INSIGHT BRIEFING SERIES

Engines and onboard systems

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The Getting to Zero Coalition is committed to accelerating shipping decarbonization by getting commercially viable deep sea zero emission vessels powered by zero emission fuels into operation by 2030 to put shipping on a path for full decarbonization by 2050. To unpack the different fuels and technologies options that could support the transition to zero emission fuels, the workstream on Fuels & Technologies has hosted a series of webinars, gathering perspectives from experts across the maritime value chain - shipowners, operators, charterers, financial institutions, classification societies, and NGOs. The insight briefing paper series aims to reach a broader audience and build a common understanding of the fuels, engines, and storage technologies that will enable the decarbonization transition.

The Insight Brief is based on analysis by Global Maritime Forum for the Getting to Zero Coalition, a partnership between the Global Maritime Forum and the World Economic Forum, made possible with funding from Mission Possible Partnership.

Date of the webinar: August 2020

Watch the webinar here.

Panelists:

- Dorthe Marie Sveistrup Jacobsen, Head of Department Engine Subsystems and Emission Control, MAN Energy Solutions
- Matteo Nathalie, Head Business Intelligence, Wärtsilä
- Odin Kwon, Executive Vice President and Chief Technical Officer, Daewoo Shipbuilding and Marine Engineering
- Christian Oldendorff, Founder, Amplifier labs
- Gerry Docherty, Director Fleet Management, Ardmore shipping

Moderator: Randall Krantz, Senior Project Advisor on Shipping Decarbonization, Global Maritime Forum/Getting to Zero Coalition

Executive Summary

Synopsis: Future-ready zero emission vessels require the right engine and propulsion technologies to be developed and deployed through multi-fuel propulsion systems or planned retrofitting. Technology availability and economics dictate that commercially viable propulsion technologies will continue to favour internal combustion engines (ICE) over the coming decades for deep-sea shipping. In the longer term, alternative technologies such as fuel cells and other non-ICE power options would need to be considered.

Key takeaways:

> Dual fuels engines, optionality for onboard fuel storage, and retrofit readiness are three factors that will allow support for the transition pathway

> As there is no single future fuel; flexibility in technologies, risks assessment, training, and solutions deployment are key in creating a plausible range of options

> Booking the first orders, supply / demand collaboration, and key drivers will accelerate the commercialization and deployment of next generation engines

Detailed Summary

1. Engines and onboard systems

a. Timeline perspective

When exploring new engines and combustion technologies, “The focus should be on the system as a whole” said Matteo Nathalie, Head Business Intelligence at **Wärtsilä**. Fuel flexibility is a matter of engine and tanks; it is about combustion as well as storage of fuels. If the engine is built with modular design, it can be retrofitted to accommodate other fuels. Tanks and auxiliary systems for a second fuel can be added at a future stage, provided that the vessel is designed to accommodate them with available space and appropriate structural reinforcements.

As presented by Dorthe Jacobsen, Head of Department of Engine Subsystems and Emission Control at **MAN Energy Solutions**, developing a new engine can take up to 10 years from the stage of research and development to successful implementation. Regulatory approval can make this process even longer. Between changes in regulation, development, and deployment of technologies, even simple changes in emission reduction technologies can take five years. Taking as example, the implementation of nitrogen oxide tier III regulation. It took MAN Energy Solutions 5 years between bed testing and the launch of the dual fuel engine in 2016 to meet those regulations. Today, some dual fuel engines are already in operation, with injection systems capable of handling multiple fuels.

b. Two stroke dual- and multi-fuel engines

On the pathway to decarbonization, in order to mitigate business risks associated with fuel-related uncertainties, it is fundamental to invest in fuel flexible solutions. In the future, two stroke and dual fuel engines can respond to the needs of new design and retrofitting [exhibit 1]. For example, fully electronically controlled engines can be rebuilt to accommodate other fuels such as LNG and methanol.

The most flexible and agnostic solution remains the dual fuel engine running on heavy fuel oil (HFO) and an alternative fuel. Dual fuel engines enable the Otto cycle and the Diesel cycle to burn both liquid and gaseous fuels. With minor retrofits, dual fuel engines can be adapted to burn a variety of fuels in a smooth and uninterrupted way, much like LNG and LPG can share the same engine. The other alternative fuel can be adapted to run on methanol or ammonia. However, dual fuel engines won’t be a panacea, as a methanol/ ammonia engine won’t be possible, for example. “To move forward, the most important for a ship owner will be the availability and infrastructure allowing the vessels to run on dual fuel engines,” said Gerry Docherty, Director Fleet Management at **Ardmore Shipping**.

Fuel types	MC	ME-B	ME-C	ME-GI	ME-GA*	ME-GIE	ME-LGIM	ME-LGIP
0.0 - 0.5% S VLSFO	Design	Design	Design	Design	Design	Design	Design	Design
High-S HSHFO	Design	Design	Design	Design	Design	Design	Design	Design
LNG	–	–	Retrofit***	Design	Design	Retrofit***	Retrofit***	Retrofit***
LEG (Ethane)	–	–	Retrofit***	Retrofit***	–	Design	Retrofit***	Retrofit***
Methanol/Ethanol	–	–	Retrofit**	Retrofit**	–	Retrofit**	Design	Retrofit**
LPG	–	–	Retrofit**	Retrofit**	–	Retrofit**	Retrofit**	Design
Biofuels	Design	Design	Design	Design	Design	Design	Design	Design
Ammonia ****	–	–	(Retrofit**)	(Retrofit**)	–	(Retrofit**)	(Retrofit**)	(Retrofit**)

* Otto-cycle gas engine
** Only one second fuel per retrofit
*** Both LNG and LEG for same engine possible
**** Ammonia burning engine development started

Exhibit 1: *MAN two-stroke engines*

Source: *Which engines can burn which fuels? (2021)*

c. Technical challenges

During the webinar, Odin Kwon the Executive Vice President and Chief Technical Officer of Daewoo Shipbuilding and Marine Engineering has shared some insights about the challenges that a fuel as ammonia could face. Indeed, such challenges are worth considering and addressing for each different fuel. To identify possible deviations, review the effectiveness of prevention, and increase safety operation, the company has run a workshop on risk management.

While choosing to run a vessel on another fuel, onboard systems, bunkering, and storage must be considered. This is true whether vessels are new or retrofitted. A change in facilities for embarking and storing new fuel must be on the agenda while density and temperature requirement plays a major role on tank size and specifications. Tank size will also influence the capacity of freight that can be carried. Fuel tanks are the most difficult component to change during a retrofit process for a dual fuel engine. As energy density in fuels differs, tank size must be considered well in advance [exhibit 2]. For example, ammonia requires more than four times the volume required for oil fuels and requires a pressurised tank. LNG or LPG tanks, which are also pressurised, can be easily adapted for ammonia.

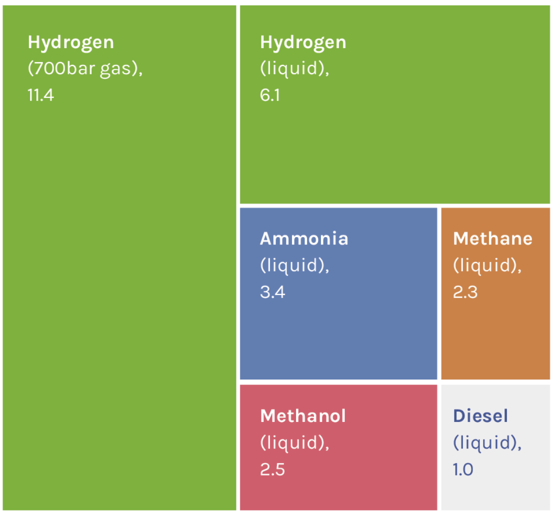

Exhibit 2: *Relative fuel storage volume for various shipping fuels (storage volume including tank relative to diesel)*

Source: Ricardo & Environmental Defense Fund, *2021, p.18* [1]

There is also an inherent risk which is related to the specificity of each fuel due to the level of toxicity, inflammability and corrosivity.

1 Ricardo & Environmental Defense Fund. (2021) South Africa: fueling the future of shipping.

2. Looking forward on the transition pathway

a. *The power of flexibility*

There are currently many options available that can be considered as fuels of the future. Their employability will, however, depend on different factors such as geography, availability of fuel stocks, and global and national regulations. Choice of scalable zero emission fuels will impact both vessel design and shipyard infrastructure, and requires an increasing need for action despite uncertainty. For these reasons, adaptability from engine manufacturers, shipyards, and fuels providers will allow actors in the maritime value chain to remain flexible in their decision-making. "Investing in fuel flexibility and dual-fuel combustion engines will help mitigate compliance and business risks" said Matteo Nathalie.

b. *Global and local training*

As widespread and systemic change is needed to speed up the maritime industry's transition to a zero-carbon future, the International Transport Workers' Federation (ITF)[2] explains on a position paper how seafarers will lead the just transition needed for a sustainable shipping future. Gerry Docherty outlined the importance to consider the diversity of markets as well as technical and cultural differences related. Indeed, during the design and construction phase of a vessel training requirement would need to be taken into account by the vessel designer, engine manufacturer and shipyards. In addition, differences in flag states will create multiple mechanisms for handling machinery onboard and ashore. This is why it is crucial to actively improve and build capacity and know-how. Workers must be brought along through the innovation phases to deliver the fuels and services and address the issues related to their own roles.

3. Building the ship of the future

a. *Containerization*

Christian Oldendorff the Founder of Amplifier Labs introduced the concept of containerization - the use of modular designs for self-contained engines, tanks, and auxiliary systems that can allow for the rapid switching or upgrading of required technologies. Used as a modular electric engine running on different types of energy, the fuel tank can be containerized for added flexibility.

Containerization is considered a disruption due to the substantial change of engine set-up. Containerized energy solutions can adapt to low cost fuels, allow for retrofitting, and keep capital costs for tanks down while increasing bunkering efficiency. Supplying fuels this way will reduce the need for onboard maintenance and associated operational costs. Maintenance could be done ashore as containers could be taken on and off the ships. While fuel selection will depend on the routes and ports, containerization can contribute to a new pathway for energy suppliers and opens a realm of possibilities for power companies.

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2 ITF. (2021). How seafarers will lead the just transition needed for an equitable future.

b. *Other technologies*

Gerry Docherty mentioned that wind technologies could be part of the transition pathway. In this case, wind power could serve as primary propulsion offering a completely different solution which would imply reconsidering the vessel design. Different solutions at different stages of maturity are already on the market and can be adapted to retrofit vessels. Reaching medium and large scale commercialization, TOWT is a modern Smart Sailing Cargo Ship with a carrying capacity of 1,000 TEU.

The **Windship Technology** is scalable and can be installed on vessels over 30,000 tonnes. It is an auxiliary power supply and each rig is a three vertical wing set 35 metres high. Eco Marine Power (EMP) has announced that sail-assisted propulsion and solar powered devices for ships are ready for demonstration and testing in Japan. The **Wing Sail Mobility (WISAMO)** project is an automated, telescopic, inflatable wing sail system that can be fitted on both merchant ships and pleasure crafts.

4. Enablers

It was noted that needs and interests differ along the value chain, so flexibility in engines and installations offer a broader range of options. From a timeframe perspective, technology could foster proactivity for first movers. Panellists discussed a range of enablers for the commercialization and deployment on next generation engines, onboard and storage systems:

- Collaboration is key as collective action allows stakeholders to amplify their voices and explain their needs to the value chain, enabling the acceleration of pilot and demonstration projects for new engines and technologies.
- External drivers for change will accelerate the implementation of new technologies, develop more business cases, and push for a legislative framework. The Call to Action[3] made by the Getting to Zero Coalition is one example of an accelerator that made headlines with over 200 signatories calling for full industry decarbonization by 2050.
- Public dialogue can improve the overall development. Indeed, in implementation phases, there is a mix of regulation, technology development, and public pressure that will push investment. While raising public awareness is a challenge, the message could find an echo as civil society plays a central role in the supply chain system.

Conclusion

In this webinar we were reminded that two-stroke engines are and will be available to burn a range of fuels while the onboard storage system must also be considered From the perspective of shipyard and ship owners the need for flexibility was highlighted as a key enabler on the transition pathway for retrofitting and new built vessels. This

3 **Getting to Zero Coalition. (2021). Call to Action for Shipping Decarbonization.**

convergence demonstrates a momentum for the industry to take action and translate into impact such as commercialization and deployment. The panel concluded with a call for coordination to include all the stakeholders of the shipping value chain to accelerate the transition.