Navigating towards Low and Potential Zero Carbon Marine Fuels

by Julia Hansson

INSIDE OUT

The International Maritime Organization (IMO) aims to reduce the total annual greenhouse gas (GHG) emissions from international shipping by at least 50% by 2050 compared to 2008 and to phase them out as soon as possible. Decarbonized shipping represents a considerable challenge since the GHG emissions are estimated to increase by 2050 in most scenarios. To drastically reduce shipping related GHG emissions, the implementation of energy efficiency measures needs to be supplemented by the introduction of low and potential zero carbon marine fuels.

There are several possible low and potential zero carbon marine fuels including, for example, liquefied biogas (LBG), hydrotreated vegetable oil (a biodiesel), other biomass-based oils, methanol, ethanol, synthetic diesel, lignin-based fuels, different kinds of electrofuels (i.e., fuels produced from electricity, water and carbon dioxide (CO_2), or nitrogen also called power-to-X) such as hydrogen, ammonia, and electricity. The fuels need to be produced from renewable energy sources to provide low or zero GHG emissions.

On the other hand, in the current conditions, liquefied natural gas and methanol produced from fossil energy sources do not seem to deliver considerably lower GHG emissions than conventional marine fuels, if well-to-wake GHG emissions are considered from a life cycle perspective. These are, therefore, not considered plausible fuels in the long-term. However, there is the possibility of combining fuel use or electricity production with carbon capture and storage (CCS) in order to reduce CO_2 emissions. There is also the possibility to use wind power for propulsion, which represents an interesting option likely to be combined with other fuel options. These technology options are being explored for marine applications.

There are a range of different factors that influence the prerequisites for different fuel options such as supply potential, technical maturity, cost, environmental impact, security, and availability (Table 1). Some fuels are also more suitable for certain shipping segments. Which, then, are the key factors that influence the prerequisites for different marine fuel options?

The key aspects for marine biofuels are linked to the supply potential and the cost. Is there enough sustainably produced biomass for the shipping sector when considering also the potential demand from both transport and other sectors? A large-scale introduction of marine biofuels would require significantly higher overall global production volumes, but low blending makes it possible to increase the use today.

The potential for electrofuels in shipping mainly depends on the expansion and cost of renewable electricity and the cost development of electrolyzers, but also on the development of CCS technologies. Some electrofuels are possible to blend with existing marine fuels.

Fuel option	Technical maturity	Use in ICE and FC?	Cost: Fuel cost/Capital cost	Production potential	Safety	Possible sailing distance
Methanol	Medium	Yes	Medium/ Medium	Medium	Low risks	Medium
Biodiesel	High	ICE only	Medium/Low	Medium	Low risks	Long
LBG	Medium	Yes	Medium/ Medium	Medium	Low risks	Medium
Hydrogen	Low	Yes	High/ Medium	High	Risks	Short
Ammonia	Low	Likely	High/ Medium	High	Risks	Medium
Batteries	Medium	n.a.	Low/High	Medium	Low risks	Short

Table 1: Prerequisites for different low and potential zero carbon marine fuels. ICE: internal combustion engine. FC: fuel cells.

Battery electric propulsion represents a very efficient way to use energy on board ships and there is a range of ships with this solution in operation, or soon will be. This option is primarily of interest for smaller vessels and the main challenges include cost, weight, sustainability, and availability of batteries.

The key aspects for hydrogen for shipping is related to the issue of storing large amounts of cryogenic hydrogen on board ships and the cost development of electrolyzers and renewable electricity. Also, for ammonia the expansion and cost of renewable electricity are important, but safety is a key concern to consider. For both hydrogen and ammonia, the technological maturity is lower than for biofuels and electric solutions, and continued development for marine applications is required. Ammonia fueled fuel cells and internal combustion engines have somewhat lower technology readiness levels than corresponding hydrogen solutions.

A mix of different alternative marine fuels and propulsion technologies are needed to decarbonize shipping. Energy system modelling studies indicate that the development in other sectors clearly influences the cost-effective fuel choices in the shipping sector. Methanol (or other biofuels), hydrogen, and/or ammonia are found to be the most interesting options for shipping in many studies. The role of biofuels for decarbonizing shipping seems particularly important, for example, in the Nordic region.

Policy initiatives are needed to promote the introduction of renewable marine fuels. On a global and regional level, the most interesting policies include CO_2 tax or levy on marine fuels, cap and trade systems (setting an overall cap on GHG emissions for maritime transport or larger system), so called goal based measures (e.g., mandatory efficiency limit for ships), quota systems promoting a specific level of renewable marine fuels, and subsidies for investments in and further development of systems for low and potential zero carbon marine fuels. Independent of the fuel and propulsion technology chosen, the implementation of energy efficiency measures is still highly important to ensure an efficient fuel use.

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