The role of new fuels in reducing marine industry GHG emissions

This paper discusses the potential impact of the International Maritime Organization's (IMO) ambition to reduce greenhouse gas (GHG) emissions from international shipping and the likely role of lower-emission fuels (LEF) in achieving those targets.

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Foreword

The International Maritime Organization (IMO) has set revised ambitions to reach net-zero greenhouse gas (GHG) emissions from international shipping by 2050. It has also set two interim goals – the reduction of annual GHG emissions by 20% (striving for 30%) by 2030 and 70% (striving for 80%) by 2040, compared with 2008.[1] Discussions are already underway about the best route for vessel operators to meet the IMO's GHG emissions reduction goals and tests of new fuel formulations have started to reveal promising results. However, the findings to date indicate that there won't be one clear winner – vessel operators are looking at a multi-fuel future.

This paper analyses the possible fuel choices needed to turn the IMO's ambitions into reality and includes insights from leading stakeholders from across the maritime sector. I want to thank Ash Jenkins, Director, Whitaker Tankers, Anurag Wadhwa, Marine Senior Advisor, SeaRiver Maritime, Alexander Feindt, Global Business Development Manager, MAN ES, and Tim Wilson, Principal Marine Consultant Engineer, FOBAS, Lloyd's Register for their invaluable contributions.

The marine industry came together and delivered a cohesive, coordinated response to the very low sulphur fuel regulations set out in IMO 2020 that was both effective and efficient. Now that the 0.50% sulphur debate is settled, the IMO has new ambitions – to reduce total annual GHG emissions from international shipping by at least 20% by 2030 compared with 2008, pursuing efforts towards net-zero GHG emissions by 2050.[1]

Making these objectives a reality will require extensive modifications to the marine industry's fuel and engine technologies. The scale of the challenge has prompted vessel operators to ask questions about the best ways to achieve the IMO's ambitions and what fuel options will be available to take the industry from 2030 to 2050. What is clear is that meeting the long-term GHG emission reduction ambitions will require significant changes to vessel technology and fuels. As with IMO 2020, collaboration will be the key to success.

Formulating the answer

It is unlikely that a single fuel will answer the IMO's ambitions – a number of fuel options will likely be needed. Vessel operators will need to assess the alternatives based on individual needs and operational profiles. "The choice of a certain type of fuel in a certain region will largely be driven by costs, which could disincentivise certain fuel or technology choices," explained Alexander Feindt, Global Business Development Manager, MAN ES. "We strive to offer solutions for a wide range of marine fuels; we are agnostic."

Although there are a number of future fuel formulations under consideration, there are two potential solutions available today: biofuels and liquefied natural gas (LNG). Both have advantages and drawbacks. The advantage of biofuels is that they are a 'drop in' alternative requiring minimal changes to bunkering and operational procedures. There is also a marine fuel specification for the bio component, fatty acid methyl esters (FAME), in marine gas oil grades DFA and DFB.[2]

However, cost and availability are a challenge as regulations for on-road diesel drive competition for the same molecules. There are also concerns that crop-based FAME can impact food production or the availability of arable land. The good news is that the marine industry can leverage bio components that are not suitable for on-road applications, while FAME components comprised of used cooking oil methyl ester (UCOME) don't compete for agricultural resources.[3]

> **"The Netherlands gave an incentive to suppliers to provide FAME to the marine industry, which operators immediately picked up on," said Tim Wilson, Principal Marine Consultant Engineer, FOBAS, Lloyd's Register. "We started to see people requesting a 20% or 30% FAME component, which resulted in a whole series of trials. This shows the role the stakeholders have to play. I've been personally involved in about 10 sea trials."**

Well-to-Wake calculations

LNG is the most used alternative to conventional marine fuel today. It is available in major ports, with fuel handling and safety guidelines in place. A fuel spec (ISO 23306) has been published. In addition, all major engine manufacturers supply LNG engines for various applications and many ship owners have already ordered LNG or LNG-ready vessels. However, published literature suggests that the Well-to-Wake GHG emissions of LNG are often viewed as only marginally lower than heavy fuel oil (HFO).[4] As a result, some marine stakeholders consider LNG to be a mid-term solution.

A journey into the future

Hydrogen has been garnering headlines as a potential marine fuel and there are good reasons for this. Hydrogen can be produced from many sources, including natural gas and renewable energy. It can then be used in internal combustion engines and fuel cells. Both MAN ES and Wärtsilä are developing hydrogen engines.[5] On the flipside, it has a low volumetric density as a liquid at -253°C. On the same energy basis, it requires five times more space than diesel, resulting in a loss of cargo space. Liquefied hydrogen also boils off faster than LNG and therefore many in the industry currently view long-term storage as impractical.

Methanol has also been gaining a lot of interest lately, in part because it is easy to handle and store; it is a liquid at ambient temperature and pressure. It's also proven – the Stena Germanica ferry has run on methanol for five years (around 10,000 running hours) with few issues.[6] It is, however, toxic and has a low flash point, while its low energy density means that tank sizes need to be 2-3 times that of diesel for equivalent journeys.

The third fuel under consideration is ammonia. It's attracting interest because it contains no carbon, so there are no carbon emissions during combustion, while its NOx emissions are comparable to diesel.[7] In addition, it is traded globally as a fertiliser/chemical feed – there are around 200 ships specifically designed for carrying ammonia as cargo.[8] Its disadvantages are, however, significant. It is toxic, corrosive and has a low Cetane number and heating value. It is stored as a liquid at -33°C, or at an ambient temperature at ~8 bar pressure, and requires tanks 2-3 times larger than those for diesel. Currently, there are no fuel standards or safety codes and no dedicated ammonia bunkering infrastructure.

> **"Methanol, ammonia and hydrogen are all considered as new fuels," said Anurag Wadhwa, Marine Senior Advisor, SeaRiver Maritime. "Potential supply chain disruptions are out there, which we have to manage, and then there are issues with finding the right crews with the right training."**

Another potential source of propulsion are hydrogen fuel cells due to their high efficiency, quiet operation and zero GHG emissions. But raw materials are expensive and it's not a proven technology for maritime use; just a few demonstration projects have been carried out over the past decades.[9]

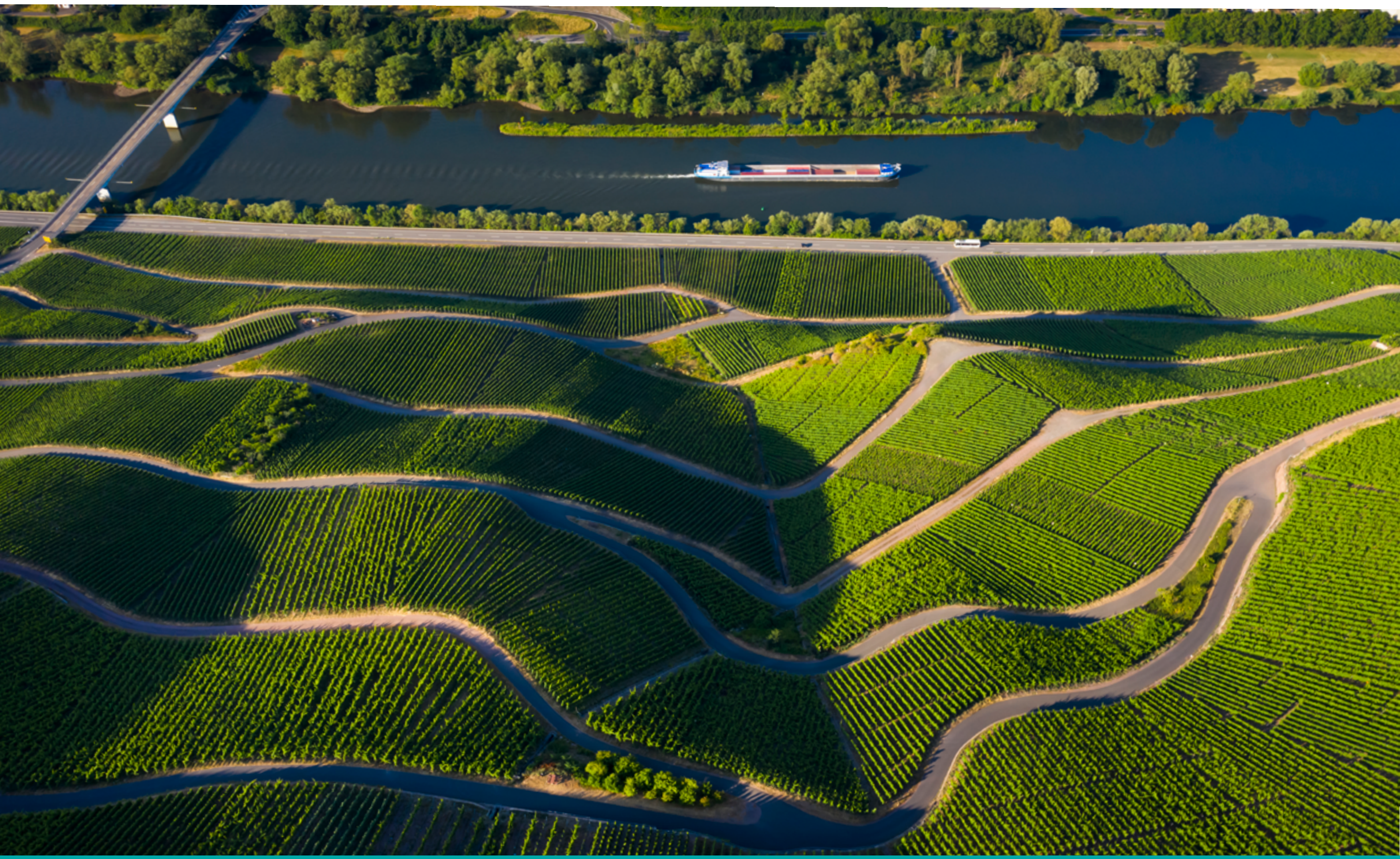
Green for go?

"We want the transition to happen as smoothly and as quickly as possible for all these alternative fuels, but safety must be our first consideration and there are other factors to consider, too," said Ken Kar, Engineering Associate, ExxonMobil.

What is clear, however, is that it's not going to be easy to switch 300 million tons of conventional fuel over to new, lower GHG emission alternatives. To meet the IMO's bold ambitions, the marine industry needs to work closely with suppliers to ensure the new fuels and propulsion technologies vessel operators want are available in time, where and when required.

"The biggest challenge is getting all the different options market-ready as soon as possible," explained Jenkins. "And ship owners and operators need to be engaging with regulatory authorities. We are essential to the world economy, but we are a little bit of an invisible industry. I think we need to be a bit more proactive."

A successful transition will require multiple solutions, collaboration and market-based approaches. Crucially, the maritime industry should already be considering how existing and new build ships will be retrofitted and designed for future fuel operations. Tomorrow's fuel choices are already having an impact on today's operations.



1. https://www.imo.org/en/MediaCentre/PressBriefings/pages/Revised-GHG-reduction-strategy-for-global-shipping-adopted-.aspx
2. ISO 8217:2017
3. Second generation biofuels are defined as those produced from UCOMEs (used cooking oil methyl ester), non-edible crops, crop residues or biologically generated gas and therefore do not take away from the total food or fresh water supply.
4. Environ. Sci. Technol. 2021, 55, 7561-7570 by Tan E. C. D. et al.
5. Hydrogen-powered combustion engines for the maritime sector (man-es.com) Commercially operated Wärtsilä engine runs on 25 vol% hydrogen blend, a world first (wartsila.com)
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