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Methanol vs Green Ammonia: The future of marine fuels

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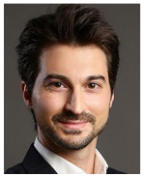
The International Maritime Organisation's (IMO) 2020 sulphur regulation changes are now in the rear-view mirror and the focus of future regulations and targets in the marine bunker industry is shifting to focus on decarbonization.

Jonty Richardson
Manager, Consulting Group
Argus



Andrea Valentini
Principal – Projects, Consulting
Argus

IMO 2030 targets a reduction in average carbon intensity (CO_2 per tonne-mile) of at least 40pc by 2030. This is an improvement in the relative efficiency per tonne-mile from the perspective of CO_2 emissions. This represents the IMO's medium-term goal. Based on Argus analysis, zero carbon fuels are not required to meet this target, but we are still likely to see growth in the market for alternative bunker fuels.

IMO 2050 will introduce far stricter targets, necessitating a 50pc reduction of greenhouse gas (GHG) emissions from shipping by 2050. In order to meet this more aggressive target by 2050, zero carbon fuels will need to play a part in the fuel mix beyond 2030. There are a multitude of possible options, each with its own unique selling points and caveats.

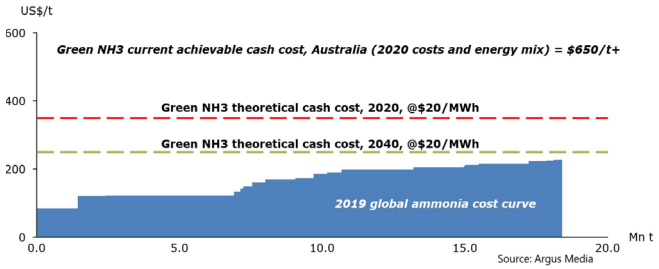
Q: What do you think the market for ammonia and other potential zero carbon fuels will be in 2030 and 2050?

A: Although low and zero carbon alternatives to bunker fuel will be a hot topic over the next decade, they are not essential to meet IMO 2030 targets. Tighter design specifications for newbuild vessels, increased operational efficiency, slow steaming and LNG will all contribute to the IMO's 2030 target being met without the need for zero carbon fuels.

This does not mean that there will not be growth in demand for zero carbon fuels. It just means that their growth will be driven by voluntary investment on a company level, rather than necessity to meet targets. For example, several large shipping companies indicated that they intend to skip LNG and focus on low/zero carbon fuels, while others indicated that they see LNG as an important intermediate step to achieve long-term decarbonisation. We see the same trends for bulk freight (e.g. in iron ore, BHP recently ordered LNG vessels while Fortescue is focusing on ammonia). So it will be crucial to track companies' investment activities in order to have some visibility on how the fuel mix will evolve.

In the longer term, zero carbon fuels will be essential to meet GHG reduction targets. Ammonia vs methanol vs hydrogen is going to be something that will be debated a lot when it comes to meeting IMO 2050. For hydrogen, the major challenge will likely be energy density and all of the resulting logistical issues. Necessary tank size, storage and most notably the difficulty of transporting hydrogen.

Global ammonia cost curve and green ammonia cost estimates



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Regional insight: Asia/Singapore

Sammy Six
Deputy Editor, Marine Fuels
Argus

Q: What does Singapore's roadmap look like regarding low carbon marine fuels?

A: As the world's largest bunkering hub, Singapore is advocating for an 'all-of-the-above' approach. The city state has already invested heavily in LNG bunkering infrastructure, as part of its wider ambition to become an LNG trading hub in Asia. LNG is a mature fuel and readily available and should therefore play a large role in the short to medium term. Other, truly low or zero carbon fuels, such as ammonia, hydrogen, biofuels and methanol, are expected to come into the mix at a later stage given that more time is needed to develop them in terms of availability, scalability and affordability.

The Maritime and Port Authority (MPA) of Singapore is supporting biofuels trials for ocean-going vessels, and it has also joined The Castor Initiative, which is looking into developing ammonia-powered tankers. Several companies have announced plans to set up a green ammonia supply chain in the port. The Nanyang Technological University is also working together with the Methanol Institute to study methanol's adoption as a future marine fuel.

Singapore is also looking at how to transform its economy to one powered by hydrogen, similar to other large Asian economies, and oil major Shell will start trialling hydrogen fuel cells for ships in Singapore soon. Plans to set up a Maritime Decarbonisation Centre were recently unveiled, which aims for Singapore to develop into a focal point for the maritime industry to jointly work on decarbonisation and innovation issues.

Ammonia and methanol have a lower energy density than conventional marine fuels, but significantly higher than hydrogen. The main hurdle for ammonia will be bringing down the built up cost of green ammonia and availability.

Note that even though ammonia has an established market and infrastructure, potential additional demand from new uses such as marine fuels and power generation might require huge investments in new infrastructure, which in the short term might slow down market penetration. Methanol also has an established global infrastructure, but it too is well below what would be necessary to facilitate it becoming a notable contributor to overall bunker demand. The costs associated with direct air capture, even in the longer term, will likely be the most significant hurdle for methanol, with the long-term cost competitiveness of green methanol still a big question mark surrounding potential growth of the fuel in the bunker market.

Global ammonia terminals, 2020

—Argus

METHANOL

Anita Gajadhar
Managing Director, Marketing, Logistics and Shipping, **Proman**

Q. What do you consider are the key reasons why methanol should be adopted as a marine fuel?

A: Methanol has several advantages as it is a clean burning fuel with significantly lower emissions than traditional marine fuels. Utilizing methanol eliminates sulphur oxides (SOx) and particulate matter emissions and cuts nitrogen oxides (NOx) by approximately 60%. Grey methanol also brings an immediate 10-15% CO_2 reduction on a well-to-wake basis. Methanol could become the leading alternative fuel, as it will help shipowners to reduce their GHG emissions in the here and now, and to meet the limits of the relevant emission standards for ship exhausts and IMO targets in the future.

Methanol has been shipped globally, handled and used for over 100 years. Risk classification societies and the IMO have developed standards and guidelines for methanol as a marine fuel already. Unlike some alternative fuels, methanol only requires minor modifications to existing terminal infrastructure, bunkering and fuel storage facilities to support shipping operation and is already available at 122 ports worldwide. On-board, methanol behaves like established fuels and is easy to store and to pump for direct injection into the engine.

Methanol is also a clear, colourless liquid at ambient temperatures that quickly dissolves in water and biodegrades rapidly, making a methanol spill far less damaging for the environment compared to those environmental effects from an equivalent MGO, VLSFO, HFO or other fuel spill.

Crucially, methanol also has a highly scalable sustainable pathway, with many companies – including Proman – investing in fully renewable green methanol production. When produced from renewable sources, methanol reduces CO_2 emissions further, with savings of over 90%.

Q. What do you see as the main hurdles to achieving wider adoption?

A: As with any significant changes within the industry, investments are needed at the outset, and shipowners can be put off by the costs of adopting an alternative fuel. However, there are advantages for those who make investments now, as any modifications made for grey methanol can be leveraged once green methanol becomes widely available in the future, as the methanol molecule is wholly fungible with the same energy density no matter how it is produced.

Of course, when it comes to adopting lower emissions marine fuels, there is significant momentum at the moment, and the need to comply with IMO 2020 regulations and established targets for 2030 and 2050 is galvanising the sector. From the perspective of vessel owners, 2050 is already only one vessel life away.

In order to foster methanol's adoption — and thereby capitalise on the potential benefits and emissions savings — the industry will need to consider ways to confront pricing challenges which are making some low-carbon fuels prohibitively expensive. Carbon taxes on fossil-based fuels could be part of the solution in order to create a more level playing field.

Shipowners' confidence in the use of methanol as a low-emission fuel was boosted by the IMO's acceptance of the product as a low-carbon marine fuel at the start of this year, when we saw Maersk Shipping, the world's largest shipping company, announcing the launch of the first 2,000 TEU liner vessel to operate on carbon-neutral methanol by 2023. So while there are hurdles, at Proman we are confident that methanol will be adopted more widely, partly thanks to a number of influential early adopters demonstrating its commercial and technical viability, as they immediately reduce their emissions profiles, which is significant for them and their stakeholders.

Q. Now that methanol has regulatory acceptance under the IMO's IGF Code, what do you see as the current timelines for expanding its use as a fuel?

A: Regulatory acceptance was vital and has provided shipowners with the necessary information to support their decision-making, as well as given them confidence around the safety considerations of using methanol. In terms of timelines, over the next few years we expect to see more than 30 methanol-powered vessels entering the market, including Proman's six 49,900 dwt methanol dual-fuel MR tankers, three of which are jointly owned with our JV partner, Stena Bulk.

Given the versatility and convenience of methanol as a marine fuel, we also expect to see more vessel owners and shipping companies looking to invest in dual-fuel engines, and considering the possibilities of retrofitting.

Q. What role can dual-fuel vessels play in supporting the shipping industry's transition?

A: Dual-fuel vessels will be vital for the shipping industry to continue to operate while also complying with IMO targets. In fact, three of our vessels will be traded globally for shipping and clean petroleum products, allowing others to experience the benefits of these state-of-the art vessels, and hopefully encouraging others to consider methanol as a marine fuel for their own fleets. We also see significant potential for the ferry and cruise industry to benefit from dual-fuel vessels — as evidenced by the recent 'world first' journey of Stena Line's Stena Germanica from Sweden to Germany, powered by methanol.

Q. What are the opportunities for low-carbon methanol in the marine sector?

A: One 2,000 TEU vessel, such as the vessel which Maersk plans to launch in 2023, will require approximately 25,000 mt of green methanol, demonstrating how quickly production from bio-methanol plants will be consumed in the marine fuel pool.

So as other shipowners begin to consider their options for alternative fuels, demand for marine methanol produced from renewable sources is going to increase substantially. Proman is already active in this space, including with the Varennes Carbon Recycling facility in Québec, Canada, which will include one of the world's largest waste-to-methanol plants.

In the more immediate term, 'blue' or low-carbon methanol, which is produced using recycled CO_2, can be used to reduce the carbon intensity of methanol as a marine fuel — providing another key advantage as compared with traditional fuels.

Q. If you could communicate one message to the maritime industry, what would it be?

A: That unlike the majority of other alternative marine fuels, methanol can be the solution in the short, medium, and long term. In light of the IMO's approval, the increase in take-up by leading shipping industry players, and methanol's qualities as an available, easy-to-handle fuel with a sustainable production pathway – methanol is truly hard to beat as the shipping sector's pathway fuel to the future.

GREEN AMMONIA

Magnus Ankarstrand
President, Yara Clean Ammonia
Yara International

Q. How do you see new market opportunities, such as in the maritime industry, for Yara, and what is the role you envision in the transition to a low-carbon economy?

A: Yara is the world's largest ammonia distributor and supplies a global network of plants and customers, backed by our own production system and third-party sources. As the maritime industry increasingly sharpens its targets towards carbon reduction, ammonia is gaining ground as a key zero-emission fuel opportunity. This will take time, but the first engines are under development, and Yara's global system is scalable to increase supplies. Yara is also working on a broad portfolio of green and blue ammonia projects. We aim to be present when the first tonnes are required, and will work closely with shipping companies that are taking the lead on decarbonisation

Q. What do you see as the key challenges and opportunities for the maritime industry in the adoption of green ammonia as a low-carbon fuel?

A: Engine technology and fuel-tank solutions require development, there is no doubt about that. Luckily, this is developing quickly, with leading engine suppliers taking pole position. Obviously, supply availability in the right locations will be a limiting factor too, but we believe there can be significant demand in certain key bunkering hubs such as Singapore and Rotterdam. This will require collaboration between suppliers, distributors and shipowners to get going. Naturally, safety protocols and regulation for expanded use of ammonia will also be required.

Q. What are the main regulatory incentives that will be needed to activate the market? Do you envision maritime companies being willing to a pay premium price for green ammonia?

A: There are many consumers that are willing to pay a premium to ensure their products arrive on a green value chain – and the added cost per iPad or pair of sneakers will be very manageable. But ultimately the timing and speed of development will rely on regulation – or the prospect of it. Ships are built to sail for long periods of time. The IMO targets, albeit long-term targets, will require the introduction of zero-carbon fuels. But we see a clear trend towards tightening those targets through EU regulation, and we believe that the interest to get going can possibly exceed available supply in the early years of clean ammonia.

METHANOL vs GREEN AMMONIA

Berit Hinnemann
Director, Head of Decarbonization Business Development, **Maersk**

Q: Can you tell us how Maersk is demonstrating its commitment to the transition to low-carbon fuels on the journey towards decarbonising the shipping sector?

A: In 2018, Maersk set a target of achieving carbon-neutral operations by 2050, and at the time this was considered a moonshot. Today, we see it as a challenging yet achievable target. For our container vessels, we continue to explore several carbon-neutral fuel pathways, with green methanol (e-methanol and biomethanol), alcohol-lignin blends and green ammonia as the primary fuel candidates for the future, along with the use of biofuels. As specific commitments, we recently announced our first carbon-neutral liner vessel to be launched in 2023 — seven years ahead of our initial 2030 ambition. We also announced that all future Maersk-owned newbuilds will have dual-fuel technology, enabling carbon-neutral operations or operation on standard very-low sulphur fuel oil [VLSFO]. With these commitments, we want to kick-start the transition to green marine fuels in collaboration with our customers and partners across the supply chain.

Q: What do you consider the key reasons why green methanol and green ammonia should be adopted as marine fuels?

A: To decarbonise shipping, any considered future marine fuel needs to be carbon-neutral on the basis of a well-to-wake life-cycle analysis, taking all greenhouse gases into account. In addition, marine fuels need to be technically feasible to use on vessels, need to have sufficient energy density, and the production pathways need to be scalable in a commercially viable way. Among the many fuel candidates, we find green methanol and green ammonia to be the most promising options. Methanol is already in use as a marine fuel and therefore the technical feasibility is established. At the same time, green methanol production can be scaled up, so by using green methanol, we can make an impact on our shipping CO_2 emissions in this decade already. Green ammonia is very promising, as it is a zero-carbon fuel and can be produced from green electricity, water and air alone. However, green ammonia cannot yet be used as a marine fuel to power vessels, as an ammonia combustion engine is still under development and other technical and safety issues need to be solved. We are working in close collaboration with the Maersk Mc-Kinney Moller Center for Zero-Carbon Shipping and other partners to work on the technical feasibility of ammonia as a marine fuel.

Q: Maersk has backed green methanol as one of the most viable future fuels. In your opinion, what are the key opportunities associated with the adoption of methanol as a marine fuel?

A: In our opinion, green methanol is a viable way to make an impact on our CO_2 emissions in this decade, since methanol as a marine fuel is technically proven. It is a liquid at ambient conditions and does not pose major technical or safety roadblocks. There is no large-scale green methanol production yet, but some production is under development. It will be a significant challenge for us to source an adequate supply of carbon-neutral methanol within our timeline, but by strengthened collaboration with fuel manufacturers and technology partners, we want to accelerate the ramp-up of production.

Q: In your opinion, why have carbon-neutral fuels not yet been widely adopted by the industry?

A: Carbon-neutral marine fuels come at increased cost compared to conventional fuel oil, especially in the beginning when production volumes are low, but also in the medium term. At the same time, there is no carbon price associated with CO_2 emissions from international shipping, To bridge the gap between fossil fuels consumed by vessels today and greener alternatives, Maersk has recently called for a carbon tax of at least $450/t on bunker fuel [$150/t of CO_2 equivalent]. This would level the playing field and allow for the introduction of green marine fuels through creating a real market for future fuels.

Q: How do you see Maersk's role in helping solve the chicken and egg problem with current supply and demand of low-carbon fuels such as methanol and ammonia?

A: Maersk already today offers the ECO Delivery shipping product, where we sell carbon-neutral shipping to our customers. More than half of our top 200 customers have set or are in the process of setting ambitious science-based or zero-carbon targets and they need us to decarbonise their supply chains. However, these biofuels are not scalable. By introducing carbon-neutral vessels to the market and sourcing carbon-neutral fuels, we work to overcome the chicken and egg problem and kick-start the scaling of green fuels production.

Q: What do you see as the current timeline for the wider adoption of green methanol-powered shipping?

A: We will introduce the first carbon-neutral container vessel in mid-2023 and plan to operate it on biomethanol or e-methanol from day one. We see collaboration across the value chain as key to solving challenges associated with the introduction of new marine fuels, and we look forward to developing existing and new collaborations.

METHANOL vs GREEN AMMONIA

Tsutomu Yokoyama
Senior General Manager, Green Business Group, **NYK Line**

Q: Can you tell us how NYK Line is demonstrating its commitment to sustainability in the shipping sector?

A: We are organising and participating in various R&D and demonstration projects related to zero-emission shipping with external partners that are expected to take a key role in the development of the future zero-emission shipping industry. For the Demonstration Project for Commercialisation of Vessels Equipped with High-power Fuel Cells, we got financial support from New Energy and Industrial Technology Development Organisation (NEDO), which is a Japanese governmental body. We seek to accumulate our own expertise through this kind of activity to get ready to implement our zero-emission and sustainable shipping business. On the other hand, it is not practical to jump into zero-emission shipping immediately — we understand that the usage of LNG as marine fuel works to achieve lower emissions for the time being as a bridging solution. We have already started an LNG as marine fuel supply business and begun operating LNG powered vessels.

Q: What are some of the key opportunities for the maritime industry in the adoption of low-carbon fuels such as green ammonia or methanol?

A: There are various solutions such as electricity, hydrogen, ammonia, biofuel, synthetic methane. Our expectation is that some solution to be applied simultaneously depends on the size of the vessel and vessel operation profile.

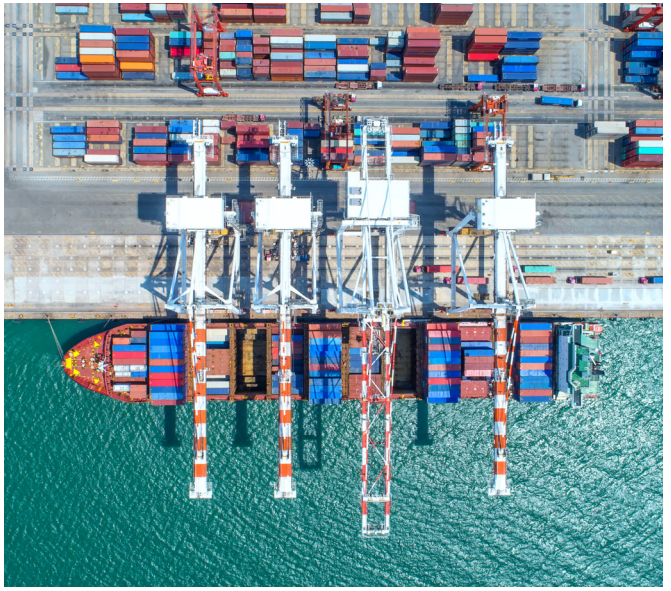
Q: What are the options for low-carbon fuels that NYK Line is considering and why?

A: It is too early to conclude which solution is to be adopted at this time. It is important to carefully monitor the development of various solution so that we can move forward in the appropriate direction in a timely manner.

Q: What do you see as the current timeline for the wider adoption of low-carbon fuels? What role will national government or IMO regulation play?

A: For LNG, we understand the chicken and egg situation has finished. Many LNG powered vessels are under construction and LNG as marine fuel supply capacity in the wider area is expanding. Considering the IMO 2050 target, the early 2030s is the time to start changing to zero-emission fuels. But in reference to continuing discussion, we have a strong impression it may happen earlier than our original assumption.

However, current relevant regulations are not sufficient to encourage the use of such zero-emission fuels, including on safety issues. Regulation change or new regulation implementation should be completed in a timely manner. We hope national governments and the IMO have close dialogue and take the initiative to accelerate such a difficult task.



METHANOL vs GREEN AMMONIA

Erik Hanell
President and CEO
Stena Bulk

Q. Can you tell us how Stena Bulk is demonstrating its commitment to sustainability in the shipping sector?

A: Our commitment is to continue to supply the world with energy and resources while reducing our environmental footprint of doing so. We are actively working to try new technology and fuels to improve efficiency and reduce emissions, and we're doing it in partnership and collaboration with others to help push the industry forward. Biofuel trials, methanol development and new ship designs are a few examples of recent initiatives, but we're also looking further ahead to make sure we take an active role in the world's transition to a more sustainable energy system.

Q. What do you consider are the key reasons why methanol should be widely adopted as a marine fuel?

A: We see methanol as a viable pathway towards carbon neutral shipping, while also delivering immediate environmental benefits in reduced SOX, NOX and particulate matter emissions, and in being biodegradable. We're seeing more and more momentum in both bio and e-methanol, strengthening the case for methanol as a long-term sustainable fuel.

Methanol also has advantages in already being widely traded and handled as well as being used as fuel in other sectors. It's technically mature and does not come with some of the challenges of other alternative fuels, such as expensive storage and infrastructure, high toxicity and very unclear cost structure. There is also a base infrastructure already in place.

Q. In your opinion, why has it not been widely adopted by the industry yet?

A: The alternative fuels landscape is scattered and shipowners are hesitant to move into new fuels that are not yet used widely, mindful of risks of limited availability, high cost and trading limitations. Changing to a new fuel is traditionally a very slow process, but we believe it can be pushed if early adopters show the technical and commercial feasibility at an early stage.

Q. How do you see sustainability attitudes in the marine fuel industry changing, especially since the onset of the Covid-19 pandemic?

A: The whole world has put more focus on sustainability during the course of the pandemic, and shipping is not an exception. Economic recovery plans supporting green development has also given the movement a strong push. In the marine fuels area, uncertainty regarding regulations and fuel pathways are holding the development back slightly, but we believe the momentum will increase dramatically over the coming years.

Q. What are some of the key opportunities for the maritime industry in the adoption of low carbon fuels?

A: Shipping is already exceptionally efficient compared to many other modes of transportation, due to the cargo volume that ships allow. Changing to low carbon or carbon neutral fuels, and improving energy efficiency with new technology, can strengthen that case further. Sustainable shipping can also play a major role in the distribution of renewable energy and resources, contributing greatly to the green transition of the world.

Q. What do you see as some of the main obstacles to the adoption of alternative low carbon fuels?

A: Cost! It has to be commercially possible to move the development on a large scale. It has to be new rules and legislation that drives this, where the global community needs to take the responsibility to drive this to make an impact.

Q. What do you see as the current timeline for the wider adoption of methanol-powered shipping? What role will IMO regulation play?

A: Compared with many other potential green technologies, methanol is a fuel that can be used today — it is technically proven. What will drive the development of blue and green methanol is what I refer to in question 6 — i.e. how will rules and regulations drive this to assure that it will be commercially possible to invest in.

Q. How do you see demand developing for methanol versus green ammonia moving forward?

A: A very good question. It seems like many are using ammonia as the most likely product for future fuel. From our side, we are of course open to looking at different solutions and we think that is the pathway we need to take today. From a technical, safety and environmental point of view, methanol seems to be the most logical solution if we are going to choose one of the two at this stage. In other words, at least for us, there are more and bigger questions around ammonia than methanol. Will that view change in the future? Good question, and even if I doubt that it will today, the unlikely has in recent years become likely at a faster pace than before. Whether this will be the case with ammonia and methanol remains to be seen. All considered, I think it to a high degree will be a political decision more than what will be in the highest demand in the future, even if in my view today I for sure see blue and green methanol as the most logical pathway ahead.

METHANOL vs GREEN AMMONIA

Ajay Singh
Managing Director, Global Energy and Executive Advisor
Mitsui O.S.K. Lines

Q: Can you tell us how MOL is demonstrating its commitment to the transition to low-carbon fuels on the journey towards decarbonising the shipping sector?

A: We have several initiatives under way in MOL to decarbonise shipping, as well as to support our clients in reducing their carbon footprints. For example, we are conducting joint evaluations for liquid hydrogen carriers and floating storage and liquefaction units with our partners; we are looking forward to introducing electrically propelled cargo vessels in Japan soon; we are growing our existing presence in the shipping of ammonia, which is a great vector for hydrogen; we are working on utilisation of wind power to reduce fuel consumption of bulk carriers; and we are designing vessels that could potentially produce green hydrogen on-board to further reduce carbon intensity. We are also preparing to leverage our group experience of shipping liquid carbon dioxide to service future CCS projects.

Q: What are some of the key opportunities for the maritime industry in the adoption of low-carbon fuels such as methanol or ammonia?

A: Ammonia and methanol are both vectors for hydrogen, and ammonia in particular holds much promise as it delivers a much lower unit cost of hydrogen transport compared with, say, liquid hydrogen. It is also already a commonly shipped commodity, which will make it easier to develop ammonia bunkering infrastructure. It can be used as a marine fuel, for which the industry needs to evolve some additional regulations to govern its use within the confines of engine rooms.

When it comes to using ammonia as a vector for hydrogen, in the end it is overall value chain economics that will determine its adoption in the future. As a shipping company, we must prepare to transport whatever the energy companies select as the main mode of hydrogen transportation, including liquid hydrogen.

Q: What do you see as some of the main obstacles to the adoption of alternative low-carbon fuels currently?

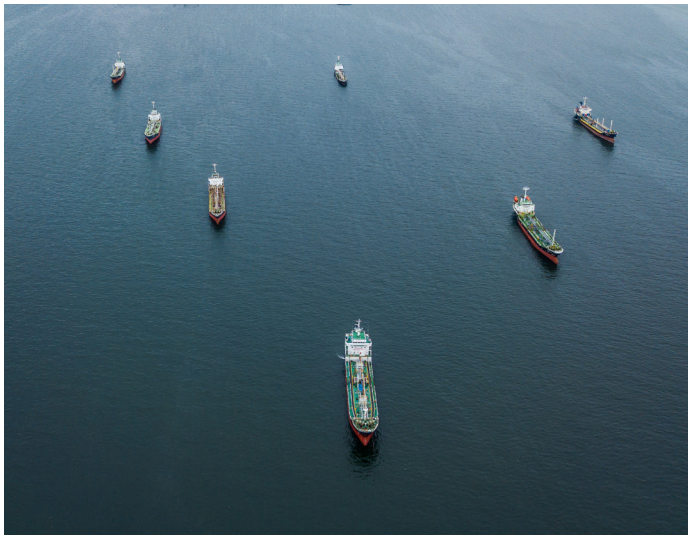
A: Lower carbon fuels will come at a higher price than the currently used fuels. There is a need to accelerate the adoption of a global framework for how these costs are to be absorbed into the global economy. Policymakers also need to direct development funding toward those decarbonisation options that have maximum potential for achieving early cost competitiveness.

Q: Given MOL's expertise in LNG, what are the main lessons that you believe may be applied to ammonia to accelerate its adoption as a low-carbon fuel?

A: We have extensive experience in carrying LNG as well as LPG, which puts us in a good position to increase our ammonia transportation business. The hallmarks of these segments of the shipping industry are safety and reliability — it will be crucial to ensure that as ammonia shipping expands, these aspects receive due attention.

Q: What role do you see LNG playing on the path towards the decarbonisation of shipping?

A: LNG has a key role to play. It is a cost-competitive, reliable and pragmatic option to reduce carbon intensity rapidly, especially as bunkering costs decline with growing scale. Deeper decarbonisation solutions such as hydrogen will take longer to mature, so even as the world pursues them, it is important to increase use of LNG both within the shipping industry as well as in the wider economy.



METHANOL vs GREEN AMMONIA

Charles Haskell
Decarbonisation Programme Manager, **Lloyd's Register**

Q: What do you see as the key challenges and opportunities for the maritime industry in the adoption of low-carbon fuels such as green ammonia and methanol?

A: We have the technologies for zero-carbon shipping, both on the vessel and fuel production side. We now need to move to scaling, commercialisation and deployment. The main challenges lie outside the technology – and focus instead on encouraging investment and building community acceptance. A big part of moving to low/zero-carbon fuels is landside rather than on board the ship – creating the infrastructure to put sufficient fuel volumes in sufficient locations.

We encourage the IMO to embrace the emerging opportunity to pursue bold market-based measures and sustainability criteria for marine fuels. We must drive supply and demand for zero-carbon energy sources while making fossil fuels less attractive.

Q: What do you see as the timelines for adoption of green ammonia and methanol as low-carbon fuels for shipping?

A: The Getting to Zero Coalition estimates that zero-carbon fuels need to make up 5pc of the international shipping fuel mix by 2030. Both methanol and ammonia can be produced in different ways. For either fuel to be zero-carbon it needs to be produced from green hydrogen.

We have over five years' experience of methanol as a shipping fuel, including our work with Stena Germanica, the first IGF code-compliant methanol-fuelled vessel, which was approved by [international classification society] Lloyd's Register. The industry is now seeing a ramp-up of orders for new dual-fuel vessels that will run on methanol. Green methanol will account for an increasing proportion of the fuel mix as production of green hydrogen is ramped up.

We expect ammonia-fuelled ships to be on the water within the next 3-5 years. Currently the bulk of ammonia production is grey ammonia, produced from fossil fuels. Green ammonia will play its part in meeting the 5pc by 2030 target as green hydrogen production is ramped up.

Q: What role do you envision Lloyd's Register playing in ensuring the safety measures around the use of ammonia and methanol as fuels?

A: Lloyd's Register's work on safety measures for zero-carbon fuels ranges from design screening and risk assessment to creation of standards and procedures, maintaining our role as trusted advisor, striving to keep our customers' businesses safe, sustainable and competitive. Specifically, Lloyd's Register has published rules for the classification of methanol ships and guidance on methanol bunkering to support the safe use of methanol as a marine fuel. We have also awarded approval in principle to multiple ammonia-fuelled vessel designs for different ship types, including an ultra-large containership, a tanker and a gas carrier.

Lloyd's Register is also part of various methanol and ammonia fuelled testbeds and pilots, including the Fastwater consortium, a project that aims to start a fast transitionary path to move shipping away from fossil fuels and reduce emissions through the use of methanol as fuel, and the Castor Initiative, a joint development project launched by MISC, Samsung Heavy Industries, Lloyd's Register and MAN Energy Solutions last year to develop an ammonia-fuelled tanker. With the addition of Yara and MPA in February, the Castor Initiative now has a complete representation from all areas of the maritime ecosystem.

The Lloyd's Register Maritime Decarbonisation Hub, a dedicated centre of excellence to accelerate the decarbonisation of world shipping, assesses the readiness of zero-carbon fuels to deliver safe and sustainable applications in the maritime sector. Through the Hub, we identify challenges to be addressed and spearhead initiatives to advance readiness and our results are openly shared with industry in order to maximise the impact and speed of transition.

Q: What is your outlook on future dual-fuel engines running on both methanol and green ammonia? What other alternative fuels are likely to play a role?

A: Engine manufacturers have demonstrated that they are able to adapt to the challenges and several dual-fuel engines are under development. For example, as part of the Castor Initiative, MAN Energy Systems has announced plans to have an ammonia-fuelled two-stroke engine in the market by 2024-25 and BeHydro received Lloyd's Register approval in principle for their medium-speed engines running on hydrogen. To stimulate further research and development clear long-term policy is required to derisk companies' investment plans.

Q: If you could communicate one message to the maritime industry to accelerate the adoption of low-carbon fuels, what would it be?

A: This is the decade of action. There is no question – decarbonisation is a monumental challenge, yet adapting to change is nothing new to shipping. We have navigated three industrial revolutions already, demonstrating resilience with each change, and now we are navigating a fourth. Collaboration across all stakeholders is required to derisk the challenges and accelerate the transition. And with this, every type of organisation has a role to play now in the commercial pilots and trials that are laying the foundations for zero-carbon shipping

METHANOL vs GREEN AMMONIA

Sotirios Mamalis
Manager, Sustainability, Fuels and Technology, **ABS**

Q: What do you see as the key challenges and opportunities for the maritime industry in the adoption of low-carbon fuels such as green ammonia and methanol?

A: There are multiple challenges for almost all future fuels that range from price, supply and infrastructure to regulation, industry acceptance and life-cycle GHG emissions.

Green ammonia is not available at present at any scale to make a meaningful contribution and the majority of available methanol is made from natural gas, so while both can offer lower tank-to-wake emissions — zero in the case of ammonia — they are some distance from large-scale commercial take-up.

Methanol has regulatory acceptance under the IMO's IGF Code and a dozen ships are in operation with another 11 on order. Ammonia will need to go through the same process, although it is likely that standards for class and flag equivalence will be available before regulation is in place.

Q: What do you see as the timelines for adoption of green ammonia and methanol as low-carbon fuels for shipping? What are the main hurdles to overcome?

A: Methanol is three to five years ahead in terms of experience-building and applicability as an alternative fuel, which means that vessel operators can use it now to begin phased emissions reduction with manageable opex and capex costs. Interest in renewable methanol from industry leaders such as Maersk in operating carbon-neutral ships within a few years has led to growth in biofuel and e-methanol production, with blue and green methanol expected to become progressively available.

The interest around ammonia has seen projects around its application — main engine availability, feasibility studies and ammonia-ready dual-fuel vessel designs — increase rapidly as owners seek to reduce emissions on a tank-to-wake basis. Technically any challenges to the use of ammonia can be overcome, although it is likely that given its much higher level of toxicity that a full regulatory process will be required by some operators, statutory bodies and local regulators.

Q: To what extent can existing safety regulations for ammonia be applied to its use as a marine fuel?

A: There are decades of experience in ammonia as cargo — just as there are for methanol and LNG — so there is a useful understanding of the handling requirements, safety precautions and training required. Of course, its use as fuel will require designs being subject to much tighter scrutiny, but these should not pose a barrier in the long term.

Q: What lessons can ammonia learn from LNG?

A: Probably that regulation drives the uptake of new fuel faster than anything else. LNG as fuel developed as a response to IMO2020 and the need for SOx and NOx reductions but its relative expense for newbuilding and conversion has meant that until recently interest has been limited. The recent take-up of LNG as fuel for large containerships and bulk carriers with IMO2030 in mind is another demonstration that the technology is proven and can be scaled up, although all fuels, LNG included, require a secure fuel supply chain as bunker infrastructure is limited at present.

Also, the importance of accounting for the well-to-wake emissions of a fuel and vessel has been made clear through the experience of using LNG and will affect all the future alternative fuels.

Q: If you could communicate one message to the maritime industry to accelerate the adoption of low-carbon fuels, what would it be?

A: The message would be leverage the knowledge learned from other sectors of the global industry and establish a global network focused on the development and deployment of technologies related to alternative fuels.

With so many fuel and technology options available and more certain to emerge in the next few years, devising a sustainable fleet-wide decarbonisation strategy that meets your company's needs is a vital — but complex — task.

ABS has been at the leading edge of this process from the beginning, investing in broadening its capabilities with specialists in sustainability, alternative fuels and propulsion. We have world-leading centres of excellence in sustainability, ship systems and digital capability making us well-placed to advise owners through the complex maze of regulation, finance and technology that makes future fleet development so challenging today.

METHANOL vs GREEN AMMONIA

Captain Saleem Alavi
President and CEO
Sea Commerce America Inc

Q: Why do you think methanol should be widely adopted as a marine fuel?

A: Shipowners must find cleaner energy pathways to comply with the International Maritime Organisation's de-carbonisation goals. These pathways need major investment for new-build vessels with a working life of 20-25 years, requiring the shipping industry to have long-term, innovative, cost-effective, future-proof and environmentally sound solutions.

Methanol has many advantages as a marine fuel including its clean-burning properties, cost economics, and simpler storage and handling compared to alternative fuels that are being proposed, such as LNG, hydrogen and ammonia.

Being a liquid fuel, similar to conventional fuels currently used by vessels, the modification required to store it is nominal, both technically and economically. The same applies to handling the fuel, whether onboard a vessel or onshore.

Methanol is a widely available and future-proof marine fuel (with near-zero carbon footprint – as bio-methanol) that can be adapted to existing vessels and engine technologies at a lower cost.

It is already an industrial feedstock, with a mature supply chain infrastructure, which would make the development of a bunker supply for shipping much easier than competing fuels.

From an environmental perspective, methanol is miscible in water, which is why there is a near-zero risk of it causing pollution or posing a threat to marine life. I cannot stress this last point enough, especially with the opening of pristine Arctic shipping routes. Accidents happen, so it is the responsibility of decision-makers to choose a fuel that is intrinsically safe for the environment and marine life.

Q: Why is methanol is not widely adopted by the industry yet?

A: It takes some pieces of the puzzle to be in place, such as regulatory framework, engine technologies and bunkering infrastructure for the take-up of alternative fuels to begin, and with that goes a need for early adopters and greater public awareness.

Q: Over the past five years, how have you seen the perception of methanol change?

A: The awareness of methanol as a marine fuel in comparison to other fuels was close to zero until 2020. This can be seen from the absence of seats for methanol as a marine fuel in bunkering conferences, seminars or webinars. Methanol did not have a seat in the 2020 IMO Symposium held in October 2019. But since then there has been a noticeable change, with industry giants like Maersk, BW, Eastern Pacific, and recently Sea Span, that are looking at the possibility of using methanol as a viable alternate fuel.

Q: If you could communicate one message to methanol producers from the maritime industry to accelerate its adoption, what would it be?

A: In the maritime industry, the shipowner is the sun and segments like ship finance, bunker suppliers, insurance, etc are the satellites. Keeping this in mind, methanol producers need to formulate a proper strategy that caters to the industry segment they want to target. They need to identify the marketing option and define their offering accordingly.

METHANOL vs GREEN AMMONIA

Kjeld Aabo
Director New Technologies
MAN Energy Solutions

Q: What is your outlook on future dual-fuel engines running on both methanol and green ammonia? What other alternative fuels are likely to play a role?

A: As technology providers, we follow the trends and requests from the market and make our priorities the design and development of our MAN B&W two-stroke engines. We have a vast number of dual-fuel engines in our portfolio and more under way. As an engine designer MAN-ES does not decide which fuels will be the future fuel(s) or the fuels used in the transient time, between now and the intake of the CO_2 free or CO_2 neutral fuels, but as the de-facto market leader in deep-sea ship propulsion it is our obligation to provide the technology and inform about the possibilities. When discussing green carbon-free fuels for oceangoing vessels of the future, where our two-stroke engine is dominating by far, the feedback from the market is centred around ammonia.

Q: What are the main differences between green ammonia and methanol that need to be taken into account when thinking about technology development for ship engines?

A: Looking specifically at NH_3 and methanol both can today be delivered as fossil produced fuels with the associated CO_2 emission in the well-to-tank process. Once green ammonia and methanol is available these can be introduced partly to our flexible dual-fuel engines until full operation with green methanol and ammonia is possible and makes a good business case. The business case would only mature if a CO_2 tax or other type of regulation makes it mandatory — or promotes — use of low-carbon green fuels. We are convinced that such regulation will come. From a technology point of view we are ready and by now 11 methanol LGIM engines are in operation and 13 more on order. So far the engines on order are for product tankers.

Q: Can you give examples of clients that are taking decisive action to show their commitment to converting to alternative fuels?

A: Maersk Line recently ordered 1+1 2200 feeder container vessels with methanol-burning LGIM engines. These have increased interest in methanol-burning engines for other shipowners and we expect that more orders for non-methanol carriers will be realised in the coming years. The ammonia engine is at the moment in the process of being developed at our office in Copenhagen. Next year it will be tested in our research centre and in 2024 we expect to have the first ammonia-burning MAN B&W engine at test bed at one of our licensees and ready to be delivered to a yard. Here we are seeing a massive interest from not only our first-line clients, but the entire shipping industry as our technology can unlock a renewable hydrogen-based decarbonisation of sea transport.

Q: What do you count as the biggest challenge to shift to alternative marine fuels that meet or beat emission regulation?

A: First of all the green fuels talked about are not yet available or are at least so expensive that they cannot give a positive business case compared with use of fossil fuels. So a CO_2 tax and other kind of incentives have to be established. But even before this, an overall and international “standard” must be provided by the IMO, to show the total well-to-wake pollution for all the different fuels. This is seen as the only way to select the right fuel for marine vessels, considering total global CO_2 and GHG emissions.

METHANOL

Gregory Dolan
CEO
Methanol Institute

Q. What do you consider the key reasons why methanol should be widely adopted as a marine fuel?

A: Methanol ticks so many boxes for shipowners in terms of ease of operations, compliance, and sustainability.

Methanol is a very clean fuel in operation with consistent quality, it is miscible in water with almost no risk to marine life and with minimal economic impact in the event of a spill or salvage operation. Safe handling procedures are straightforward and well known — its use as a fuel requires only minor structural modifications to bunkering and ship systems.

Methanol is IMO 2020 compliant with no SOx emissions, very low particulate matter (PM)l and NOx emissions that can be easily abated by use of a water emulsion, removing the need for costly exhaust gas treatment.

Methanol has regulatory approval from the IMO under the IGF Code, meaning it can be adopted with confidence by shipowners who want to get started on cleaner operations, using a fuel that can begin to lower their emissions without delay.

Conventional methanol produced from the steam reformation of natural gas offers 'in-service' greenhouse gas (GHG) emissions reductions of 10-15pc compared with fuel oil, supporting the drive towards IMO's 2030 carbon reduction targets. As more methanol from carbon capture, electrolysis and biogenic sources becomes available — e-methanol and biomethanol — we will see net carbon-neutral methanol entering the market, providing a pathway beyond IMO 2030.

Q. Who are the key stakeholders leading the charge in the adoption of methanol as a marine fuel?

A: The first movers were the operators carrying methanol as cargo such as Methanex (through Waterfront Shipping) and latterly Proman/Stena Bulk. Moving methanol from the cargo hold to the ship's engines provided a base of knowledge and experience about the safety procedures and practicalities of using methanol as a fuel.

Today, 11 methanol-powered ships are already in operation and another 12 are on order, with more selected for retrofits and newbuilds. Methanol has been the primary fuel for the Stena Germanica, one of the world's largest Ropax carriers, for over five years since it was retrofitted in 2016. Methanol is also in use on pilot boats and ferries and as a power source for fuel cells on cruiseships. Together, these vessels account for tens of thousands of trouble-free hours of combined operating experience.

Q. Why has methanol not been widely adopted by the industry yet?

A: The industry has been in 'wait-and-see' mode for a couple of years while the IMO regulatory process solidified around reductions in carbon emissions and intensity. Now that the shipping industry is starting to focus on operating in a low-carbon world, interest in methanol is gaining steam. And, again, the first methanol-fuelled vessel has only been on the water for five years.

It remains true though that vessel operators will need to contract for their fuel supply chain — as they will with all other alternative fuels — so it is important to work with suppliers. Our members are having those conversations now with ship owners and operators.

Also critical will be increased price transparency so that owners can better budget for the fuel component, a major element of total running costs, which the methanol industry is working towards. Demand is picking up for price assessments for all alternative fuels, on an energy equivalent basis compared with conventional bunkers, in major ports globally.

Q. How do you see sustainability attitudes in the marine fuel industry changing?

A: We definitely see attitudes changing but this is a function of IMO regulation, as well as the impact of unilateral EU — and possibly US — measures too. The IMO Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII) are set to enter force in less than two years, and the first IMO carbon emissions reduction deadline is less than a decade away.

The EU is determined to bring shipping into its emissions trading system, which will put a price on carbon in the sector for the first time, so the stakes are high.

More broadly, there is growing support for fuels and technologies to be assessed on a lifecycle emissions, or well-to-wake basis, going forward, which would support the use of methanol as a low-carbon and net carbon-neutral fuel. There is also a growing acceptance for pivoting to CO_2 equivalence as a means of assessing fuels specifically, to compare GHG emissions on the basis of their global warming potential.

Q. What do you see as the current timeline for the wider adoption of methanol-powered shipping? What role will IMO regulation play?

A: IMO regulation is driving the change, and interest in methanol is growing very fast as a result, not least because methanol is one of only two available fuel choices for reducing emissions now.

The decision by Maersk to build a ship using carbon-neutral methanol by 2023 sent a strong signal, and since then its peer liner company MSC has joined the Methanol Institute, together with Oldendorff Carriers, one of the largest operators of dry bulk vessels, which illustrates the breadth of interest among vessel operators.

GREEN AMMONIA

Trevor Brown
Executive Director
Ammonia Energy Association

Q. What do you consider the key reasons why green ammonia should be widely adopted as a marine fuel?

A: Ammonia is the last choice for maritime decarbonisation: first the sector needs to use energy efficiency — hull design, wind-assist — then we use electricity — cold-ironing in port, ie, plug-in, or batteries if viable but those are probably limited to very short-haul — and only then do we need a carbon-free molecule. But while this "last choice" segment represents a relatively small number of vessels — containerships, tankers, bunkers, etc — it consumes the majority of maritime fuel, so we are talking about big volumes here.

For molecules, if you can use hydrogen, you should. But if your application requires storage or transportation — ie, non-local supply chain — then hydrogen probably isn't the most economical molecule. That's when you turn to ammonia: it is more energy dense than hydrogen — literally 50pc more hydrogen than liquid hydrogen by volume, which is the measure that matters in shipping — and it does not contain carbon (which limits the attraction of biofuels or carbon-neutral versions of methanol or LNG). All fuels are hydrogen-based: with ammonia, you're attaching hydrogen to nitrogen, which is very easy to capture — 780,000ppm — and with hydrocarbons you're attaching hydrogen to carbon, which is very hard to capture — 450ppm. This results in an economic advantage for ammonia: it is cheaper to make — per unit of delivered energy — than synthetic hydrocarbons.

If we, as a society, are going to invest in atmospheric CO_2 capture, it seems like we might want to sequester that carbon, not just burn it the next day and release it all straight back into the atmosphere. And if we're not going to invest in atmospheric CO_2, then there is no scalable net zero future for hydrocarbons, and investments in this — vessels, infrastructure — risk becoming stranded assets. In reality, of course, what we're entering is an era of fuel optionality, where all these fuels — ammonia, hydrogen, methanol, biofuels, eLNG, LPG – exist in a broad portfolio of technology options.

Q. In your opinion, why has ammonia not been widely adopted as a marine fuel yet?

A: No truly sustainable solutions, beyond energy efficiency, have been widely adopted by the industry because there is no policy or market mechanism in place to address climate change or, put another way, to internalise the costs of GHG [greenhouse gas] emissions. So, we have incremental measures, but these can't move the GHG dial more than a few percentage points here or there. Until the IMO or other actors put in place support for a decarbonization transition, no future fuel will become mainstream and we'll keep chugging out emissions from heavy fuel oil, marine gasoil and LNG.

But things are changing very quickly and, in the next two, three, four years, we'll see a series of massive milestones: commercially available ammonia engines and fuel cells — and emissions verification for those systems; widespread — or local, right-place-right-amount — availability of low-carbon ammonia; certification of ammonia as a low-carbon commodity; operational safety and HAZID [Hazard Identification] analysis accompanied by mitigation designs and technologies; and regulatory development to enable early pilots and demonstrations to inform industry-wide codes and standards. These items will all be done by 2025 or soon after — we'll be able to go and "kick the tyres" of the demonstration vessels, and smell the clean air coming out the stack, and talk to the crew about how they feel about ammonia onboard. The next challenge, that is already being tackled, will be to scale up post-2025 and build an order book for engine manufacturers and shipyards, to start building the future fleet and retrofitting the existing one.

Q. How do you see sustainability attitudes in the marine fuel industry changing, especially towards ammonia's use a fuel?

A: Broadly speaking, the industry must be feeling a bit dazed and confused because learning about future fuels has been like drinking from a firehose for three years. There are so many untested options, and very few people were having this conversation before April 2018 — which might have been yesterday. Some think LNG is a long-term solution, presumably because they're sceptical that the IMO will ever enforce the GHG targets that it has proposed — with which LNG is not consistent. Some think "bridge" fuels are essential, but others think that's a cynical strategy to extend the fossil age by investing in infrastructure that would be "too big to fail"… Some think "ammonia-ready" engines and infrastructure are the answer, but others are happy to go straight to ordering an ammonia engine/vessel — and some have even invested in the green ammonia supply chain as well.

Q. What do you see as the timeline for the wider adoption of ammonia powered shipping? What are the main hurdles to overcome?

A: Ammonia demonstrations and engine availability will happen around 2024-25. Then we have five years to actually start deploying the first phase of ammonia vessels, most likely the ammonia tankers and similar: ammonia vessels should consume 2pc or more of global fuel mix by 2030 — that's almost halfway to the Global Maritime Forum/Cop 26 Climate Champions target of 5pc zero-carbon fuel by 2030. This might sound like a big number — 2pc fuel mix would mean annual demand for 12mn t of fuel ammonia, more or less — but if you look at how short the time is between 2030 and 2050, 5pc looks like a pretty small target if we aim to reach 50pc or more just 20 years later.

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