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**On the Way towards Decarbonization – Green Fuels,
Hybridization and Digitalization in Large Engine Applications**

Sustainable fuels roadmap

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The shipping industry are making big efforts in meeting the carbon emission reduction targets, that is needed for a sustainable future environment. One important aspect is, -of course-, to utilize new and alternative fuels. Today we can see that the shipping is dominated by heavy fuel and diesel oil together with an increasing share of LNG. LNG or methane is the fuel that has the lowest CO₂ emissions of the fossil-based fuels and it is hence being considered as a good alternative for many operators, and it has also shown its importance in lowering the local emissions like NO_x, SO_x and particulate emissions.

When Wärtsilä is looking at the future fuel roadmap, we can see that the alternatives are many and the timeline of the new fuels' introduction and reduction of the fossil fuels are very unsure. This means that flexibility has risen up to be the main parameter for the future fuel roadmap. By being flexible, the engine and the vessel can be optimized to be both economically profitable already today and also in the future, when the availability, cost and legislation will change the landscape.

The most straightforward route towards sustainability is to introduce bio- and synthetic fuels that can be added to the fossil fuels of today. These can be made both as liquids like biodiesel or gases like biomethane and they can easily utilize the infrastructure and the existing equipment. These will all reduce the CO₂ footprint by calculation as the carbon dioxide will return into the nature to be reused.

This will however not reduce the CO₂ emissions from the engine and vessel itself. So to reduce CO₂ emissions from the stack, we need to use a fuel that is not containing carbon. Wärtsilä is therefore developing the engines and systems to be able to utilize both ammonia and hydrogen as fuel. The development is done with different routes. One route is to utilize the engines and vessels of today and blend the ammonia/hydrogen ratio with the existing fuel and then gradually increase the zero carbon fuel according to fuel availability, legislation, fuel price, and technology maturity. Another route is to develop pure ammonia/hydrogen optimized engines. For the retrofit market, the first option is to prefer as the operation is already ongoing and the infrastructure is in place. For new vessels and engines both routes can be interesting.

The engine is by nature very flexible and by utilizing advanced designs and controls the internal combustion engine will be an optimal solution both for today's vessels and also for the shipping in the future.