphur cap is any indication, we shouldn't expect it to go away any time soon.

The people currently controlling the public debate are those arguing for a universal speed limit on shipping — notably, Extinction Rebellion in May this year, and Emmanuel Macron in August. It's easy to see why this solution is being picked up by both activists and governments alike: it's a one-size fits all, easily understandable rule that, on the face of it, quickly gets good results. However, as many critics have pointed out, it likely necessitates the building of more ships and keeps older, more polluting ships in service, which in turn negate the potential benefits.

Many others advocate that a carbon tax would be more equitable and fairer. Speaking recently at London International Shipping Week (LISW), a panel involving Martin Stopford, head of research at Clarksons; Isabelle Rojon, a principal consultant at maritime consultants UMAS; and Lloyd's Register's global head of sustainability Katharine Palmer all agreed that carbon pricing in some form would be necessary to add weight to the IMO's 2050 carbon reduction target. There are huge variations in the discussions about how much carbon would need to be priced at to make this effective and, crucially, who would benefit from such a carbon price — a question that Stopford argued would "make Brexit look like child's play".

Either way, whatever the mechanism, it's clear that carbon will be coming under far greater scrutiny — and, in turn, so will the ability of managers, owners and charterers to manage it.

The commercial realities of this were underlined by JP Morgan Asset Management Global Transportation Group chief executive Andy Dacy, speaking at an event at this year's LISW. "There is not an institutional

Concerns about the greenhouse gas emissions have led some to promote simple solutions, such as slow steaming, but they are not always the best solutions.

investor today in the western world … that is not thinking about the impact of environmental, social and governance factors." His words echo the findings of a report by the Thinking Ahead Institute, which found that climate change is the top extreme risk for institutional investors.

The management of this risk is already playing out in shipping. In May this year, Trafigura added a clause to its standard terms and conditions with shipowners, requiring information that will allow it to track how much fuel is consumed per metric tonne of cargo loaded while transporting Trafigura-controlled cargoes. This signalled a powerful shift in the way the industry approaches the topic of fuel efficiency — to give you a sense of the scale of this move, Trafigura concludes more than 4,000 shipping fixtures per year, and in the first six months of 2018 had a total traded volume of oil and petroleum products that was in excess of 5.8m barrels per day.

Trafigura isn't the first charterer to mandate these changes. In recent months, there has been a lot of talk about the requirements that international oil companies are making of offshore service vessel owners to equip their fleets with fuel monitoring systems and remote sensing equipment so that they can better understand and therefore decrease these vessels' fuel consumption and emissions. This builds on levels of carbon measurement that are now widespread in the industry, with routine collection of data under EU-Monitor, Record and Verify (MRV) regulations.

As carbon comes under further scrutiny, owners and charterers have two main challenges. The first is to ensure that the data collected is as accurate as possible. The second is to ensure that the data they collect does not retire to quiet solitude in a black box. It must be turned into useful information that can reduce emissions in a commercially optimal way.

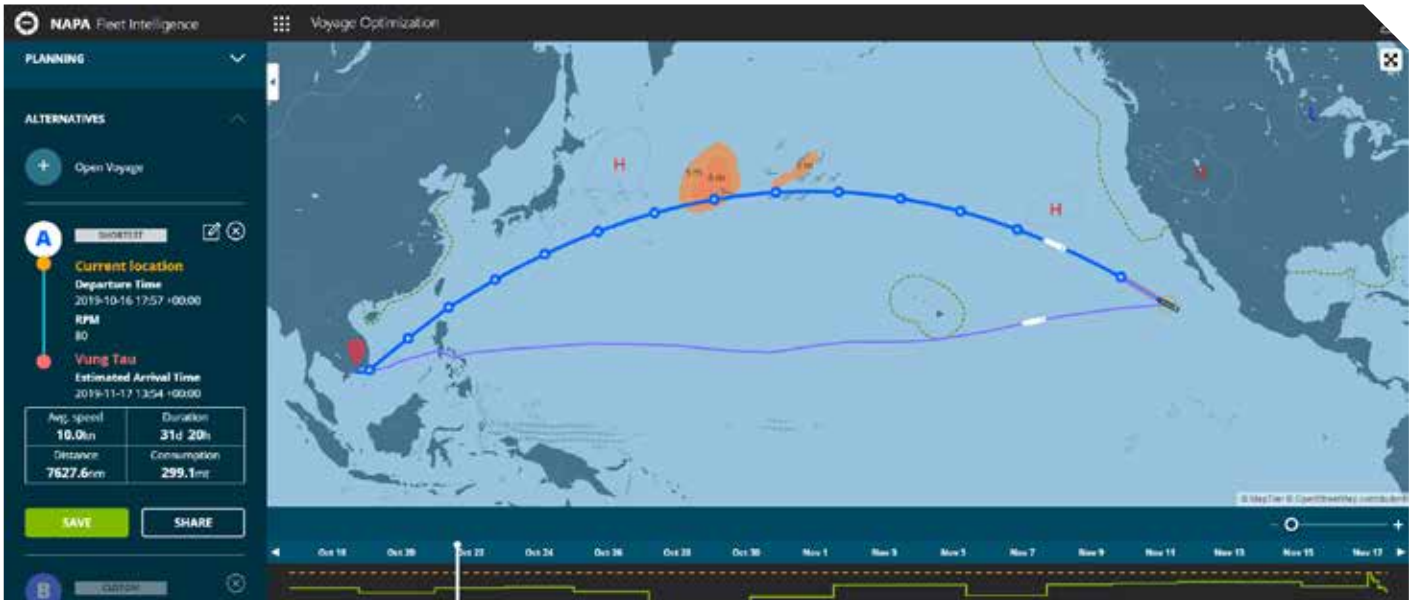
> *"With the help of the digital twin, we can extract information, monitor the performance of the vessel and conduct more precise planning of operations."*

Both of these challenges face a significant obstacle — data quality could be an issue. DNV-GL recently claimed that data quality was the number one problem for its data platform Veracity, attesting that "the market for data quality dwarfs the market for big data".

Solving this comes down to a question of cost — frequently, if sensors are not specified at the commissioning stage, it is expensive and time-consuming to install them. When we surveyed owners and managers earlier this year about their data collection and voyage optimisation habits, we discovered that a wide range of options are used, but that noon reports were relied upon by all parties involved, no matter what else they use.

What this tells us is that the measurements we need to accurately assess a vessel's performance might not always be available. For example, the ship may not be equipped with adequate sensors to measure the power of the propeller, or that data is not necessarily disclosed to all the stakeholders. The owner might not disclose the measurements to the charterer who might be paying for the fuel and is interested in the actual level of performance of the vessel. In this regard, a noon report is a good starting point when it comes to accessing information and this is often used to deduce the level of performance.

However, the shortcomings of relying on the noon report are that the data is sparse, and it gives one daily data point on the consumption. However, the weather might change during the day quite significantly, which cannot be



Weather routing will play a major role in the reduction of greenhouse gases through improved voyage efficiency.

reported in the noon report. Because the relationships between factors such as wind speed, wave height and fuel consumption are non-linear, this means that variations in weather that can't be included in a noon report can have a disproportionate effect on vessel performance.

For instance, in 800 days of operation of one dry bulk vessel, there were 233 days when the swell and wind-wave height varied more than 1m, and the wind speed varied more than 5m/s over a single day. In the noon report, we would have just one information of the wind speed and the wave height, which may be reported or not.

These weather variations have an important influence on the fuel consumption of the vessel; within the 4 Beaufort range, which is considered as good weather, to maintain the same speed throughout, a captain would need to increase fuel consumption by 50% in adverse weather. If operating at constant engine output, we would see as much as a 15% reduction in vessel speed.

A common solution to add richness to this data is to correlate weather information with publicly available AIS (Automatic Identification System) data, which allows us to overlay ship positions with weather data. This also has its limits, however — if a vessel is not equipped with sensors (and many are not), it is difficult to make assumptions about a vessel's performance.

This is where it is necessary to leverage knowledge from the realm of vessel design and modelling. By taking all the information from the AIS and the publicly available information about the ship, we can build a digital twin of the vessel, based on our knowledge and experience of naval hydrodynamics and ship design. As a result, we can overcome some of the challenges created by the lack of available data from the noon report.

This gives us generic models that can cover whichever ship we choose, providing us with a base from which to begin our analysis. We can then combine that with automation signals from 200 vessels that do have sensors installed, which gives us further datasets to enhance these models, incorporating data learning methods to continually improve them.

With the help of the digital twin, we can extract information, monitor the performance of the vessel and conduct more precise planning of operations. The twin that we have is based on NAPA's Ship Performance model, applying a hydrodynamic model that considers the coupling effects of wind, waves, current and shallow water, combined with a full model of the propulsion and engine system. We are then able to address the force balance of all these factors at the actual location of the ship, at the real operational speed, and in actual wind and wave conditions.

With increasing data, we get better accuracy. We have studied a fleet of dry bulk vessels with three years of data and, on average, after three months of data collection, the uncertainty of the consumption estimate is less than 7.5%. After half a year, the uncertainty is now less than 5%.

All of this can be used to plan vessel operation with better accuracy, with better information on the effect of fouling, the sea margin, estimated consumption and voyage time. The model also helps with maintenance planning.

On its own, does this solve the issue of how to regulate emissions and reduce the carbon footprint of shipping? Not quite. But it does do a couple of things. First, it helps us ensure that we can accurately measure and forecast the carbon emissions of a wider proportion of the global fleet, which might not have sensors equipped. Second, it helps us to better understand the potential differences in emissions that owners and operators can realistically hope to achieve and which steps might have the most impact on making this a reality.

The incentive structures that determine what happens next will remain complex (for instance, it currently costs operators far more to arrive just in time for port calls than the cost savings that would be achieved by travelling at optimal speed), but knowing what can be achieved, and how, is essential if we are to find the right solutions

CR OCEAN ENGINEERING: MAKING YOUR VESSEL 2020-WORTHY

BY NICK CONFUORTO, PRESIDENT AND COO CR OCEAN ENGINEERING

There is growing consensus in the shipping industry that scrubbers are the best solution to meet the IMO sulphur cap emissions regulations that come into effect 1 January 2020.

They are environmentally safe, a fact proven by a number of studies from various governments and environmental entities. And they solve low-sulphur fuel availability issues.

What's best, they allow shippers to burn the same fuel they've been using for years, protecting humans and nature from the toxic effects that stem from releasing harmful fumes into the atmosphere.

The question shippers are now facing is which company should they choose to manufacture, install, and maintain scrubber technology.

CR Ocean Engineering (CROE®), which recently announced deployment of two additional models in its line of marine scrubbers, is perfectly poised to meet that need.

CROE scrubbers are perfect for new builds or can be retrofitted into existing vessels. In addition to the original **In-Line** design, the new CROE scrubbers feature **U-Type** and **Side-Entry** to provide different entries configurations allowing for a better fit on certain ships. They were conceived specifically for those ships where the funnels are too narrow to fit an in-line scrubber. Therefore, the CROE Side-Entry or CROE U-Type scrubber can be placed outside the funnel and the ductwork brought to it.

These models also allow for greater pre-assembly should it be required. The new designs come as a result of discovering that, as the company's clients installed its scrubbers in various ships, in rare cases some adjustments to the basic design allowed for an easier fit.

The CROE scrubber reduces soot and nearly eliminates SO_2 emissions from the exhaust gas from heavy fuel-burning engines, generators and boilers. The CROE system can easily reduce the SO_2 stack emissions from a 3.5% sulphur fuel to well below the 0.1% sulphur fuel equivalence as required by the MARPOL regulations — even when operating in the low alkalinity areas of the eastern Baltic (when designed for that potential).

Scrubber installation in funnel

CROE's ship exhaust gas-cleaning technology is available in three standard configurations, customisable to a ship's requirements:

» **Open-Loop**: once through scrubber using seawater.
» **Closed-Loop**: a recirculating scrubber using freshwater with caustic.
» **Hybrid**: a combination of both designs for maximum flexibility.

CROE scrubbers normally replace the silencers. Due to their small size, compact configuration and flexibility of design, CROE systems are perfect for both new-builds and retrofits.
Some of the features of the CROE scrubbing systems include:

» Bottom-entry design to allow a direct up-flow configuration, simplifying the engine exhaust gas duct without requiring a bypass.
» Strategically configured exhaust gas inlet and scrubber drainage to eliminate any potential water backflow to the engine.
» Eliminated circulation water storage from bottom of scrubber vessel to a separate tank at a lower elevation to reduce weight at the higher elevations, improving stability.
» Alloy construction (external and internal) to extend the life of the system and to allow the exhaust gas to travel through the scrubber system at high temperatures in case of dry-run conditions without a bypass.
» Used proprietary internals designed specifically to increase contact area, with lower liquid flows to save on typical pumping costs associated with some scrubber designs.
» Proprietary Caustic-Assist™ feature for Open-Loop assist operating in low-alkalinity areas. These can be configured as single stream (controlling emissions from a single engine or boiler) or multi-stream (controlling emissions from multiple engines/boilers combined) configuration.

Over 150 ships have CROE scrubbers installed or are in the process of doing so. These vessels include cruisers, cargoes, ferries, tankers, and many other types.

PROVEN EFFECT

Allied Shipbroking called marine scrubbing technology the "fastest and cheapest" way to reduce harmful diesel fuel emissions and recent studies provide abundant data confirming that scrubber technology produces no harm to the environment.

Earlier in the year, Japan came out heavily in favour of open-loop scrubbing, telling the International Maritime Organization that when both human health and the marine environment is taken into account, burning heavy fuel oil with a scrubber is a better choice than simply burning 0.5%S fuels alone. The key reason for this, according to the Ministry of Land, Infrastructure, Transport and Tourism, was due to the ability for scrubbers to remove airborne particulate matter and polycyclic aromatic hydrocarbons.

The Japanese study, which focused on Seto Sea, Ise Sea and Tokyo Bay, was seen as a "major win for scrubber advocates".

Furthermore, CE Delft, a research organisation in the Netherlands specialising in environmental issues, conducted a study indicating that accumulated concentrations of exhaust gas cleaning systems (EGCS, or "scrubbers") wash-water components are at very low levels and well below applicable regulatory limits.

Scrubber being delivered

Scrubber installation

Scrubber installed

ABOUT CROE

CR Ocean Engineering is a leading supplier of exhaust gas cleaning systems (scrubbers). With its roots dating back to 1917, CROE® is one of the most experienced scrubber suppliers in the world. It leverages more than 60 years of experience in precision engineering and air pollution control to develop highly efficient and consistently reliable scrubbing systems for the maritime industry.

CROE has sales, service and manufacturing strategically located around the globe to better serve its clients.

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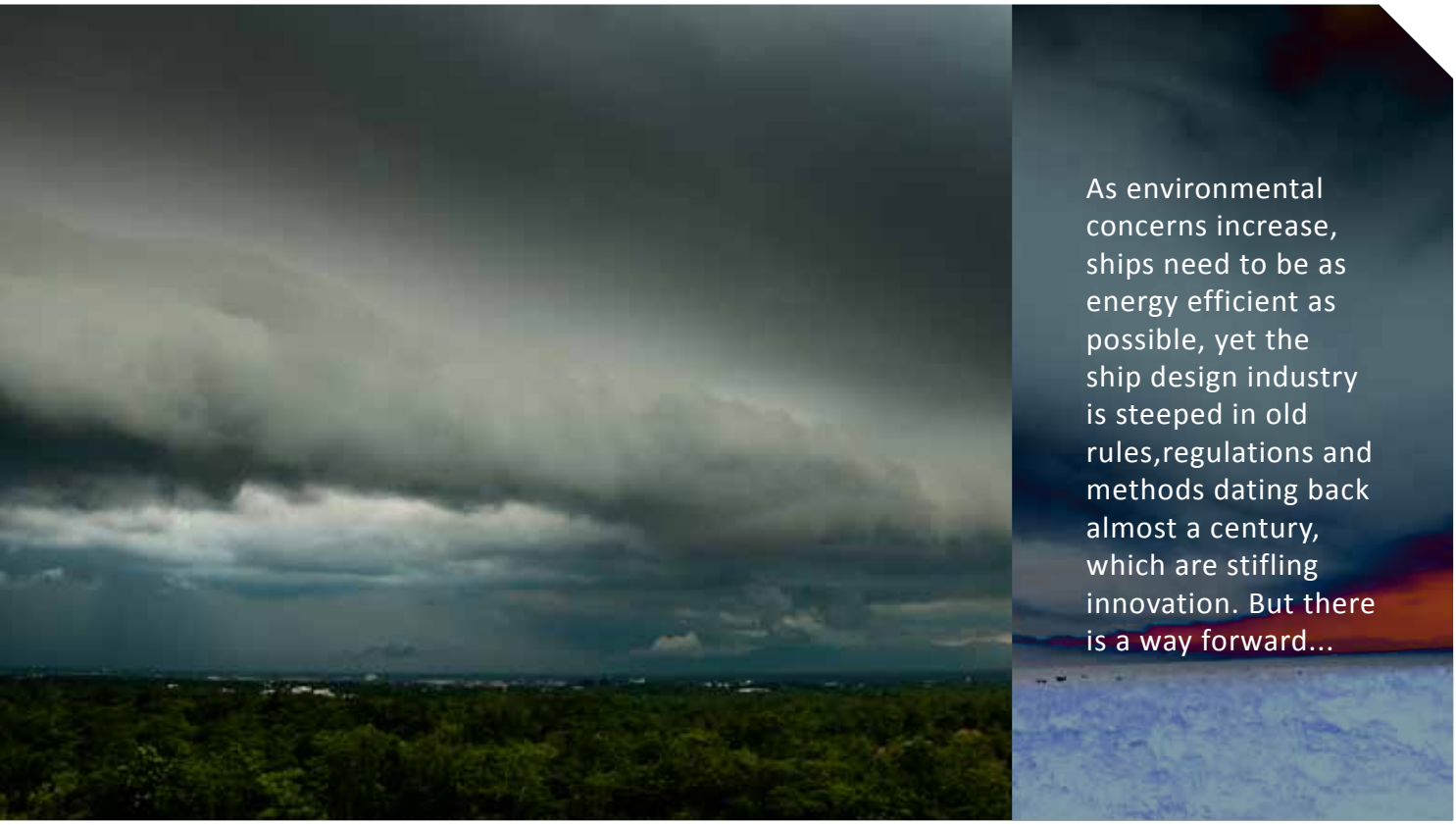


As environmental concerns increase, ships need to be as energy efficient as possible, yet the ship design industry is steeped in old rules,regulations and methods dating back almost a century, which are stifling innovation. But there is a way forward...

WHY WE NEED THE NEW NORMAL

by Dejan Radosavljevic, Director of Marine, Siemens Ship Design

Reading about and watching images of increasingly frequent extreme weather events, it is difficult to keep on ignoring the warnings of environmental change. At the same time, the human population continues its rapid increase and utilises more energy and therefore creates greater greenhouse gas (GHG) emissions for daily living.

The consumption of that energy has its negative side in the shape of harmful emissions affecting, one way or another, everyone on the planet. As consumer-driven industries slowly reach a plateau in terms of attainable efficiencies, the focus has switched to industries with less direct consumer focus, such as maritime transport.

Maritime is, in absolute terms, a large contributor to global GHG emissions, including SOx and NOx. As a result, pressure is building on the maritime sector to design, build and operate ever greener and cleaner vessels.

Underlying all the requirements for cleaner and greener ships is one fundamental fact that comes before anything else: we need to design ships that are as energy efficient as possible. In cases where carbon-based fuels are still prevalent, it will help minimise emissions and for renewables and new technologies it will make it easier to satisfy demand with low-density energy sources, whatever they may be.

For example, maximum efficiency is implicit in the initiative just announced by four Japanese companies that have teamed up to build the world's first zero-emission tanker by mid-2021, which will be powered by large-capacity batteries.

Simulation Driven Ship Design (SDSD) will offer the maritime industry a new way to design ships such as the Japanese tankers that is quicker, cheaper and achieves better results in terms of vessel efficiencies. But to understand SDSD it is first necessary to understand the status quo.

NOT FIT FOR PURPOSE

Current ship design is a very complex and time-consuming process. More than a century of rule-based requirements have

Figure 1: from cassettes to digital streaming; old normal to new normal, giving more choice and ease of use

made it a highly rigid, labour-intensive process. The rule-based focus, stemming from the need for vessels to survive the harsh sea environment before the advent of GPS, satellite technology and weather routing, meant by far the largest focus was on structural design.

Even today little has changed, from the required focus on rule compliance, the effort to go through model testing, the basic and detailed structural design, to time-consuming plan approval of the drawings. Modern technology is helping speed up some of the elements of this procedure, but it is fundamentally still the same time-consuming design process that it was 100 years ago.

That process creates many problems: for example, the initial tender phase time is very limited and proposing a hull design that minimises capital expenditure (CAPEX) during build, while meeting operational expenditure (OPEX) and efficiency demands of the customer, as well as certification requirements, remains a challenging task. One way to reduce the challenge is to use an off-the-shelf design (OTS), which may not be the most efficient design for a different specification. Even if the OTS design belongs to a similar specification, the opportunity for innovation to maximise efficiency is gone.

When energy was cheap and environmental impact of little concern, these design inefficiencies did not matter. In the past 10 years, with oil price increases and global economic uncertainties, such potential design flaws can make the difference between success (continued orders) and failure.

> *"In previous times, when energy was cheap and environmental impact of little concern, these design inefficiencies did not matter"*

The impact on the shipping business is striking: the number of active shipyards (defined as a yard that has at least one unit of 1,000+ GT on order) has declined by 65% over the past nine years, to only 330 globally, representing its lowest level on record. It is time to establish a "new normal" for marine design.

MAKING THE CHANGE

The "new normal" was the subject of a talk by keynote speaker Nancy Rademaker from Nexxworks at last year's Siemens Simcenter conference in Prague. Rademaker used cassette tapes as one example of the "old normal" — something that was the standard once, but has now been replaced by the "new normal", streaming. Music, like many things, is now digital (see figure 1). This is the new normal and younger generations have no interest in or understanding of the old normal. But what is the old normal in the marine industry, and how can we move to a new normal?

Marine design methods have not really changed in more than 100 years. While the industry has at least progressed towards using computer aided design (CAD) models instead of line drawings as standard practice in vessel design, there is continued insistence and reliance on confirming each design suitability via towing tank testing of a physical scaled model.

The limitations of towing tanks are well known — translating model-scale measurements to full-scale vessels is open to many uncertainties and requires the use of empirical scaling formulae. In addition, due to the differences in the Reynolds number — the measure of how turbulent the flow is — it is difficult to study interactions between key components accurately, such as propellers, appendages, and hulls, or understand performance

under dynamic events such as crash-stop or manoeuvring in waves.

Dependence on this limited, expensive and time-consuming method is one aspect holding the industry back from innovating in design and efficiency. This was recently exemplified by Wärtsilä in its recent presentation at the Royal Institution of Naval Architects conference on propeller design, where it showed how it could have ended up with much higher power requirements (and hence much higher emissions) had it followed towing tank test results.

Instead, the company put its trust in virtual performance prediction using full scale simulation technology, which showed that an alternative design was better and convinced the owner to trust the results.

The ship was built and trials confirmed the simulations were correct. One wonders how many of these examples would exist and how many more efficient ships would be in operation today had designers used and/or had the courage to trust simulations to build vessels rather than relying on false readings from model tests.

While it is the major stumbling block, model testing is far from the only issue sustaining the old normal for vessel design. Other clues can be found in the name: the ship design process is often referred to as the "ship design spiral", as shown in Figure 2. Just by looking at it, one gets the feeling of inefficiency, with multiple iterations over many different specialisms (often siloed in different teams, with little cross-communication). This design process is unwieldy and inefficient, especially when compared with modern design processes in other industries, including automotive and aerospace.

The disparate tools used for each step in the design process and the break of the workflow into siloes mean that more detailed analysis does not follow every design change: the expression running in circles springs to mind. And the later the change happens in the design process, the bigger the negative impact it will have on the overall cost, as well as reduced scope for any design improvements.

The lack of flexibility in this old normal design approach only increases the risk to the shipyard, hence the tendency to rely on OTS designs as a conservative approach to ensure profit margins and reduce risks.

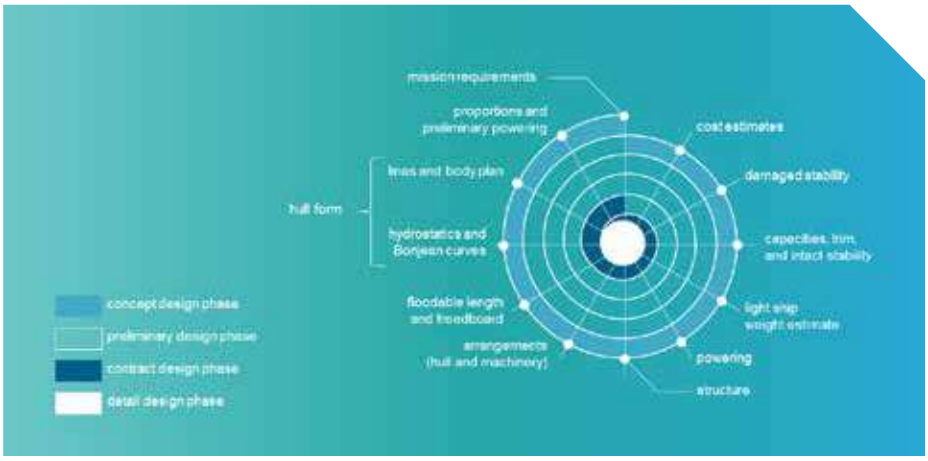


Figure 2: ship design spiral, with multiple iterations of the same processes and data passed between different teams

A new approach to vessel design is needed and the model for that new methodology has been available for some time.

MEETING THE CHALLENGES

Luckily, other industries have shown the way it can be done. To start with, we need to streamline the design process, get rid of the spiral and combine the steps to allow them to interact with each other seamlessly. We also need to move the decision-making process on fixing the design as early as possible, when there is the greatest flexibility to make changes and impact the performance. This approach requires full confidence in predicted performance, which cannot be achieved with continued reliance on model testing.

To achieve all this, we need a fully integrated ship design environment, rather than the current disparate tools and processes. Newport News president Matt Mulherin estimated that applying an integrated approach achieved savings of 15% on the design costs of the third Ford-class aircraft carrier. That is a huge amount of money, considering the estimated cost of one vessel at US$13bn. Even looking at the lower costs for standard commercial vessels, every 1% of cost savings could still save over US$1m per vessel for larger and more expensive ship types, such as LNGs.

Talking about disparate processes, one must also consider many different computer aided engineering (CAE) type analyses applied to assess various aspects of performance. Despite advances in technology, a surprisingly large number of analysts involved in the "design spiral" still use a highly manual approach to testing the performance of a design. This would most often be to validate existing designs or troubleshoot design flaws late in the product development process.

In the case of a detected under-performance, the process would be repeated, starting by modifying the CAD model and so on... back into the spiral. For today's requirements this is a highly inefficient, unreliable way of designing a ship that is simply not fit for purpose. Instead, there is a much better way of doing it by utilising a fully automated design environment. Combination of parametrisation, automated meshing, templatisation and full process automation (pipelining) allows us to repeat as many simulations as we want by simply changing any of the parameters following a prescribed pattern. Once all the simulations have completed, we can look at the consolidated results.

The final ingredient to help achieve better designs is utilising the latest development in intelligent algorithms, which apply computer power to seek defined objectives on behalf of engineers. This still seems to be a surprisingly under-used element of modern technology within ship design

considering the verified capabilities of computers to beat the best humans in their respective fields of expertise when it comes to dealing with complex problems.

Designing a ship is a complex task so we must allow computers to do the heavy lifting for engineers and do the most time-consuming and difficult elements of the work. Computers can seek the best possible designs and only evaluate those that come on top after thousands of variants have been checked, rather than basing everything on one OTS design. This way, engineers can focus on engineering and innovation, rather than building and running simulation models.

SIMULATION-DRIVEN SHIP DESIGN

When we combine integration, automation and intelligent design exploration with full scale vessel simulation under realistic operating conditions, we have the virtual digital framework in place to perform Simulation Driven Ship Design (SDSD), which will with time, in the author's opinion, completely replace the design spiral as we know it.

A simplified graphical representation of the SDSD concept is shown in Figure 3. At the centre, we have the "single source of truth" — a ship master model that can contain any or all the information about any aspect of vessel performance or design needed, from general arrangement, to structural design, to marine systems and so on.

All these different representations can be pushed through the simulation in various combinations depending on how all-inclusive a scenario we want to target. What it is key to understand is that simulations allow perfect comparative assessment like no other method could do. By seeking to maximise efficiency or minimise power requirements, we are just looking for a design that is better than another.

If we let the SDSD process do that hundreds or thousands of times, we will always end up with the best possible design within the specified constraints. Other methods that target a single performance point and rely on a handful of analyses or model tests can never achieve the same outcome. And that is why we need urgently to adopt this new normal.

The SDSD concept makes the design and build processes flexible and agile and able to respond at short notice to any changes in regulations or requirements. It also makes it possible to meet both environmental requirements as well as owners' requirements for their vessels to be future proofed against expected further changes in the regulation with a faster shift to alternative energy sources, such as hybrid or battery power. In short, it enables innovation.

TOWARDS A MARINE DIGITAL TWIN

As the master model progresses through virtual production, actual production and operation, it slowly grows into a true digital twin with full scope for utilising its benefits. Allowing the real time feedback of operational data through the laid-out digital thread owners can quickly test multiple "what if" scenarios: what is the impact on safety and performance of the damage or adverse weather conditions? What if we re-design part of the hull? What if we re-purpose the vessel to alternative routes? What if we change to a new engine?

If SDSD and a full digital twin sounds too far-fetched to you, consider: even 10 years ago would you have predicted that you would stream music from the cloud? And yet that is the new normal today. With all the challenges that it is facing, the marine industry needs to shift away from the old normal — designing ships using the design spiral — and embrace the power of digitalisation to make SDSD the new normal.

Siemens already has in place the necessary technology framework to manage SDSD and all the tools required to use this approach today. Interest is growing in many companies in ways to make this process a reality: The only question is, when will we come to accept it as standard?

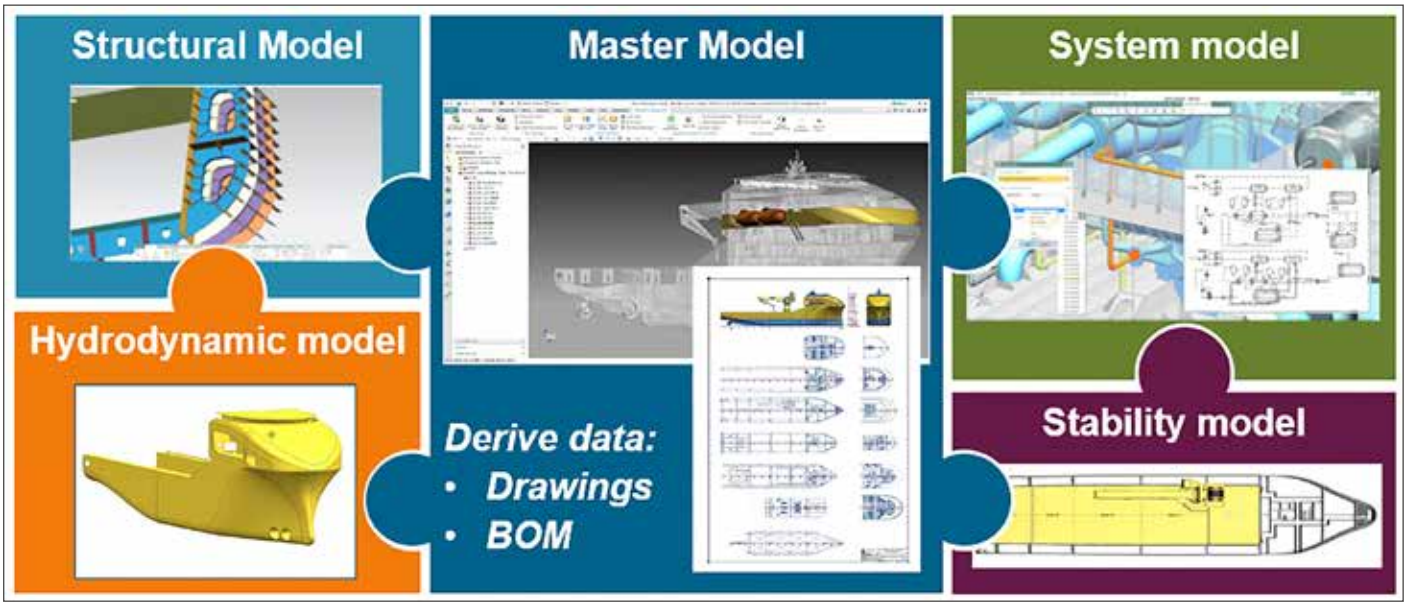


Figure 3: Simulation Driven Ship design concept

ANDRITZ: PROVIDING THE RIGHT SCRUBBER SOLUTION

ANDRITZ is one of the world's leading suppliers of plants, machinery and services for many different branches of industry in the public, municipal and private sectors. The group has its headquarters in Graz, Austria, and operates worldwide with around 29,600 employees and 280 locations. In the exhaust gas cleaning sector, ANDRITZ has been successfully supplying plants for wet and dry separation of sulphur oxide (SOx), nitrogen oxide (NOx), dust, and other air contaminants for more than 35 years.

Cleaning of exhaust gas from shipping is a challenge that is perfectly compatible with the comprehensive know-how ANDRITZ has gathered from supplying and optimising several hundred plants worldwide. In the maritime sector, the company offers proven technologies, such as open-loop and closed-loop wet scrubbers, as well as hybrid designs and is developing its product portfolio continuously in order to provide all customers with the perfect solution for their requirements. The latest of these developments is the innovative, world's first combined desulphurisation/de-dusting plant based on a dry process for shipping.

BACKGROUND

Exhaust gas emissions from maritime engines — especially NOx, SOx, unburned hydrocarbons and dust particles — harbour considerable potential for causing damage to human health and to the environment. In order to counteract this potential, the International Maritime Organization (IMO) has implemented a code of practice for control of emissions from shipping exhaust gases in Annex VI to the MARPOL International Convention for the Prevention of Pollution from Ships. Annex VI regulates the emission limits stipulated for SOx and NOx globally, but also for designated zones, with particular focus on avoiding emissions (ECA zones).

Attention to and awareness of emissions have increased substantially in the past few years. This is also reflected in the development of emission limits in recent years. As from 1 January, 2020, the limits are 0.1% sulphur content in fuel in ECA zones and 0.5% globally. In order to comply with these limits, ships must carry low-sulphur fuel or have a system for desulphurisation of exhaust gases, which is an attractive alternative in terms of operating costs.

To support clients with their strategy to comply with these limits, ANDRITZ has developed different types of desulphurisation systems under the brand name "SeaSOx", based on the company's extensive experience carrying out hundreds of installations over the past few decades. As the only supplier in this field, ANDRITZ offers all types of wet scrubbing systems (open or closed loop, hybrid mode or hybrid-ready) in I-Type or U-Type configuration (circular or rectangular footprint), as well as a unique dry scrubbing solution in single or multi-inlet configuration. In addition to the desulphurisation effect down to 0.1% sulphur content in all scrubbing solutions, the dry system offers many other benefits:

- Simultaneous removal of more than 99% of particulates (verified in independent measurements)
- No discharge water
- No exhaust gas plume
- No corrosion problems
- Easy installation (no dry dock needed).

The dry system has special space requirements, hence it is not always the best solution for all ships. In addition, the operating costs are normally higher than traditional open loop systems, but comparable to or even lower than those of closed loop scrubbers. As ANDRITZ can offer all systems, the best solution for a specific vessel needs to be discussed in detail with the client to understand the specific needs and provide the best solution.

TECHNOLOGY

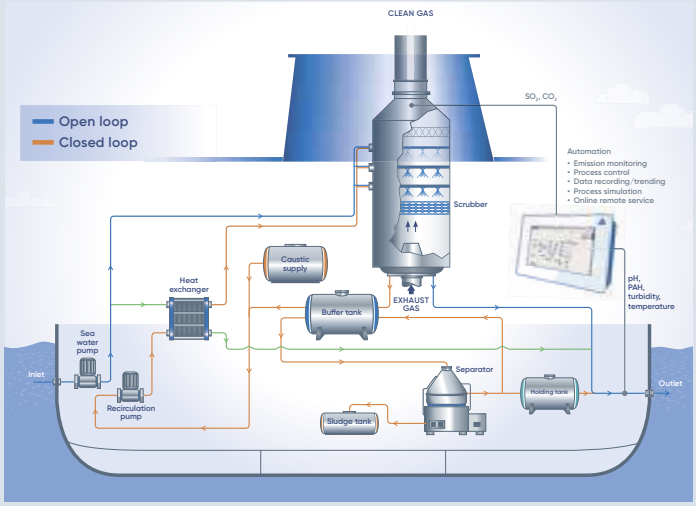
ANDRITZ SeaSOx$_{wet}$

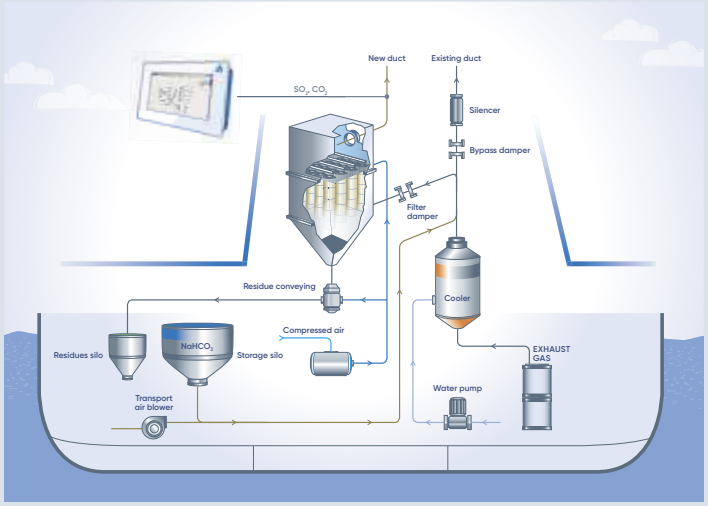
In **open loop** mode, seawater is used as a washing medium to clean the exhaust gas. This simple process makes use of the natural alkalinity of the seawater in the chemical absorption of the SOx. For this reason, the washing medium is pumped from sea chests to the absorber, where absorption takes place by means of spray scrubbing.

The exhaust gas treated can then be released into the environment and the effluent is also discharged. Both the exhaust gas and the effluent have to meet several critical, environmental constraints, which are validated by continuous emission monitoring.

If the natural alkalinity is too low or discharge of the effluent is not allowed, SOx scrubbing is performed in a **closed loop**. In this mode, the washing medium is recycled and a neutralising agent (50% by wt. NaOH, Na_2CO_3, $Mg(OH)_2$) is added in metered doses to obtain a certain absorption capacity. In order to control the absorption temperature and maintain the water balance, an inline heat exchanger is provided on request to cool the washing medium down. Consequently, the effluent has to be cleaned periodically depending on the engine load, the ship's route, and its fuel specification.

For this application, a washing water treatment unit is installed to separate the particles and salts from the washing medium, in accordance with the MARPOL Convention, before it is discharged into the sea. The sludge generated is collected in a separate tank, while the treated washing water





is either stored in the holding tank or discharged into the sea, depending on local discharging restrictions.

A combination of open and closed loop operations is called **hybrid mode**. In hybrid mode, it is possible to switch between these two processes depending on the predominant basic conditions (seawater alkalinity, discharge restrictions, and so on). This option provides high flexibility and enables customers to choose the best process, both economically and technically.

ANDRITZ SeaSOx$_{dry}$

In the SeaSOx$_{dry}$ desulphurisation process, powdered sodium bicarbonate ($NaHCO_3$) is added in metered doses to the exhaust gas stream. As a result of the high temperatures in the exhaust gas, the sodium bicarbonate is activated, causing it to decompose into reactive sodium carbonate that subsequently reacts with the SO_2 and SO_3 in the exhaust gas. This activation process requires temperatures of more than 150°C. The product of this reaction is solid sodium sulphate (Na_2SO_4). The reaction product, the excess sodium bicarbonate, and the soot and heavy metal particles from the exhaust gas form a porous layer — the so-called filter cake — on the surface of the filter bags in the fabric filter installed.

Without this filter cake, it would be impossible to achieve the low SOx emission values required in the ECA zones (0.1%). What is more, the filter cake improves contact between the SOx molecules and the sodium bicarbonate, resulting in much better utilisation and lower consumption of the absorption agent.

When a pre-set, maximum differential pressure is reached, the filter cake is cleaned off the filter bags by jets of compressed air and the solid material produced drops into the filter's collection hopper where it is discharged downwards. A conveying receiver is placed beneath each filter hopper and conveys the solids to the residual material container by means of compressed air. To prevent damage to the filter bags as a result of the exhaust gas temperatures being too high, the gas temperature can be lowered by injecting water. As an alternative, it is possible to install a fan to mix cool outside air with the flow of hot exhaust gas.

It is important to underline the fact that no waste water (or other residual material) is discharged into the sea, unlike in the open-loop scrubber process. The auxiliary and operating materials do not present any health risks, and the noxious soot and dust from the exhaust gas is contained in the residual material in a bonded state.

CASE STUDIES

The following studies show a typical scrubber choice for these kinds of vessels, both installed by ANDRITZ. Only the technical data is provided in order to have a good basis for comparison and an overview of these systems.

SeaSOx$_{wet}$

The following table shows the boundary conditions of an installed wet scrubber project:

Vessel type	Bulk carrier
Vessel operating area	Worldwide (between China and South America)
Engines connected to EGCS	Main engine only (18.6 MW)
Scrubber operating mode	Open loop
Scrubber type	I-Type (square footprint)
Scrubber design load	85% SMCR
Design exhaust gas flow	130,000 kg/h
Design sulphur content in fuel	3.5%
Sulphur removal efficiency	< 0.5% (0.1% also possible) S fuel equivalent

The following parameters result from design and operation of the system:

Scrubber dimensions (square)	2.8 x 2.8 x 10.9 m (L x W x H)
Pressure drop at design load	< 15 mbar
Wash water flow at design load	800 m³/h
Power consumption	approx. 180 kW

For a bulk carrier operating most of the time in deep waters, an open-loop scrubber is usually the best choice. In ports and coastal areas, the vessel switches to low-sulphur fuels. Additionally, low-sulphur fuel is used to drive the auxiliary engines and also operate the boiler. Most of the fuel is consumed by the main engine. Hence, the $SeaSOx_{wet}$ technology is the right choice.

$SeaSOx_{dry}$

The following table shows the boundary conditions of an installed dry scrubber project:

Ship type	RoRo ferry
Vessel operating area	Mediterranean Sea (between France and Corsica)
Ship owner	La Méridionale
Engines connected to EGCS	Main engine (9.6 MW) **Auxiliary engine (1.26 MW)**
Scrubber operating mode	Dry
Scrubber type	Bag filter with bypass
Scrubber design load	100% MCR for main engine 0% SMCR for auxiliary engine
Design exhaust gas flow	65,000 kg/h
Design sulphur content in fuel	3.5%
Sulphur removal efficiency	< 0.1% S fuel equivalent

The following parameters result from design and operation of the system:

Filter dimensions	12.5 x 4.9 x 13.3 m (L x W x H)
Pressure drop at design load	< 15 mbar
Sodium bicarbonate consumption at design load	230 kg/ton of fuel
PM1 removal rate (per number)	> 99%
Power consumption	approx. 30 kW

La Méridionale requested the installation of a dry system on its RoRo vessel as this technology is able to remove particulates and ultra-fine particulates in addition to SOx. Furthermore, no water is discharged into the sea. The absence of a white or black plume was another advantage for the ship operator as the ship also carries many passengers. The space requirements were a challenge, but collaboration between the ship owner, the ship integrator, Solvay (as sorbent supplier) and ANDRITZ resulted in a favourable solution.

CONCLUSION

The choice of the right system for a specific vessel has always to be discussed in detail. In order to make this decision, the scrubber supplier, the ship owner and the ship operator or charterer have to clarify the boundary conditions (for example, local scrubber restrictions, environmental aspects such as additional particulate removal, routing of the vessel, space availability on board, costs, and so on).

It is not easy to make general recommendations for the choice of system, but the following points can help in coming to the right decision.

Arguments in favour of wet systems:

- Vessel operates mainly in deep waters
- Seagoing time is more than 80% of the operating time
- Ship is a bulk carrier
- Medium-to-large engine loads (more than 8 MW)

Arguments in favour of dry systems:

- The vessel has frequent stays in port
- Ship is a ferry
- Ship is operating in areas with wash water discharge restrictions
- Ship is operating in waters with low alkalinity (Great Lakes, Baltic Sea) or in sensitive areas (coastal regions)
- Small-to-medium engine loads (3–30 MW)

These arguments are only a rough guideline and, of course, higher engine loads are also possible with dry systems for example, as are lower engine loads with a wet system.

In addition, ferries are good candidates for wet systems, but it is also worth considering a dry system, especially for this type of vessel.

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Why wind assisted power is the silver bullet the industry has been looking for


© Joe McCarthy

Simon Rogers, Director, Windship

HEADING BACK TO THE FUTURE

The gathering environmental storm is driving shipping back to the future with the development of highly efficient wind systems that will cut carbon emissions by a minimum of 30% on standard 2008 bulk carrier models.

Wind assisted ship propulsion (WASP) systems is clearly not new, but modern sailing vessels will bear little resemblance to ships of old – these new ships will outperform such vessels by a substantial margin. Wind-tunnel testing, computerised sail control that will optimise the wind energy and modern materials will offer owners a substantial upgrade on the 19th-century traders.

A number of owners are interested enough in the Windship design to be considering a 10-ship order for bulk carriers in the 100,000-125,000dwt range, either as newbuildings or retrofits. If a client builds just one ship, it will obviously be more expensive, but if they build 10 then the costs per ship will decrease substantially.

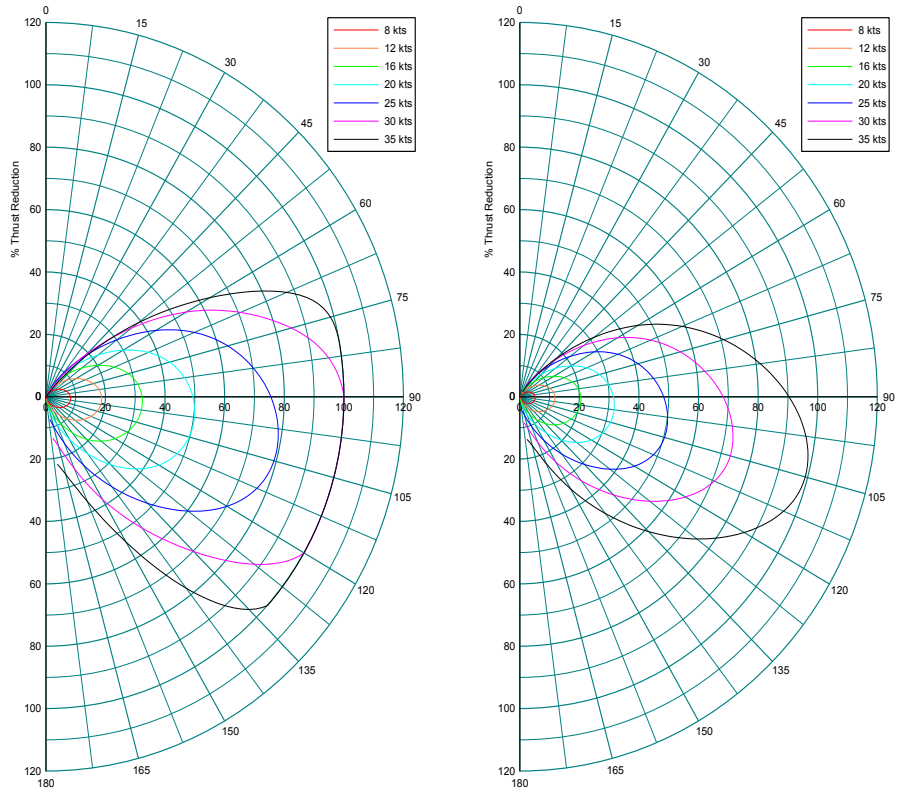
Coupled with carbon-neutral biofuels, the systems will deliver more than the 50% carbon reductions demanded by the International Maritime Organization (IMO), well in advance of its 2050 deadline.

Windship announced its triple-wing mast last year in an understated press conference, but the system will increase a vessel's power substantially and now Windship is gathering the data that will prove its concept through the Wolfson Unit testing laboratory.

Three 35m rig sets on a ship would produce on average 200 kilonewtons of thrust on an annual basis, including sailing ballast and sailing at times when the engines are needed using the diesel electric power.

This number is a result of 10 years' weather routing between Brazil and Dalian in China and allows for full load and ballast and all wind strengths and directions over this period. It is a good average, and on Windship's 59,000dwt test vessel, it produced on average a 33% fuel saving.

The Wolfson unit, based at the University of Southampton, UK, has also provided



3 x 45m rigs

3 x 35m rigs

These figures represent the percentage thrust reduction resulting from the assistance of the rigs based on a simplified performance prediction approach.

These predictions are for the 125,000 DWT ship based on limited parameter information and the Cape Horn CFD predictions of the 35m rig configuration in isolation. This has been scale to the 45m rig using geo-similarity.

WOLFSON UNIT

Polar Diagrams for a 125,000 DWT Tanker with 3 x 45m and 3 x 35m Windship rigs showing fuel consumption reductions at 12kn.

polar charts that were calculated using computational fluid dynamics to show the possibilities for Windship.

The vessel design has been backed up with a diesel-electric propulsion system with four auxiliary engines installed driving a single variable-pitch propeller. The engines will operate on biofuel and maintain the ship's performance in adverse wind conditions while keeping the emissions totally carbon-neutral.

Using Windship's experience in America's Cup yacht design, it developed an optimised 60,000dwt bulk carrier using lightweight carbon composites to manufacture the "wings" and essentially the base of a wind turbine to anchor the 70-tonne foils to the vessel structure. The patented triple-foil concept was developed from the single-foil concept.

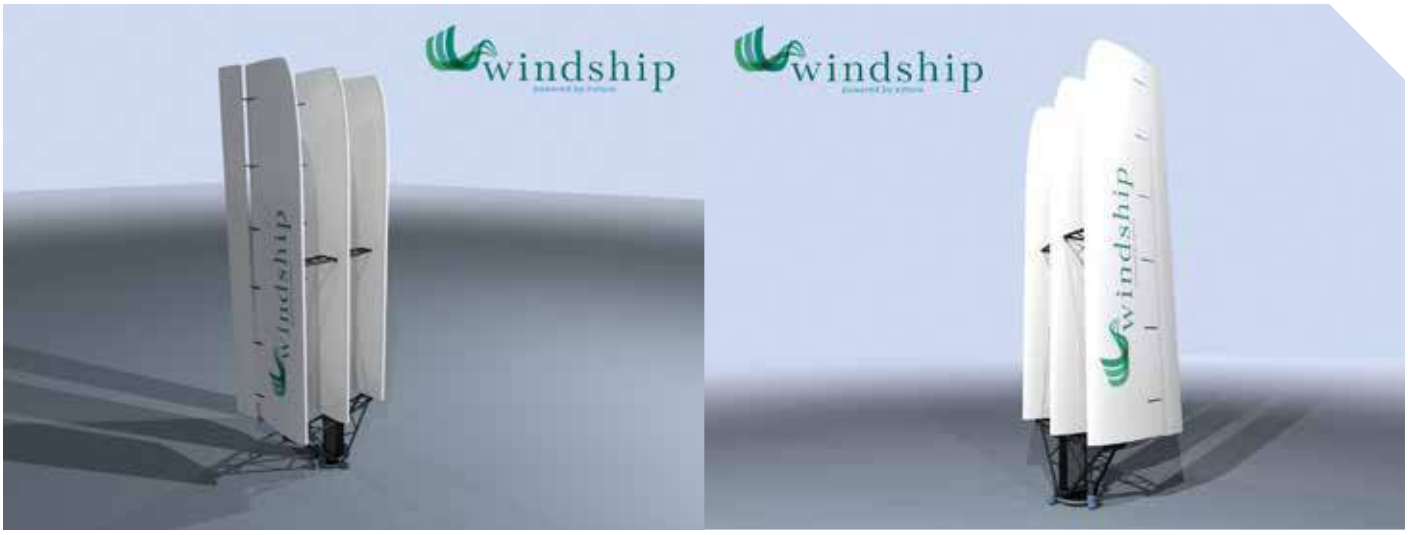
Former Stena executive and Windship director Lars Carlsson believes that Windship's conservative projections show that the triple-foil WASP system would generate sufficient power on a Panamax vessel to cut emissions by 30%.

"Optimisation of the ship and the ship operation for the IMO comparison vessel type, built in 2008, is projected to save a further 20% in fuel consumption"

Classification society Lloyds Register, which has been assisting Windship, says: "This is the silver bullet that we and many of our customers have been looking for."

Windship says: "Optimisation of the ship and the ship operation for the IMO comparison vessel type, built in 2008, is projected to save a further 20% in fuel consumption. This is existing technology among more advanced shipping companies."

Retrofitting foils can take up to two weeks, but no drydocking is necessary and the training of a single crew member to operate the wings is comparatively straightforward as the wings, which like an aeroplane's wings have flaps at the trailing edge, are fully automated and essentially operate at a flick of a switch.



The ship can be steered using the triple foil sails and flaps. The sails themselves are computer controlled and are mounted on converted wind turbine posts, weighing 70 tonnes.

Should the sails need to be in a neutral position due to high winds, the sails can be feathered or will feather automatically, releasing the positioning mechanism and allowing the sails to freely move to the neutral position like a weathervane.

Similarly, the variable pitch propeller would be feathered in a situation where the vessel is using sail power only in order to reduce drag.

The Wolfson Unit's calculations show that a 125,000dwt tanker, fitted with three 45m rigs, with a 16kn wind can reduce fuel consumption by more than 30% with wind blowing from a number of directions. With a 20kn wind, reductions can be up to 50%.

The 45m rigs are designed to be able to pass under the Bosphorous Bridge, but even the smaller rig design, at 35m has 2,300m^2 surface area. The wing foils are fitted with three flaps at the rear and they are very efficient, with a very low drag and that allows us to make up to 40% [fuel] savings in winter and 30% in summer.

Fuel savings will be dependent on the trades that vessels operate in and the conditions that they face. However, the 2030 IMO targets can be met with existing technological knowhow.

That makes wind the silver bullet that the industry has been searching for.

The triple foil sails are constructed of composite materials and can produce significant sail power even where the angle of wind direction is unfavourable or in low wind regions.

LECHLER: MAKING SHIPS MORE ENVIRONMENTALLY FRIENDLY

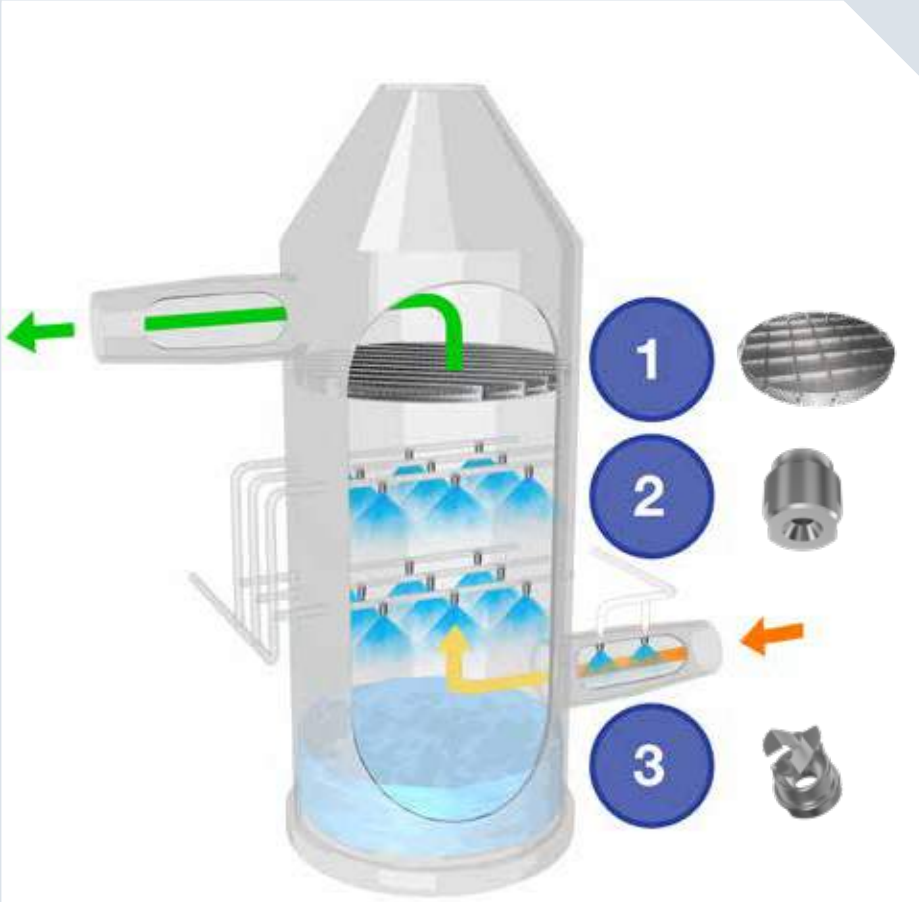
Around seventy thousand merchant ships, ferries and cruise ships are underway on the world's seas every day. Most of them are powered by heavy fuel oil with a high pollutant content. They have the reputation of causing significant air and water pollution. According to the International Maritime Organization (IMO), either low-sulphur fuels or suitable exhaust gas cleaning technology must be used from 2020.

With its practically unfiltered pollutant emissions, commercial shipping has been one of the greatest polluters of the air and oceans for many years. Serious estimates come to the conclusion that the industry causes 13% of sulphur emissions and 15% of nitrogen oxide emissions worldwide.

The topic came into the wider public view due to the boom in cruise tourism: in 2018 alone, 18 new cruise ships went into service. A further 25 ships with 43,000 beds are set to follow this year. In ports, isolated bays or tourist attractions such as Venice, where ships with several thousand passengers regularly drop anchor, the effects of sulphur and nitrogen oxides, soot particles and fine dust also affect those who have nothing to do with modern shipping.

Almost all ships are operated with heavy fuel oil, a highly polluted leftover from the refining process. Since ports rarely have a land power connection or this is not used for cost reasons, the stacks continue to smoke even when the ships are at anchor. Yet the pollutant content of the exhaust gases is sometimes up to 100 times that of the older diesel vehicles that cities currently want to ban from their centres.

IMO introduced new regulations for emission control in accordance with the MARPOL Annex VI some years ago. The annex specifies binding limit values for sulphur and nitrogen oxide emissions. Since 2015 already, the sulphur dioxide content in the exhaust gases in ECA areas (EU waters and along the US coasts) is not permitted to exceed a limit value of 0.1 %. A value of 0.5% will apply on all oceans as from 1 January 2020.



Example of scrubber with Lechler products:
1: Droplet separator
2: Nozzle series 4H5
3: Nozzle series 405

This regulation means that shipowners are forced to act: either they fuel their ships in future with low-sulphur, but expensive marine gas oil (MGO), or they equip their pollutant emitters with a kind of catalyst technology that guarantees corresponding exhaust gas scrubbing in accordance with the specifications.

The scrubbers used for this are generally wet scrubbers. Per megawatt of engine power and depending on the alkalinity of the sea water, these require approximately 40 to 50m^3 of sea water per hour. Depending on the performance requirements, scrubbers have a diameter of between two and six metres and a height of up to 10m. Since space on ships is always at a premium, the maxim is as large as necessary and as compact and light as possible. Scrubbers can be designed as open-loop, closed-loop or hybrid systems.

The open-loop system uses only sea

water. Closed-loop systems use sea water that is enriched by addition of an alkaline solution (often caustic soda) for the cleaning process. This system therefore functions independently of the alkalinity of the available sea water. The hybrid system exploits the benefits of both systems.

All three types are equipped with a matched set of nozzles for gas cooling (quencher) and gas scrubbing (absorber) as well as a system of droplet separators for reliable exhaust gas cleaning and removal of particles and droplets.

Described in simplified terms, the exhaust gases of the ship engines are routed through the scrubber via several stages and layers. Like in the catalytic converter of a passenger car, most pollutants are removed in this process. The quencher first cools the hot gas with a temperature of several hundred degrees to below 80°.

Gas scrubbing reduces the sulphur content of the exhaust gases by 90% to 95%. Sulphur dioxide is converted into sulphuric acid as a result of a chemical reaction with the water stream and is thus removed from the gas. Before the cleaned exhaust gases are discharged from the stack, droplet separators bind the remaining liquid contained in the gas so that no black soot particles are deposited on the deck.

THE LECHLER DIFFERENCE

Lechler offers an efficient nozzle range for each scrubber type that is tailored to the individual performance requirements and size. Only Lechler also offers a range of droplet separators that are exactly matched to the nozzle systems. Customers therefore receive a complete gas scrubbing and cleaning system from one source.

In view of the pending conversion of numerous ships, time is in short supply and lay times cost money. In many cases, there is hardly time to install the scrubber technology and in some cases this will have to take place while at sea. For this reason, Lechler offers its customers a realistic computer simulation in advance that shows the gas flows as well as the optimum use, scope and installation of nozzles and droplet separators in the scrubber. Scrubber manufacturers can therefore avoid inefficient and expensive development errors and can guarantee reliable cleaning results.

In the absorber area, homogeneous liquid distribution is usually most important. Full cone nozzles of the Lechler series 403, 405 and 421 are normally used here. For gas cooling (quencher), the focus tends to be on small droplets (for example, generated with the Lechler full cone nozzles of series 491) in order to achieve the most effective and fastest cooling of the gas stream.

Since droplets are carried along in the gas stream during the absorption process, droplet separators from Lechler are used to remove these droplets from the gas stream. Full cone nozzles from the Lechler series 490 are used for cleaning the separators.

The 4H5 nozzle developed by Lechler is a genuine innovation for both gas cooling and scrubbing: it dispenses with a housing and consists only of a swirl insert and a nozzle tip. It is screwed directly into the pipe and comes on board with only a fifth of the weight of a classic full cone nozzle.

The new 4H5 nozzle offers very good liquid distribution and has low sensitivity to clogging thanks to its special swirl insert design and the large free cross-sections. Its lower mass and compact dimensions also make it immune to vibrations, thus also increasing its stability and process reliability.

The efficient nozzle impresses with a very good price-performance ratio in the quencher and absorber sections. With an average pressure of 2 bar, the 4H5 nozzle is suitable for flow rates of 100 l/min to 1,250 l/min. The nozzle is available with standard connection threads from 1" to 3" and different spray angles.

Lechler offers droplet separators that are precisely matched to the quencher and absorber process with a separating performance of up to 6m/s gas velocity. The droplet separators from Lechler are insensitive to clogging, easy to clean and offer maximum design flexibility.

The wide product range of the nozzle specialist, founded over 140 years ago, is also used for other important tasks elsewhere on ships. Lechler window cleaning nozzles do not just ensure a clear view on the bridge, but also clean the huge glazed areas on cruise ships. Both above and below deck, Lechler nozzles form part of automated fire protection solutions in many different locations. Nozzle technology from Lechler is also used for cooling the tanks of gas tankers and cleaning gray and blackwater tanks.

Thanks to cross-industry expert knowledge and many years of experience, Lechler is much more than just a supplier of nozzles. Lechler develops optimum and efficient solutions together with its customers for practically all applications and processes.

Among other things, Lechler is an Associate Member of the EGSCA (Exhaust Gas Cleaning Association) and is thus always up-to-date with the latest requirements. In a highly mobile industry such as shipping, a worldwide sales network and production centres in different countries provide an efficient basis for fast response times for service and repair work.

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VEROLME: MEETING THE GLOBAL CHALLENGES

IMO 2020 is fast approaching and it is estimated that approx. 3,500 vessels will have scrubbers installed by 2020. For the majority of owners and their crew members, scrubber systems are new technology and, as with any new system, teething problems can be expected.

With the installed base of these high alloy equipment increasing, it's extremely important to be able to react quickly to challenges and implement possible modifications and adjustments.

Many shipowners are making important investments in scrubber systems. In view of the acidic nature of the scrubber washwater, correct material selection for the scrubber body, pipework, components and accessories, together with good fabrication and installation workmanship are critical to avoid subsequent safety issues, failures and repairs. The structural integrity of the scrubber and associated pipework has to be constantly checked for signs of leakage or corrosion.

"With the designs still improving, the availability of lessons learned from system and material corrosion failures is growing. Previously installed systems need repairs, replacements and modifications and this can only be done by certified personnel "

As a manufacturer for scrubbers and other high alloy related piping and equipment, Verolme has recently been tasked with providing specific alloy-welding related site support during the scrubber system retrofit activities on the shipyards, as well as deal with a growing number of scrubber and pipe repair cases and modifications at some major ports around the globe.

Product manager Willem Kemps joined the company in 2016 and was asked to evaluate and further develop the market related to marine scrubbers and related systems design, material selection and manufacturing.

Kemps has been impressed with the pace at which this market has developed over the past few years, but highlights the enormous challenges all stakeholders face in the few months remaining before the new compliant fuel requirements become mandatory.

"Before the deadline of January 2020, shipowners with vessels on which scrubbers are installed could still choose not to operate the systems 24/7. Running a scrubber in a non-ECA

before this date will result in additional fuel consumption. But with the deadline approaching, systems are being operated more often for testing, crew training, monitoring of systems, and so on. We are seeing a growing number of scrubber pipe repair cases with plenty of reports of corrosion leading to water ingress on ships. Problems in as little as eight months of installation are being reported."

Furthermore, he says, it will be very important for shipowners to be able to rely on the monitoring equipment as any failure would mean that the scrubber operation may need to be stopped and a much more expensive compliant fuel used instead.

With the designs still improving, the availability of lessons learned from system and material corrosion failures is growing. Previously installed systems need repairs, replacements and modifications and this can only be done by certified personnel during berthing or on-board during sailing. When problems or failures prevent the scrubbers from operating, shipowners are forced to use more expensive compliant fuels.

With knowledge, tools and teams available, Verolme is able to perform any kind of welding and repair service to high-alloy equipment worldwide. A number of specialised and containerised workshops, positioned at strategic locations around the world — Antwerp/Rotterdam, Singapore and Houston — provide our workers with all the tools they need to perform the job.

VEROLME

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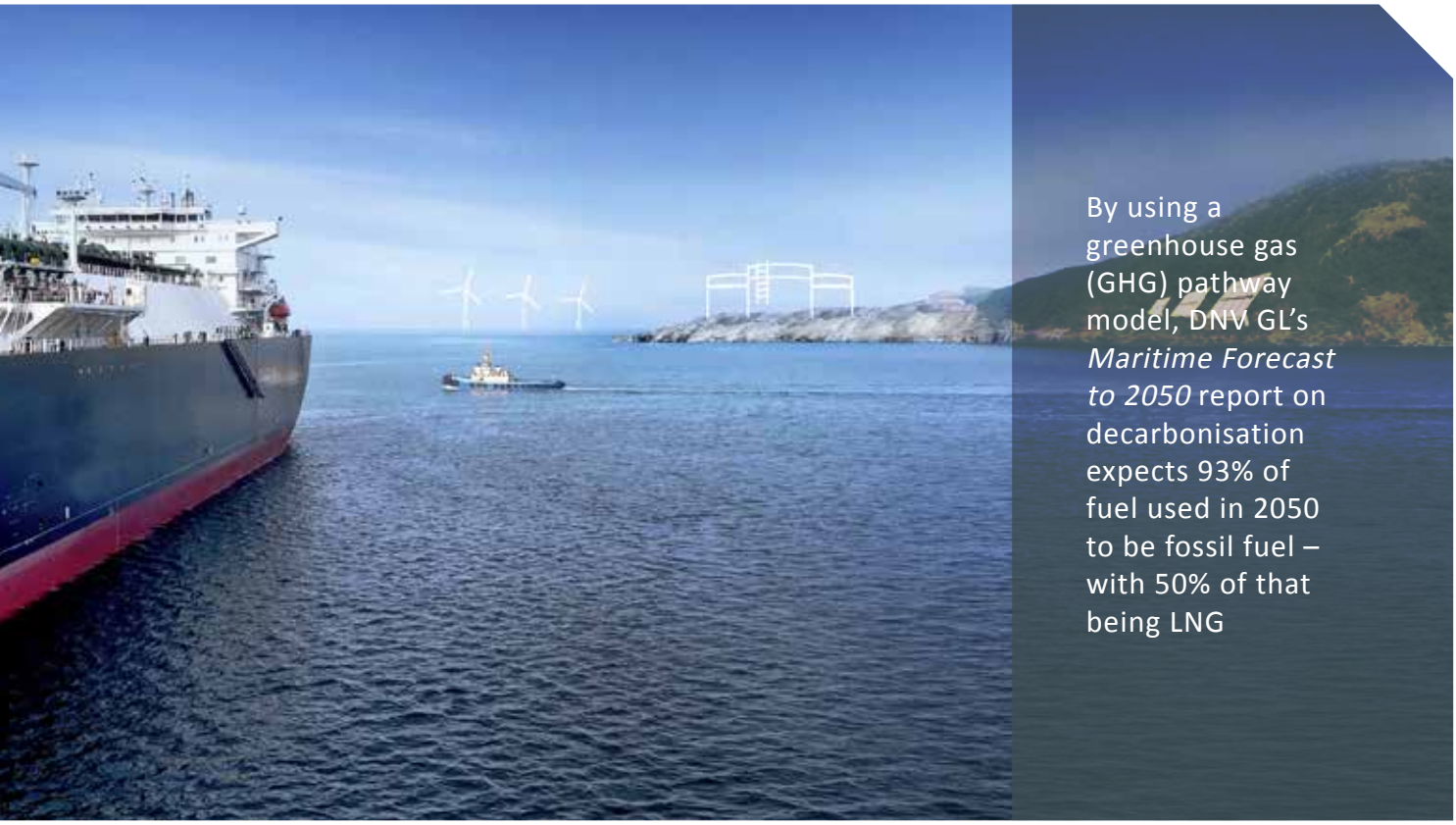


By using a greenhouse gas (GHG) pathway model, DNV GL's *Maritime Forecast to 2050* report on decarbonisation expects 93% of fuel used in 2050 to be fossil fuel – with 50% of that being LNG

A PATHWAY TO THE FUTURE

A new greenhouse gas (GHG) pathway model from DNV GL's latest *Maritime Forecast to 2050* report can give guidance to the maritime industry, with a view to assessing and preparing the industry for the effects of regulatory and technological change in reducing world fleet GHG emissions.

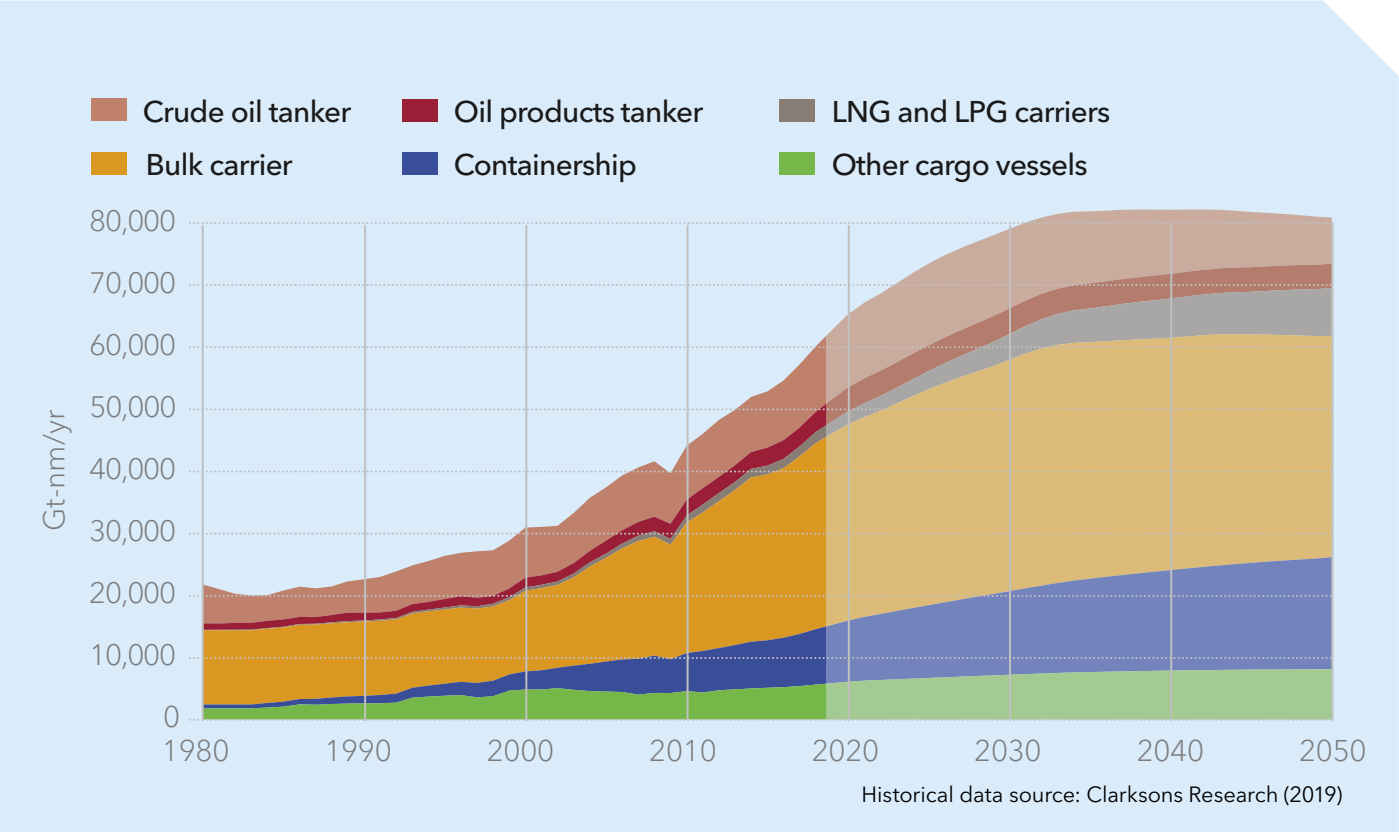
The model was developed by classification society DNV GL and Tore Longva, one of the authors of *Maritime Forecast to 2050*, says: "Meeting International Maritime Organization (IMO) targets for reducing GHG emissions from shipping will take mandatory requirements for individual ships and other policy measures to support the development and the use of new fuels and technologies."

He went on to say that this was the clear message from the results when the model was used to consider various regulatory pathways for reducing GHGs from shipping. The findings are timely as the IMO discusses how to prioritise and decide which measures to pursue."

MODELLING FUTURE EMISSIONS

The Maritime Forecast to 2050, one of DNV GL's Energy Transition Outlook 2019 reports, takes its focus from the IMO GHG ambitions, and from growing external pressure on shipping to cut emissions. It examines how shipping may meet the GHG targets given various potential developments in energy efficiency, logistics and alternative fuels. Applying the GHG pathway model based on long-term trends, the report projects possible pathways for the world fleet size, fuel mix and CO_2 emissions towards 2050 for the expected transport demand.

"We believe the results make this required reading for stakeholders in the maritime ecosystem," Longva suggests. "These include vessel designers, shipbuilders, shipowners, operators, charterers, engine producers and storage systems, public and private developers of infrastructure such as bunkering and shore-based power for vessels in harbour, and for



World seaborne trade in tonne miles by vessel type.

the banks, insurers and other finance sector players."

The GHG Pathway Model assesses several future scenarios. The fleet development module adds and removes ships annually to balance fleet supply capacity against seaborne trade demand projections. The abatement uptake module evaluates available GHG reduction measures on all existing ships and newbuildings for each year.

A feedback loop adjusts for ship speed reduction by adding new ships to maintain the fleet's trading capacity. Another loop ensures that the uptake of technical measures and fuels in the fleet result in year-by-year reductions in the cost of future installations. This accounts for technology development and the effects of its maturation on the market.

MEETING CARBON-INTENSITY TARGETS

The report describes the results for three modelled GHG pathways. Two of them focus on vessel design or operational requirements to achieve IMO ambitions. In both pathways, regulations will be in place for individual ships to incentivise the necessary emissions reduction, but the specifics of the regulations differ.

"Meeting IMO targets for reducing GHG emissions from shipping will take mandatory requirements for individual ships and other policy measures to support the development and the use of new fuels and technologies"

The first pathway assumes that current ships and those built over the next 20 years will not make a major shift to alternative, carbon-neutral fuels. In this scenario newbuildings will have to make a complete fuel shift from 2040 to reach the IMO targets. Under these assumptions the shipping industry will not have to consider retrofits and fuels compatible with current converters but continue to design newbuildings for the most relevant fuel.

In the second scenario, a more gradual improvement is enforced through operational requirements for ships in service. Drop-in fuels such as advanced biodiesel and liquefied biogas (LBG) are preferred to avoid costly retrofits.

A third "current policies" pathway describes what happens if no further policies are introduced. It assumes that IMO will not issue any other

requirements beyond the existing Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP).

SHIPPING TOWARDS 2050

Shipping emitted an estimated 921 megatonnes of carbon dioxide ($MtCO_2$) in 2008, and 870 $MtCO_2$ in 2018. If carbon intensity remains static, emissions in 2050 would be 1,210 $MtCO_2$ based on the 39% growth in demand for seaborne trade projected by DNV GL's Energy Transition Outlook.

"In all pathways, we see a big impact of energy-efficiency measures and vessel speed reduction which can be achieved early in the period up to 2035," Longva explains. "This is because these measures do not require renewing the fleet. We see emissions peaking in mid-to-late 2020."

Without further regulation, a sufficient uptake of alternative fuels to meet IMO GHG targets is not expected unless prices for alternative fuels move to the same level as those for fossil fuels. For the "current policies" pathway, the forecast projects 670 $MtCO_2$ of emissions in 2050, little more than a quarter (27%) below 2008 levels. In this case, carbon intensity ends at 8.2 gCO2/tonne-mile, 62% less than in 2008.

In the two pathways where IMO GHG targets are achieved, a carbon intensity of 5.6 grams of CO_2/tonne-mile in 2050 is projected, three quarters (74%) less than in 2008. The results indicate that even with low to moderate seaborne trade growth, the IMO's ambition for a 50% absolute reduction in CO_2 emissions by 2050 is stricter than its 70% carbon-intensity reduction ambition.

THE FUTURE ENERGY MIX

The total energy use in international shipping is forecast to rise from about 10.6 exajoules (EJ) in 2018 to a peak value of 11.6 EJ (about 210 Mt of oil equivalent) in 2025. It will then decrease to 9.0–9.5 EJ in 2050, with the container (23%), bulk (16%) and tanker (13%) segments accounting for the largest shares.

Total energy use does not vary greatly between the modelled GHG-reduction pathways, although there are significant differences in the energy mix. In all the pathways, liquefied methane has a dominant share of 40-80% of the fuel mix in 2050 (see charts for the design and operational requirement pathways).

The primary energy source of the methane varies between fossil, biomass and other renewables. Ammonia is the most promising carbon-neutral fuel option for newbuildings. Another alternative would be a gradual shift of existing ships relying on drop-in fuels compatible with current fuel converters, such as bio/electro-diesel replacing liquid fuels, or bio/electro-methane replacing LNG.

The preference for ammonia is due to the lower cost of the converter, storage and the fuel itself compared with hydrogen and liquefied biogas (LBG)/synthetic methane. Carbon-neutral fuels have to supply 30-40% of the total energy for international shipping by mid-century if IMO GHG ambitions are to be achieved.

For the "current policies" pathway, the model anticipates a partial transition to other fuels, the energy mix in 2050 being 93% fossil fuels, specifically 50% liquefied natural gas (LNG) and 43% liquid fuels. High LNG uptake seen in all modelled pathways is driven largely by gas fuel prices, which are expected to drop towards mid-century.

HFO WITH SCRUBBERS?

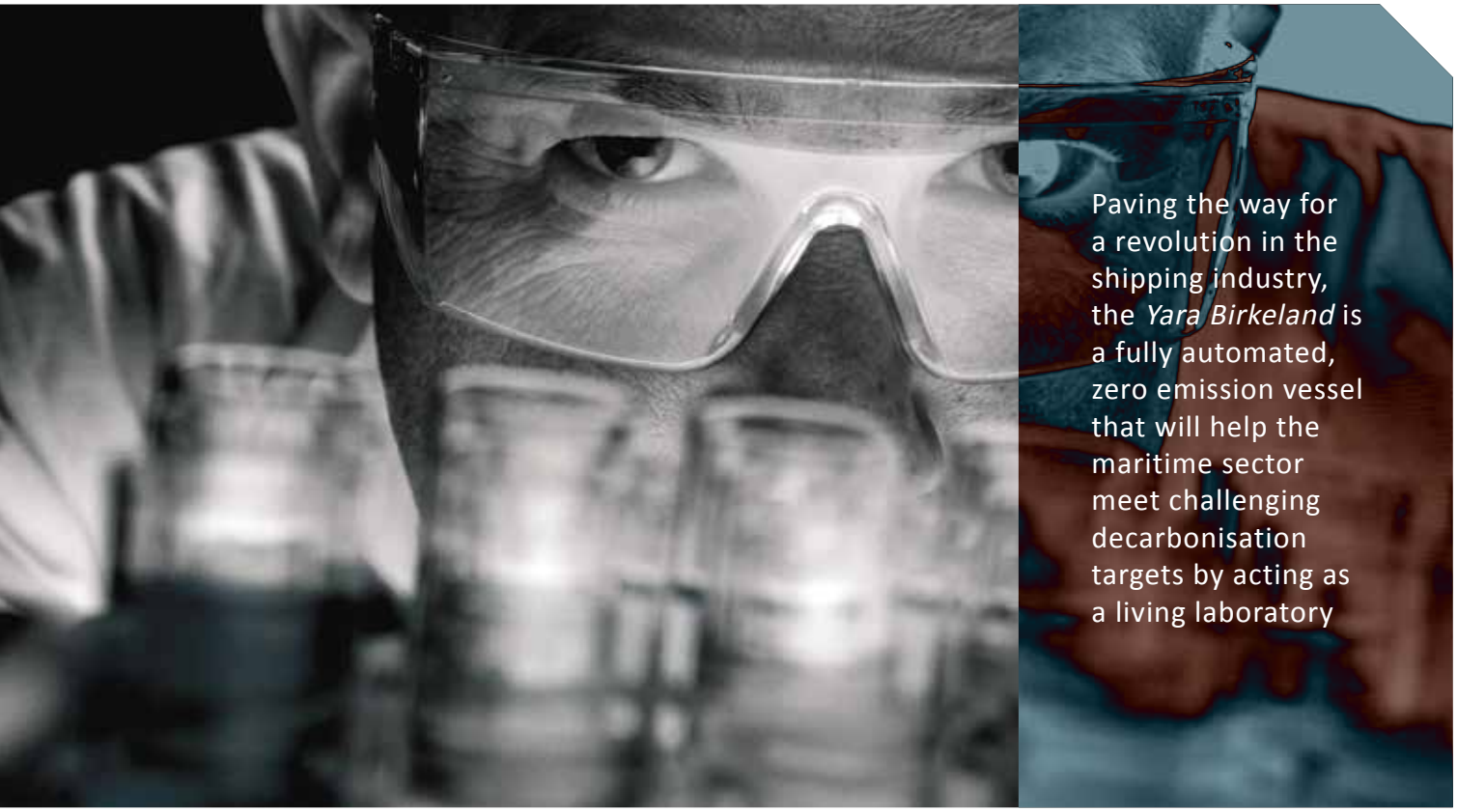
In all scenarios, shore-based electricity provides about 5-7% of the total energy consumed by ships in 2050, delivered via batteries and shore-to-ship power. This amounts to 150-170 terawatt hours. The service and passenger segments will have the highest share, with almost 18% of their energy provided by grid electricity.

Use of heavy fuel oil (HFO) with scrubbers depends largely on price differences between HFO, LNG and low-sulphur fuel oil/marine gas oil. In all modelled scenarios, the price favours HFO with scrubbers. In the "current policies" pathway, the share of HFO with scrubbers in the fleet fuel mix is 17%.

The cost and availability of HFO is further discussed in the *Maritime Forecast to 2050*, which also further develops DNV GL's carbon-robust model for future-proofing vessels for new developments in regulation, alternative fuels, fuel converters and fuel-storage systems.

"Our modelling shows that achieving IMO GHG reduction ambitions is challenging, but possible," Longva summarises. "Further modelling can be useful for policymakers and the maritime industry to anticipate the need for scaling up the supply of alternative fuels to satisfy the demand generated by new regulations."

Vessel refuelling in the future will look different, depending on which fuel, of a variety of choices, you will be using.



Paving the way for a revolution in the shipping industry, the *Yara Birkeland* is a fully automated, zero emission vessel that will help the maritime sector meet challenging decarbonisation targets by acting as a living laboratory

AN AUTOMATIC **RESPONSE**

Regulation in the maritime industry can be expedited through the use of regional research labs, according to industry figures at the Dubai Maritime Week in September.

Iqbal Alikhan, the programme director for blockchain at IBM Corporation, told delegates that the adoption of new technology in the shipping industry is too slow. While the pace of technological change is increasing, regulatory progress is lagging behind. "We need new regulations to allow the adoption of new technology," he said.

In order for regulation to catch up with technological advancement, Alikhan believes there is a need to develop what some call regulatory labs or living labs. In these local laboratories, technologies can be safely tested and regulations developed that will help the International Maritime Organization (IMO) put in place the global initiatives that will see the shipping industry achieve its challenging climate targets.

These types of laboratory are being used increasingly to test technology, by companies such as IBM and Alikhan said that the United Arab Emirates is handing out around 10 licences for new technology a year. In a recently completed European study on logistics provision within the EU, living labs, where industry, academia and regulators tested technology, also featured.

One such laboratory has been defined in the Trondheim Fjord in Norway, which has been designated as an area where autonomous vessels can be tested. It is expected that the Trondheim Fjord will expedite any new regulations necessary for autonomous ships through the testing of the *Yara Birkeland*, which is expected to be delivered next year. Autonomous ships and other vessel types will help the maritime sector meet its challenging decarbonisation targets.

As challenging targets go, last year's decision by the IMO to halve carbon emissions from the maritime industry by 2050 is perhaps the most testing to date — not because it is just difficult to achieve for

an industry already burdened with great change, but also because the collective failure of other industries, along with the maritime sector, could be the end of civilisation as we know it.

In this context, it is necessary for all industries to play their part to meet, what the Swedish climate activist Greta Thunberg calls "the beginning of a mass extinction", arguing that those still talking about "fairy tales" and growth must confront reality. "How dare you look away," Thunberg berated world leaders at the United Nations General Assembly in September.

According to Thunberg, the science on climate change has been clear for the past 30 years and it is because we have the technology that we are able to accurately see the damage done to our ecology.

Science and technology could also provide some of the many answers to the crisis facing the planet and its inhabitants. And in recent years, elements of the shipping industry have sought to play their part, however small, in providing environmentally friendly answers.

Autonomous shipping, that is ships that operate with little or no crew, are expected to be an element of the remedy for the climate catastrophe currently being felt globally. Autonomous ships, or Maritime Autonomous Surface Ships (MASS) as the IMO has labelled these vessels, will be introduced in coastal waters where regional authorities, rather than the IMO hold sway. One of the first commercial vessels, the *Yara Birkeland*, is set to enter service in 2020.

The vessel is currently under construction in the Vard Brevik yard in Norway, following the construction of the hull at Vard's hull yard in Romania. The vessel will be the first commercial ship to be operated fully automatically.

Yara itself is an agricultural products manufacturer, with one of its factories based in Porsgrunn in Norway, less than 10 miles from where the vessel itself will be completed.

Yara executive vice president, Peter Due, told *Clean Shipping International*: "Sea trials of the *Yara Birkeland* are due to begin in the second quarter of 2020 and the first operations are due to take place in the third quarter, but the ship will initially be operated manually."

Due says that the ship is really pushing the boundaries of innovation combining new technologies with zero emissions technology. "However, *Yara Birkeland* is not just a ship," he says. "It's a fully autonomous, zero emission, logistics solution that starts within the factory."

Electric straddle carriers that lift containers automatically within the factory also then transport the boxes to the quayside, where an electric crane will load the vessel with its cargo. The vessel itself is fully electric and will travel on a circular route from Porsgrunn to Brevik and Larvik delivering cargo for onward transportation.

> *"Yara Birkeland is not just a ship. It's a fully autonomous, zero emission, logistics solution that starts within the factory"*

The whole operation will replace the 40,000 truck journeys undertaken from the Yara factory to ports every year, explains Due.

"We are the first mover so the costs of the project are considerably higher than will be the case for those coming after us. We have had to build into the project an extreme amount of redundancy with automated straddle carriers operating in a mixed traffic environment that includes other cars and pedestrians, but in the future that redundancy will be considerably less," says Due.

Yara is also keen to point out that the project itself is part of a necessary collaboration between the agri-products company, technology group Kongsberg, cargo handlers Kalmar, vessel designers Marin Teknikk, the Norwegian maritime authorities, the Vard shipyard and safety assurance providers such as DNV GL.

"In addition, the IMO, which is carrying out a scoping exercise to see what regulations need to be adapted for automated ships that will operate in international waters, are watching very closely," says Due.

But the IMO will not be the only regulatory authority watching closely — the Central Commission for the Navigation of the Rhine (CCNR), which in effect sets the regulation for all European rivers and canals, is also interested in the development of *Yara Birkeland*.

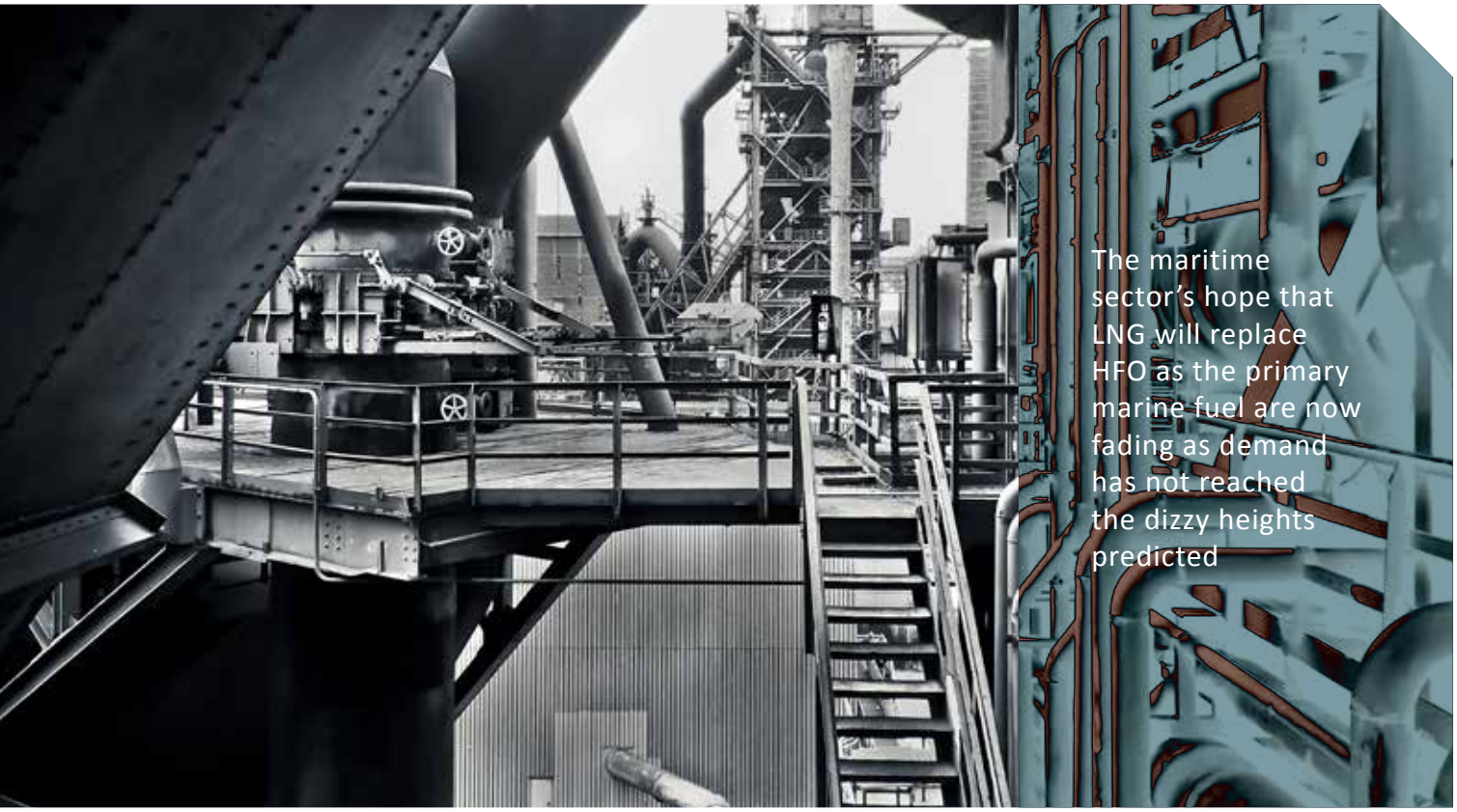
CCNR administrator Benjamin Boyer had already made the point in January 2019 when he said that the IMO does not regulate the more than 5,600 miles of inland waterways in Europe. The CCNR is already conducting trials for barge trains and the authority can see the advantages of automated ships, too.

Due, however, also points out that there needs to be integration between the modes of transport and that port energy supplies need to be improved to operate on cleaner energy also.

That may take time and the costs can be high; Yara invested in remodelling its factory building and production line as well as building a new quay and designing and building the ship, although Due said that much of this work would have needed to happen in any case.

"But the real benefits of this solution is that there is less noise, less air pollution and safer roads and to cap it all this solution [*Yara Birkeland*] is cheaper, up to 30% in operating expenses, than the previous solution," says Due.

Living labs in the technology industry are set to push the industry further and faster than ever before. The pace of change is pulsating, but the key to the change is collaboration rather than competition.



The maritime sector's hope that LNG will replace HFO as the primary marine fuel are now fading as demand has not reached the dizzy heights predicted

LNG FACES AN UNCERTAIN FUTURE

Liquefied natural gas or LNG has been seen as a either the fuel to end the maritime sector's reliance on heavy fuel oil (HFO), or more recently as a bridging fuel for the industry as it shifts to a carbon free future, but serious questions are being asked about its role as a replacement for heavy fuel oil or even as a transitional fuel.

Given the uncertainty over the "fuel of the future" as it was once called, it could be seen as surprising that so many big names are still investing in gas carriers and gas-powered vessels.

Much of the uncertainty around LNG as a fuel was created by the industry itself, particularly when the International Maritime Organization (IMO) agreed in the spring of 2018 to a 50% cut in carbon emissions from 2008 levels by 2050. This appeared to seal the fate of LNG as the fuel of no future.

Observers at a Posidonia event in Athens last year could be excused for accepting that LNG was a technology whose time had passed before it had matured. One of the stand-out events held at Posidonia 2018 was hosted by ABS in the Onassis Cultural Centre in Piraeus. Three major Greek shipowners — John Angelicoussis of Angelicoussis Shipping Group, which operates Maran Gas, Peter Livanos, the owner of GasLog, and George Procopiou of Dynacom Tanker Management faced questions about their companies and about the prospects for LNG in the coming years.

A query from the audience on the future of Dynacom saw Procopiou dodge the question, answering that he would be retired on his yacht by then. Somebody else asked Livanos what shipping sector he would switch to given that LNG could not help industry meet its carbon goals? His answer was revealing; after a pause, he quipped: "I'll be on the yacht with him," pointing to Procopiou.

Although Livanos' remark was clearly a joke, the subtext of his response was that there is a problem for the LNG industry on the horizon. And that sense of gathering storm could see more blood on the boardroom carpets as shipowners are left

The oil and gas industry faces an uncertain future as the decarbonisation process gathers pace.

high and dry by falling demand and too much capacity in the LNG sector, should LNG be shown to be as carbon intensive as HFO.

More recently, the respected academic Dr Tristan Smith told a high-level panel at the London International Shipping Week (LISW) conference "build the transition into zero LNG now", so that early adopters of the fuel are not penalised.

Smith works at the University College London Energy Institute and is voicing the belief held by a number of shipowners that the 20% carbon savings expected from LNG are unlikely to materialise with the well-to-wake carbon footprint for the gas actually exceeding that of HFO.

Even so, LNG as a fuel on land is likely to continue to develop, particularly as carbon capture and storage techniques develop, although demand may not reach the highs industry had originally envisaged. But the demand for LNG as a marine fuel is unlikely to achieve the original expectations.

In the short-term, with Asian demand for gas, which burns cleaner than other fossil fuels, demand appears assured, but that demand is largely for electrical power generation. In the maritime sector, the hope in the recent past was that LNG would replace HFO as the primary marine fuel.

In 2015, one of the major proponents of LNG as a maritime fuel, class society DNV GL, argued: "The number of ships using LNG as fuel is increasing fast and more and more infrastructure projects are planned or proposed along the main shipping lanes. Sixty-three LNG-fuelled ships (excluding LNG carriers) already operate worldwide, while another 76 newbuildings are confirmed (as of May 2015)."

> *"LNG as a fuel on land is likely to continue to develop, particularly as carbon capture and storage techniques develop, although demand may not reach the highs industry had originally envisaged"*

According to DNV GL at the time, the company "firmly believe" that there will be more than 1,000 non-LNG carrier ships operating on the gas by 2020. Today, the figure is considerably less, with the class society itself admitting that only about half that number will be operational by next year.

By last year, DNV GL was less bullish about the uptake of LNG as the "fuel of the future". In 2018, in a paper entitled *Alternative Fuels and Technologies*, the company said: "The IMO target of reducing greenhouse gas emissions by 50% by 2050 is ambitious and will likely require widespread uptake of zero-carbon fuels and further energy efficiency enhancements."

Nevertheless, orders for new LNG carriers continue to be placed at shipyards that have little other business. Earlier this year, Qatar reportedly confirmed that it would order 60 new LNG carriers and Maran Gas has confirmed a sixth order for 174,000m^3 LNG carriers from Daewoo Shipbuilding and Marine Engineering group in South Korea, for delivery in 2021.

In all, up to the end of 2018, according to Danish Ship Finance the LNG fleet consisted of around 500 vessels totalling 75 million m^3 with an orderbook of 123 vessels, comprising around 24% of the total fleet as at the end of last year.

This year at LISW, DNV GL launched its Energy Transition Outlook 2019 report and it is again pushing LNG,

this time as a bridging fuel. Knut Ørbeck-Nilssen, marine director at DNV GL told *CSI* that what is crucial about LNG is that the bunkering infrastructure is already available in many areas and that would simplify the transition.

Asked if the advent of carbon pricing or some sort of tax on emissions would bring uptake in the fuel to a halt, Ørbeck-Nilssen said he thought it would increase the uptake as it was the only fuel that could cut carbon and help the industry to meet its 2030 milestone.

According to DNV GL, the IMO's interim goal is to reduce carbon emissions from the maritime sector 40% by 2030, and the industry is already "off course" said the class society.

A number of paths could be open to the industry to correct its trajectory, and DNV GL believes the speed of decarbonisation will need to progress at a significantly higher rate. In fact, new orders for LNG carriers and for LNG bunker vessels are coming, but if Smith and others are correct, that may not be the answer.

Currently, the number of new LNG vessels remains small, although there have been some new contracts this year, which has pushed up the on-order total, but the market fundamentals remain very similar with the growth in demand for gas — mainly driven by China's switch to the cleaner fuel —driving, what DSF calls, the short-term positive outlook for the industry.

This year and next year, there are 31 and 32 vessels due to be delivered, respectively, with 23 destined for contracted work from this year's order book while 23 vessels from next year's deliveries will enter the spot market.

In its analysis of the LNG market, DSF believes that the sector will be positive up to the end of 2021 as new vessel capacity, which is expanding up to the end of next year, will be supported by new liquefaction projects in the US with an increase of 62% in liquefaction capacity, and 18% increases in Russia and Australia.

"Around 110 vessels will be required to service the new liquefaction capacity. Given that 118 vessels are expected to enter the fleet, utilisation should be fairly balanced until the end of 2021. There could be periods of oversupply if liquefaction projects are delayed, although any project slippage will help smooth the growth rate by pushing liquefaction start-up from 2019 to 2020 and 2021," said the DSF report.

Asian demand, particularly China's coal-to-gas switch, will absorb much of the growth with any excess supply expected to be taken up by European markets. The authorisation of new liquefaction projects will be necessary for further growth to take place in the three years from 2022.

However, authorisations for new liquefaction projects have slowed significantly since 2016 as a result of more general cuts in capacity expenditure in the oil industry.

In addition, DSF argues that, "Project sanctioning will be further limited by the massive expansion of liquefaction capacity expected in 2019. LNG buyers are reluctant to enter into new long-term contracts amid prospects of plentiful supply in the coming years. If project sanctioning does not increase in the coming years, the LNG market will experience a major slowdown in the first half of the 2020s."

In the longer term, DSF believes that if speculative new orders continue after 2021 and beyond the end of the current liquefaction capacity increases the gas carrying sector could enter into a period of over-capacity that would ultimately hit rates. That decline could be further exacerbated if trade flow optimisation takes place, reducing the capacity necessary to meet demand.

However, the biggest threat to the industry could be the rise of renewable energy. According to DSF, climate change considerations are driving the use of LNG for power generation, but that "by 2040 power generation from gas will be limited by the climate goals of the Paris Agreement".

Furthermore, the increasingly competitive pricing for renewable energy will mean that gas will be of decreasing importance in the future with demand falling further as a consequence.

SCRUBBER CORROSION QUERIES

By Anders M. Sørheim, M.Sc. Chem. Eng, Technical Sales Manager, Yara Marine Technologies

How important is quality when selecting a scrubber system?
If the intention of a scrubber installation is to operate the scrubber for the remaining lifetime of the vessel — assuming a minimum of 10 years — then the material quality is imperative. A study performed by the American stainless-steel manufacturer ATI, *Evaluation of Alloys for Marine Exhaust Scrubbers — Effect of Welding and a Crevice*, confirmed the importance of correct material choice for scrubbers.

The corrosion rate and consequent weight loss of five alloys commonly used in marine scrubbers were tested in a simulated scrubber environment. The results revealed that for a severe corrosion case, the alloy 254SMO had a crevice corrosion rate of approximately 0.7mm per year, while a corrosion rate close to 0 was found for Alloy59.

Over the course of 10 years, these crevice corrosion rates could in theory grow up to 7mm deep, which in some cases is more than the thickness of the scrubber wall. Such weak spots in the scrubber tower structure can lead to cracking or other fatigue issues caused by the constant mechanical vibration and the thermal expansion-contraction cycles onboard a vessel, which could result in severe leakages if not addressed.

Hopefully such corrosion damages would be detected and repaired before progressing to that stage, but expensive repair work and rewelding of the scrubber will undoubtedly increase the operational expenses of scrubbers produced in lower quality materials.

Stainless-steel producer Outokumpu confirmed the results of the ATI study in its own corrosion test last year, where a range of material samples of varying qualities were placed inside an operating scrubber for 14 months and then taken out and tested.

It concluded that, overall, the conditions in the scrubber had been very aggressive and that Ultra 254 SMO and other grades with equivalent corrosion resistance might could be used for some parts of the scrubber. For complete corrosion resistance, Ultra 654 SMO or Ni-base alloys such as Allo59 are likely to be required for other parts. It also mentioned that duplex grades might not be the best choice for this type of scrubber, due to embrittlement at higher temperatures.

What are the most important factors in building a corrosion-resistant scrubber, in addition to alloy quality?
Welding, welding and welding. Even if a scrubber was built in pure nickel, it could be susceptible to corrosion damages if the welds were not properly performed by approved welders, following an approved welding procedure using approved welding materials.

A good rule of thumb is that the welding material should be of a higher grade than the material being welded together, also known as "overmatching the filler material".

In addition, the amount of heat applied during welding should be kept to a minimum to avoid hot cracking caused by the formation of carbides and intermetallic compounds in the weld.

Furthermore, the welds should be properly pickled and cleaned, and finally subject to 100% NDT testing to ensure the absence of crevices caused by poor welding, including visual surface examination and ultrasonic testing. A high focus on quality is as important in the scrubber material selection as in the post-manufacturing inspections.

Are there any significant developments underway in scrubber materials or in construction methods?

Over the past few years we have seen a shift in scrubber makers' material choice towards more corrosion-resistant alloys, although not to the extent we would have hoped for. We have seen players in the market experimenting with ceramic materials for scrubbers, which is an interesting approach, as ceramics do not corrode, but they are unfortunately susceptible to other types of damages due to their brittle nature.

Various kinds of plastic composites, such as GRE, have been tested, but are not a realistic option due to their low melting point. Some manufacturers have even tried different coatings inside the scrubber, but unfortunately these coatings do not last long in the extreme environment. The next developments will most likely be the continued optimising of the scrubber tower design using different types of nickel-alloys.

What are some of the most common reasons that shipowners opt for lesser quality in scrubbers?

We cannot know for certain the true reasons behind these decisions. Some shipowners prioritise low capital expenditure over low operating expense, while others may not realise the extent of the corrosive environment, or simply do not believe that high grade nickel-alloys are necessary. As technology providers, we have a responsibility to educate and inform different stakeholders and support shipowners in making informed, long-term feasible choices.

YARA

Knowledge grows

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With all eyes on the IMO 2020 sulphur cap, it is vital that the shipping industry continues to look ahead in order to keep up with the predicted strategy towards a cleaner future. So what are the options available?

A PRAGMATIC APPROACH TO SUSTAINABLE SHIPPING

by Gijs de Jong, Sales and Marketing Director, Bureau Veritas

An initial, ambitious strategy for the reduction of global greenhouse gas emissions (GHG) and carbon intensity was adopted following the April 2018 meeting of the International Maritime Organization's (IMO) Marine Environmental Protection Committee (MEPC 74), with further efforts in alignment with the Paris Agreement temperature goals expected to be rolled out. And with some regulations already in place for newbuildings, such as the Energy Efficiency Design Index (EEDI), with further phases being introduced in 2020 and 2025, the next decade will be critical.

While still in development, it is readily anticipated that the IMO will mandate GHG regulations in the near future. With this in mind, the groundwork must be laid now in order to ensure compliance pathways are outlined for the purposes of reducing the carbon intensity of fuels — this cannot be achieved without significant investment in research and development. A collaborative and unified approach when it comes to this preparatory work will be vital in order to realise competitive, sustainable and scalable solutions.

A MULTI-PATHWAY APPROACH

When it comes to propulsion solutions, shipping has a rich history. However, as many who work in the industry will know all too well, change takes time. Our industry has a clear evolutionary path – wind power via coal-fired steam to fuel oil and now gas. But the path to transition is far from linear, with new propulsion technologies often co-existing for significant periods – vessel type, size and operational profile will all impact solution suitability. With this in mind, the trend for multi-pathway approaches to regulatory compliance is likely to continue for the next few decades.

This multi-pathway approach to

PONANT's order for an ice-breaking expedition class ship incorporates LNG as fuel for a hybrid electric propulsion system, as well as an icebreaking hull

propulsion will almost certainly include hybrid solutions, a concept that is in no way new to shipping. Steam- and sail-powered vessels co-existed on a large number of vessels in the 19th century, and there is no reason to think that when it comes to reducing EEDI and carbon intensity in the 21st century it will be any different. Electric-hybrid power systems employing batteries alongside oil or gas are already surfacing in ferries and offshore vessels, and wind power is also being re-visited for merchant vessels.

Planning for the future is vital, but it does not answer the question of what we can do today. Many options are under the microscope, hydrogen and ammonia for example, while presenting viable options for future zero-emission solutions are not yet ready for widespread adoption. To meet the current regulations, the gap must be bridged, requiring a pragmatic approach to progress.

LNG

Unlike other options, this clean-marine fuel is available now and presents a viable bridge towards alternative carbon-free and carbon-neutral fuels, with the possibility to switch-over to carbon neutral fuels as and when they become available.

However, LNG has caused some consternation. It is a fossil fuel and the applied heat cycle will impact the amount of methane slip, although this is dependent on engine technology. Ultimately, with an expanding distribution network, it is a positive move towards lower GHG emissions, particularly when it comes to CO_2.

BATTERIES

Electrification, either wholly or in a hybrid configuration, is another potential pathway. Vessels that operate on short, fixed routes with moderate power requirements may be suitable for electrification using energy storage systems. Higher power demand fluctuations or temporary electric power requirements would be more suited to an electric-hybrid propulsion system, with electric energy generated at an optimum efficiency in order to adapt to power demand fluctuations. This can have a significant impact on fuel reduction, and therefore emissions.

In line with the above, Bureau Veritas has developed a dedicated set of class notations and technical rules in order to streamline safe and reliable operation management, and is

currently involved in the classification of a variety of electric-hybrid ships and fully electric ferries. Bureau Veritas' rules provide an overview of three operating modes: power management, power backup and zero emissions.

WIND POWER

Flettner rotors, sails and kites are the key initiatives driving the trend in wind-assisted propulsion (WAP). While unlikely to become the main power source, with some obvious performance factors such as weather to contend with, the energy saving potential is notable for both EEDI and carbon intensity reduction. Bureau Veritas, in recognition of these benefits, is currently updating its class rules and will be actively engaging on future wind-power projects with a view to assessing operational and safety factors.

SPEED REDUCTION

The financial crisis of 2008 highlighted the energy reduction benefits of slowing down, with operators choosing to cut speed in favour of energy and cost savings. And with the 2030 carbon reduction target of 40%, it is likely that slow steaming will once again be employed.

However, there are a couple of factors that need attention. In order to manoeuvre safely in heavy weather, vessels need a propulsion power minimum, acknowledged in the IMO's supplementary guidelines for EEDI requirements.

Another consideration is the cubic relationship between speed and power. For existing ships designed to operate at higher speeds, the associated reduced engine load is likely to increase the specific fuel oil consumption (SFOC) of the engine, while the propeller and auxiliary systems may also no longer operate at their design point. Hull resistance optimisation will also be compromised. Modifications may be required on the propulsion train or potentially the hull, in order to ensure savings objectives are met. When it comes to retrofits for (ultra) slow steaming operations, Bureau Veritas has a proven track record with existing containerships.

2008 highlighted the energy reduction benefits of slowing down

Newbuilds, however, have the potential to be optimised for the predicted slow steaming operations. The potential to combine slow-steaming optimisation with hybridisation would streamline the design point, opening up additional pathways for future energy efficiency improvements.

It would be remiss to forget the bigger picture when it comes to slow steaming, particularly when considering the impact on the entire supply chain. Maintenance of cargo throughput would mean adding additional ships, necessitating adaptation across the entire logistics chain.

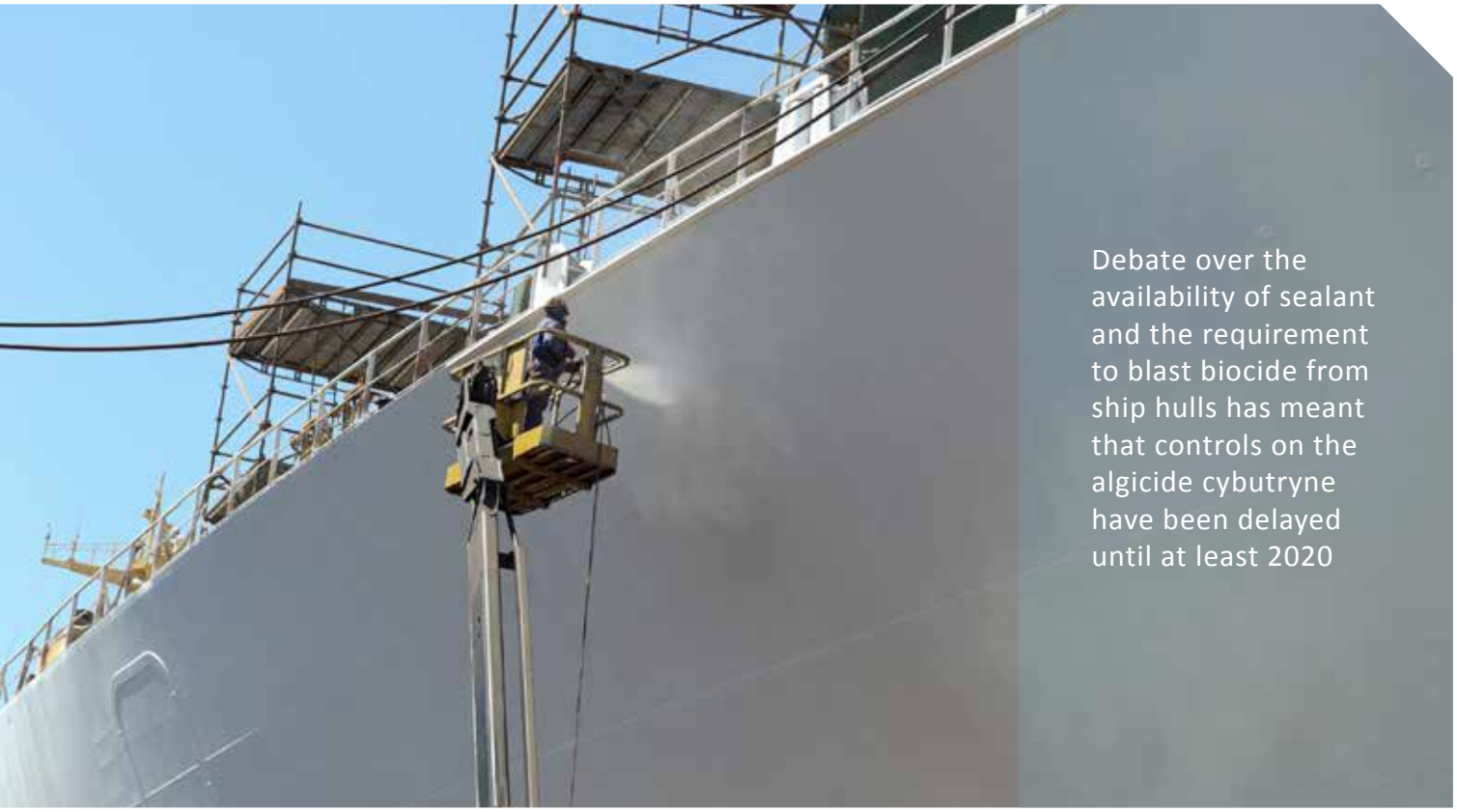
Another option with logistical significance is scale-enlargement. By increasing the ship size, emissions are decreased per ton-mile sailed. Container ships have already undergone this process and, to a lesser extent, bulk vessels. However, global trading patterns, increased insurance risk and port restrictions present roadblocks for ultra-large ships.

COLLECTIVE ACTION

The route to decarbonisation is far from straightforward and collective action is a must if the industry is to achieve the research and development goals that will overcome the technical and logistical challenges for a carbon free industry.

New fuels should be a priority. Biofuels, hydrogen, ammonia and synthetic fuels produced with renewable energy are obvious options for a lower-carbon future. Fuels and batteries need to be developed in order to offer a realistic alternative for a broader spectrum of vessels.

Bureau Veritas is committed to working with industry partners on a variety of pilot projects in order to contribute workable solutions to the regulatory framework, while supporting the movement towards a more sustainable future.



Debate over the availability of sealant and the requirement to blast biocide from ship hulls has meant that controls on the algicide cybutryne have been delayed until at least 2020

IMO'S CYBUTRYNE DEBATE **STALLS REGULATION**

Discussions over the future of the chemical substance cybutryne, which is used in marine coatings, could delay the introduction of a regulation that will prohibit the use of the substance in paint used on ships and smaller vessels.

Cybutryne is used as an algicide in marine coatings — it works by limiting the ability of plants to photosynthesise. Usually produced as a white powder, cybutryne is available under the commercial names of Irgarol 1051, Irgarol 1071 and Irgaguard D 1071, but it has already been banned by the European Commission, which outlawed the chemical in January 2016.

Irgarol, which was used in Europe from the mid-1980s, is applied to ships' hulls and is effective against freshwater and seawater algae rather than aquatic animal organisms. It is often combined with copper or copper compounds in anti-fouling paints. It is this use that has drawn the attention of the International Maritime Organization (IMO) as well as other regulatory bodies, including the EU.

In a 2011 study on cybutryne, conducted by consultants Entec UK, the particular difficulties associated with the chemical were highlighted. In the first instance, it found cybutryne "does not easily degrade in water".

According to the Entec report, cybutryne has a half-life of between 100 and 350 days in seawater. "Under anaerobic conditions the degradation in sediments is considerably slower. Irgarol is persistent in sediments whether adsorbed to sediment particles or associated with paint particles," the report stressed.

European regulation has led the IMO to also consider its position on the chemical and discussions on banning cybutryne began in earnest at the Marine Environmental Protection Committee (MEPC) 74 last spring.

Initial discussions at PPR 6 (Pollution Prevention and Response) in February at the IMO concluded: "The AFS (Anti-Fouling

Cybutryne is used as an algicide in marine coatings, but the chemical is facing a ban

Systems) Convention currently has controls on only one active compound — it prohibits the use of biocides using organotin compounds tributyltin (TBT). The Sub-Committee agreed that new controls on the biocide cybutryne, also known under its industry name Irgarol-1051, should be included in the AFS Convention."

However, the Japanese delegation to the IMO has raised some concerns over the banning of cybutryne that could ultimately delay the regulation controlling the chemical.

According to Japan's paper presented at PPR 6 in February, the country supports the proposal to ban cybutryne from being applied to new vessels, but it had "significant concerns on the retrospective application of such a prohibition to ships which have already applied cybutryne".

The ban on cybutryne use will extend to all vessels, including domestic vessels, barges, fishing boats and pleasure craft, and MEPC has not been informed of the extent of cybutryne currently in use on vessels around the globe and the "extent of the burden and the impact on maritime industries that would be brought by the retrospective application of this regulation."

As the proposals stand, vessels that have already applied cybutryne as a part of their anti-fouling system will be required to either remove the biocide or seal it by 3 October 2026, which is five years after the date of the enforcement of the amendment.

Japanese concerns also centre around the limited data on how long cybutryne would remain in AFS and whether the five-year grace period would be "appropriate and justified for the retrospective mandatory requirement".

Further concerns were raised by Japan with respect to the possibility that sealed AFS could, after some wear and tear, leach cybutryne into the ocean with few environmental benefits, "the requirement would just be a burden", on the industry, said the Japanese report to PPR 6.

In addition, the paper suggests that sealer coats for cybutryne may not be readily available for AFS with cybutryne. This was a view that the paper says was rejected by the technical group as "without foundation". The timeline is considered by the technical authorities as giving ample scope to develop appropriate sealer coats.

What is more, the Japanese presentation makes clear that should the sealer coat be unavailable, the only option available to owners will be the removal of the chemical through sand blasting. That, says the report, could release dust particles into the air, which would include cybutryne, and could pose a "direct risk to human health".

As a result of these concerns, Japan called for MEPC to "take further careful consideration with more concrete information," before approving the amendment to the AFS Convention to consider cybutryne. Nevertheless, Japan stressed that it "supported the immediate prohibition of applying and re-applying anti-fouling systems that contained cybutryne".

One of the proposals put forward by Japan was to strike out the second part of the proposals and to just ban new applications and re-applications of the biocide. The original proposals also had a second element requiring the sealing coat or the removal of cybutryne; it was this second element of the amendment that Japan suggested removing from the amendment until more data allowed for a more considered decision.

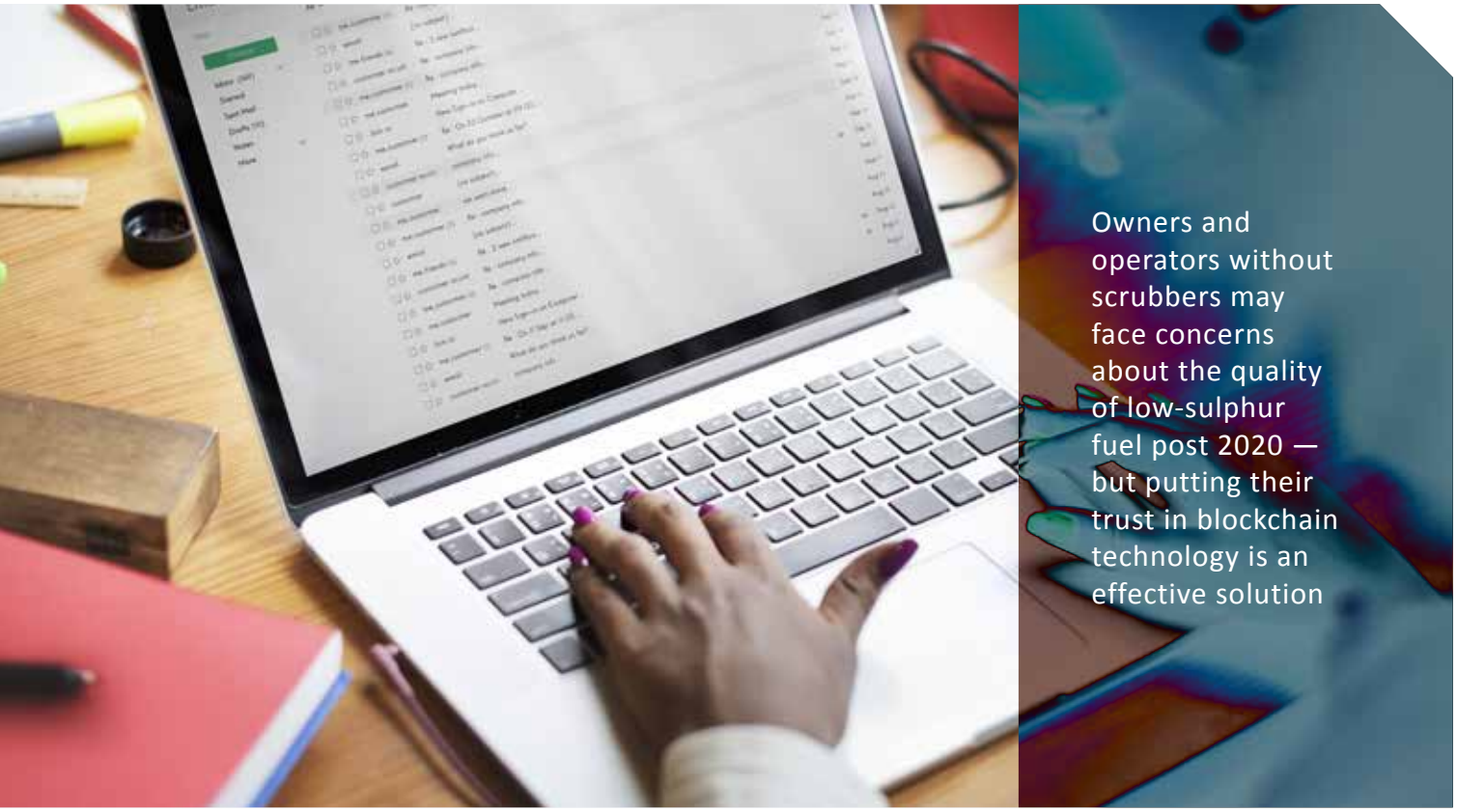
Many delegations at MEPC opposed to this plan pointed out that Japan's proposal was in contravention of Article 4(2) of the AFS Convention that compels owners to remove controlled substances at the vessel's next drydocking or within five years.

One delegation also pointed out that the controls on another biocide, TBT, had been introduced in a similar manner without any issues.

Furthermore, The International Paint and Printing Ink Council (IPPIC) said that sealer coats used for TBT could also be effective for protecting against cybutryne and that there may also already exist other methods for dealing with cybutryne, including tie coats, primers and other anti-fouling coatings.

In order for the investigations into possible alternatives to be completed, MEPC agreed to defer its decision on the banning of the substance until at least the next round of meetings in early 2020.

As a result, the effect of Japan's intervention has been to delay the application of the cybutryne ban, with an agreement at MEPC to revisit the issue in February 2020 at the next meeting of the PPR 7 sub-committee.



Owners and operators without scrubbers may face concerns about the quality of low-sulphur fuel post 2020 — but putting their trust in blockchain technology is an effective solution

CHAIN REACTION

by Marc Johnson, Chief Sustainability Officer and Director, Maritime Blockchain Labs

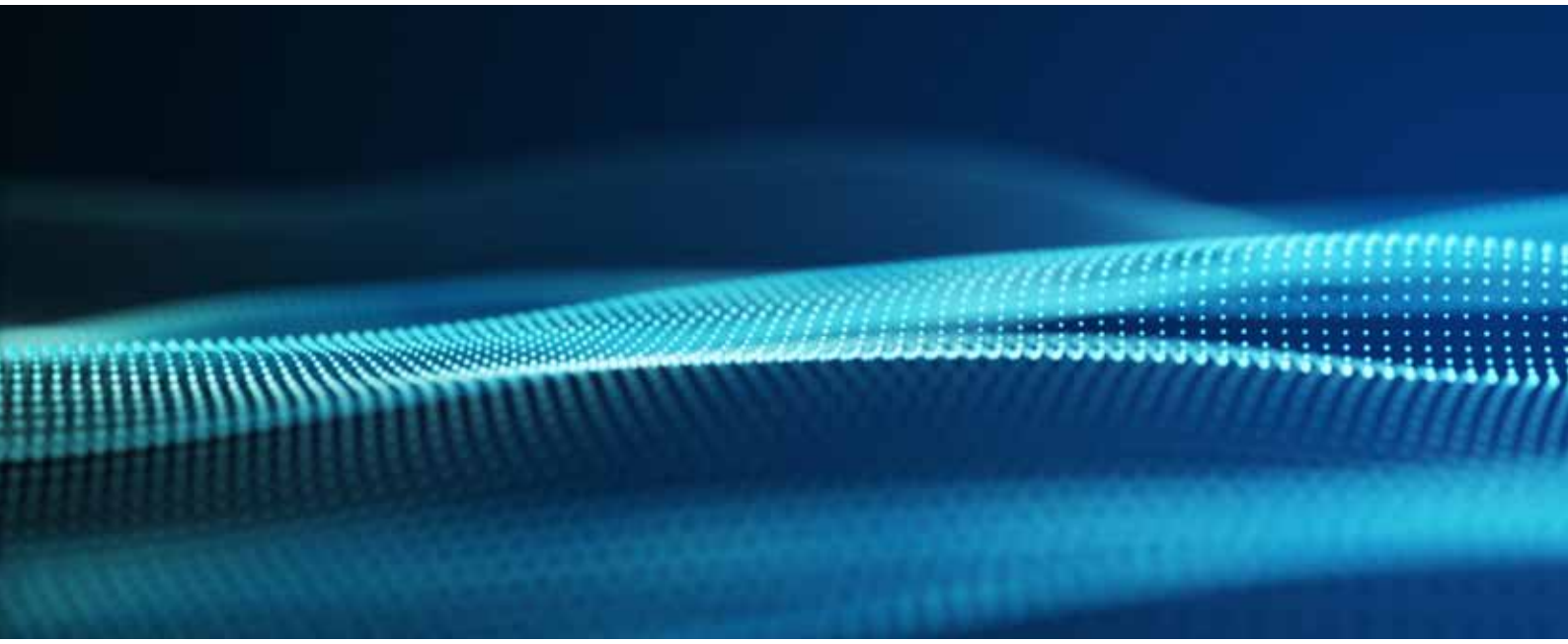
Recent reports from Singapore, the world's largest bunkering hub, indicate both the opportunity and complexity that IMO 2020 creates for the shipping industry. Several bunker fuel suppliers, according to Platts, are re-entering or expanding their presence in the Singaporean market to meet the demand for 2020-compliant fuels. Petrobras, Mitsui, Marubeni and Freeport are all named as stepping up operations to meet the need for low-sulphur fuels.

These steps reflect the fundamentally different dynamics in the bunkering market that we should expect post-2020, which present both challenges for buyers looking for compliant fuel and opportunity for suppliers who can meet the demand. The key change is that shipping will have to get used to no longer being at the front of the queue for its fuel, as it was in the days of heavy fuel oil (HFO).

Instead, for the proportion of the market that will be looking to use compliant fuel, as opposed to HFO (which will be used by scrubber users only), it will be necessary to compete with a range of other industries for middle distillate product. But ultimately, it does mean less availability of fuels, compared to the current situation. Speaking to *Bunkerspot* at Nor Shipping this year, ExxonMobil's marine fuels venture manager Luca Volta said: "I don't think we will ever go back to the situation we are in today, where marine gasoil and fuel oil are available at every port around the world in whatever quantity you want."

What's happening in Singapore, then, is arguably the best-case scenario. Other regions around the world may not be able to rely on an influx of major players into the market and may have to rely on new suppliers with less of a marine track record, or those who decide to cut corners to meet demand.

As Volta outlined: "I think some of the issues that we have seen in 2018 and 2019 in terms of contamination will resurface... if the industry is trying to tackle the issue of availability, you will need to go deeper into the refinery processing, and you will need



to start blending in a more extreme fashion than happens today. We may see some less scrupulous suppliers; I see the market potentially stratifying between quality, reputable suppliers, and those that are less so... anything that has a low-sulphur content is a likely candidate to try to find its way into a marine stream."

So far, there have only been small tests of compliant fuel analysed, with little to go on in the way of conclusive results regarding compatibility and stability. The prevailing thought in the industry is that many ultra low-sulphur fuel oils may be incompatible with one another.

Additionally, there is confusion about the standards that different fuels might meet, as there are crucial differences between the ISO 8217 standard and the ISO 8217:2017 iteration of the standard. Blending can also increase the presence of cat fines in fuel, which can cause engine damage. Ultimately, in the worst cases, issues with fuel quality can cause loss of propulsion and power, with the attendant safety and insurance issues. Based on this, insurers are preparing for higher levels of claims activity.

It's no surprise then, after last year's "epidemic" of bad bunkers, owners and operators are concerned about the quality of fuel available. Beginning in Houston, over 100 vessels were ultimately affected by contaminated fuel last year, which resulted in blocked filters and clogged fuel injectors. Legal responsibility is cloudy, as is often the case in a supply chain that is historically fragmented and opaque.

In tandem, these fundamental changes to the dynamics of the market, pose risks: risk for owners, charterers, credit providers and financiers in the fuels they buy or fund, risk for insurers in establishing the risks they must manage, risk for operators and the fuels they burn, and for enforcers policing the fuels market.

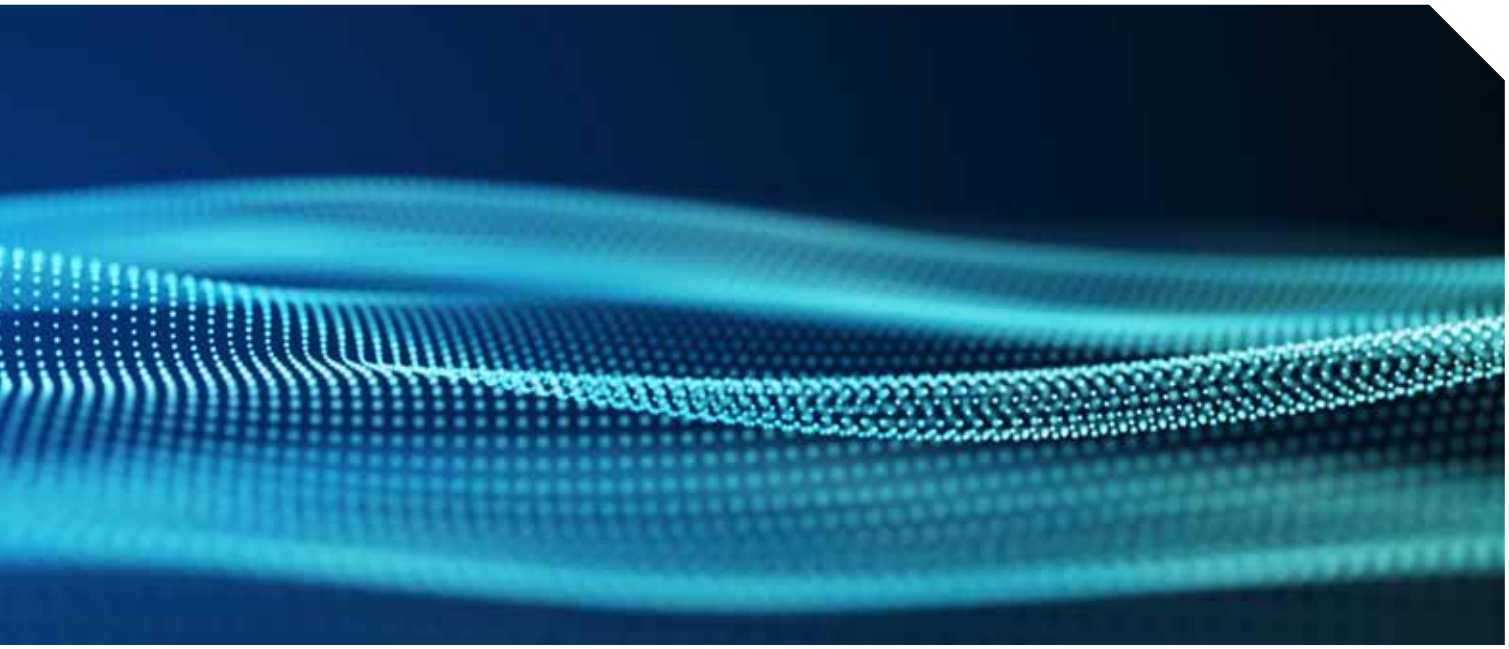
Among others, this situation was one of the reasons why, in 2018, when we began to look at where blockchain could make the biggest difference in shipping, it was obvious that the marine fuels supply chain was one of the most compelling places to start.

> *"It's no surprise then, after last year's 'epidemic' of bad bunkers, owners and operators are concerned about the quality of fuel available"*

Transparency and traceability are, ultimately at the core of this technology. It enables a shared, immutable store of data that allows, in theory, new levels of trust to be established between parties with limited intermediation. This is how, for instance, cryptocurrencies like monero and bitcoin allow transactions between parties without the intermediation of a bank.

The route to making this work for shipping, however, hasn't been easy — largely because the fragmented nature of the industry itself makes it hard to find a starting point. A recent report from the Boston Consulting Group argues that "the best blockchain networks are often the hardest to create", and that is because the crux of the issue is that the fundamental element of blockchain — trust — runs counter to many of the competitive business models that are embedded in the legacy shipping industry.

"By increasing transparency, these distributed digital ledgers can mitigate the mistrust that often exists among the industry's transacting parties," the authors of the study argue. "Yet this same mistrust makes it hard to bring together the industry's diverse participants into a common blockchain ecosystem."



This paradox is at the heart of blockchain and an important reason why so many applications in transport and logistics have struggled to find their feet. If a single company creates a blockchain-based application that only they and their direct customers can use, for example, it's unlikely to succeed, as it requires a level of transparency between multiple stakeholders that the creator may be unwilling to facilitate.

Luckily, however, this potential stumbling block is almost the exact opposite of what we've experienced through our open calls for collaboration and it speaks directly to the value of our consortium-led approach. BLOC brings together industry stakeholders by invitation and we align interests to address shared friction points across entire value chains. These stakeholders include suppliers, producers, customers, competitors, regulators and governments, to name a few.

Our subsidiary Maritime Blockchain Labs, which was created in April 2018 with an initial grant funding from the Lloyd's Register Foundation (LRF), developed a prototype application for digitising the bunker supply chain. This was a valuable start in simplifying chains of custody, which have previously been paper based, and open to loss and inaccuracy, either through error or deliberate falsification.

Last September, we used this system to conduct the first blockchain bunkering transaction and soon after used it to record the carbon savings from a GoodFuels' delivery of biofuel to the BHP-chartered, NYK-owned bulk carrier Frontier Sky.

One of the main findings from our early-stage trials was the fact that digital solutions, such as our prototype application, are limited in their ability to accurately represent, in the digital realm, what occurs in the physical realm. The conclusion to this dilemma is that digital solutions work best in combination with physical solutions.

The reasons for this are significant and obvious — by combining physical and digital information, the attestations we're able to gather are abundantly more robust, as the dual-sided solution safeguards against data misrepresentations because it becomes harder to input incorrect information deliberately and creates a stronger incentive to input correct information. However, how do you add physical information to fuel?

The answer came from an unexpected corner, in the form of Forecast Technologies' synthetic DNA. By creating synthetic DNA, it's possible to add information to any hydrocarbon — such as marine fuel — that carries information in the same way that DNA carries information around the human body.

In fuels, ideally, a tracer can be added at the top of the bunker fuel chain, at the refinery. At subsequent points along the supply chain, other tags can be added and demonstrate where fuel has been tested and found to be compliant. By the time it reaches a vessel, crew members can easily test for the presence of the necessary DNA markers and, if they are absent, make an informed decision about whether to proceed with the fuel onboarding process.

Where the DNA markers tag the provenance and movement of the actual fuel, the blockchain solution traces interactions that occur on the human level — by recording the information relayed and agreements between stakeholders as digital "handshakes" that occur as the fuel moves along the supply chain.

This is not a magic bullet by any means. As we've outlined above, the marine fuels supply chain is complex and will need multiple parties to work together to make sure that post-2020 fuels are safe and reliable.

What this solution, BunkerTrace, does do, is provide the basis for systems that give owners, charterers, credit providers and financiers more confidence in the fuels they buy, insurers a better picture of the risks they must manage, operators more assurance in the fuels they combust, and enforcers better tools to use to effectively police the fuels market.

ADDING FUEL TO THE DECARBONISATION DEBATE

In the UK, the population is suffering from a new ailment: Brexit fatigue, For the uninitiated, the three and half years of intensive debate have taken their toll on the British population.

The shipping industry equivalent will be the introduction of the much-considered sulphur cap on 1 January 2020, which will reduce the sulphur content in bunkers to 0.5% from its current 3.5% level. It's a subject that has caused much collective hand-wringing in the maritime circles.

However, for the shipping industry and the broader global constituency, neither Brexit nor the sulphur cap will match the intense debates to be had around decarbonisation, with a global call for major reductions in carbon emissions.

Maritime industry regulators have responded to these calls with a raft of regulations designed to lower carbon emissions from the industry, currently estimated at 2.6% of all emissions from the trade. That's roughly the equivalent to carbon emissions from the world's fourth largest economy, Germany. In addition is the commitment to reduce maritime's carbon emissions to half that seen in 2008, about 400 million tonnes.

Projected industry growth means shipping must cut its emissions by close to 80% by 2050 and to have achieved a 40% reduction within the next decade. That is a tall order. Nonetheless — like Brexit — there have been surprises, not least at the recent Shipping Symposium at the International Maritime Organization's headquarters in London, when oil major Shell's representative Dr Alexandra Ebbinghaus called for some form of carbon charging.

Ebbinghaus believes the industry must collaborate to develop the technology, and to achieve our low carbon goals we need an enabling policy. "We need a policy framework that is supportive" of the development of zero carbon fuels, she said. And by that she concluded some sort of carbon levy that would bridge the costs between using the established fuels and the new cleaner energy sources.

Ebbinghaus's views raised some eyebrows. It was perhaps the first time an oil major had called for a levy on its main product. But there are likely to be many twists and turns as this debate develops, not least because the technological changes will be key to the evolution of the discussion.

It is the chemistry in the technology that will be first up for scrutiny, with some industry figures preferring a gentle transition, while others want to see more radical change. In this inaugural *Clean Shipping International* magazine, there has been a flavour of how the debate within the maritime sector may develop. Some are calling for a bridging fuel such as LNG to reduce NOx, SOx and carbon emissions to lower levels. Others claim that LNG is a fossil fuel and the industry's energy should be focused on alternative fuels, such as wind, battery and clean hydrogen.

Efficiency gains will also play a part, with new vessel hull designs reducing the energy required, and other innovations such as the Windship's triple wing sail rigs claiming to substantially cut the need for other types of fuel by a minimum of 30%.

Decarbonisation has begun in the maritime sector, and beyond, and the major difference between Brexit and the debate over carbon emissions is that the latter is an existential problem for all sentient beings on the planet. And that means that the path to decarbonisation is a one-way street — there is no turning back, so we might as well accept the challenge and motor on at pace. At least that will prevent another ailment — decarbonisation fatigue.

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