Study: Methanol as a marine fuel

Advantages and limitations

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The study concludes that methanol as a marine fuel and energy carrier bears low environmental risks compared to other potential fuels. It can offer sufficient energy density for most voyages and is comparatively easy to handle. E-Methanol enables a well-to-wake climate-neutral operation of a ship if produced using renewable energy and if CO2 is sourced from the atmosphere. The main obstacle tends to be the huge amount of renewable energy necessary for production. The biggest chance to overcome this is straight forward regulation that increases demand, provides planning security for first movers and investors, and puts a price tag on greenhouse gas (GHG) emissions. If used in combustion engine air pollutant emissions from methanol must be reduced by proven technical measures.

Upscaling the production and supply of RNFBOs is crucial to decarbonize maritime transport. So far, there is little experience using hydrogen, e-methanol or e-ammonia as a fuel in shipping. It is further not yet clear which fuel is the most appropriate for use in deep-sea shipping and which option will gain the highest share in the future fuel mix.

The study investigates whether the potential benefits and risks of e-methanol are sufficiently reflected in the current discussion about future marine fuels and whether methanol is preferable to current fossil marine fuels and other RFNBOs[1].

Climate impact, pollution, and hazard risks

There are many aspects to consider for the suitability of a future marine fuel. E-methanol and e-ammonia are both discussed as promising candidates for the decarbonization of deep-sea shipping. Both have advantages and disadvantages. The characteristics of methanol make it easier to handle compared to ammonia and hydrogen. While further research on the level of formaldehyde emissions from marine engines is necessary, e-methanol provides steep reductions in GHG and considerably lower air pollutant emissions. To be carbon-neutral, it is of upmost importance that the fuel is produced with renewable energy and a sustainable CO2 source. Carbon-free RFNBOs (like ammonia) have the advantage of not needing CO2 as an input and thus having

[1] Renewable Fuels of Non-Biological Origin

higher efficiency in the production process. Some long-term cost scenarios indicate that ammonia-fuelled vessels will outperform methanol-fuelled vessels in operation costs. However, ammonia is more toxic and hazardous to crew and environment. Potential nitrous oxide emissions bear an additional risk to shrink ammonias greenhouse gas reduction potential. The study concludes that there will be a more diverse mix of fuels and drives where different fuels will find their markets. Methanol's share will be determined by several factors: upscaling of green methanol production, decrease in renewable electricity cost, and the still uncertain acceptance of ammonia.

Methanol is toxic to humans when ingested as it causes irreversible damage to nerves. However, methanol is unlikely to be ingested in the normal handling as fuel. Risk of poisoning is therefore considered to be very low. In contrast to the toxicity to humans, methanol is less toxic to aquatic organisms (fish, invertebrates, algae and microorganisms). In case of spillages, methanol dissolves very quickly in sea water. Vapours that get into the air are dispersed very quickly. It is fully biodegradable with no potential to bioaccumulate. According to current knowledge methanol is thus the fuel with the lowest toxicity and hazard risks compared to diesel, heavy fuel oil or ammonia.

Fehler! Ungültiger Eigenverweis auf Textmarke. compares e-methanol with other fuels when used in ICEs (internal combustion engine) based on key criteria from a well-to-wake perspective.

Table 1: Comparison of RFNBOs and fossil HFO/MGO based on key criteria

Criterium	E-Methanol	Hydrogen	E-Ammonia	HFO
GHG reduction potential (lifecycle)	5	5	4*	1
Air pollutants (incl. exhaust gas aftertreatment)	4	5	5	1
Aquatic ecotoxicity	5	5	2	1
Human toxicity	3	5	2	3
Flammability	2	1	2	5
Explosion risks	5	2	4	5
Infrastructure (plants, bunkering)	4	1	3	5
TRL production/engine, retrofits	3	1	2	5

Notes: Ranking: 1= high risk/ low performance to 5=low risk/ high performance, assuming fuel use in ICE with exhaust gas aftertreatment system; *uncertainty about N_2O emissions; TRL: Technology Readiness Level
Sources: Authors' own compilation

The years up to around 2030 will likely be key as this decade will be decisive for where investments will be made. Policy makers should therefore implement the right incentives as soon as possible.

Policy recommendations

Today methanol is primarily produced from natural gas and is not able to provide GHG savings compared to conventional fossil fuels like diesel, heavy fuel oil or LNG. Thus, all regulation must be targeted to green e-methanol but not neglect air pollutant reduction, especially nitrogen oxide. Moreover, formaldehyde emission prevention has to be incorporated in further development. Green hydrogen production and the DAC technology need to be scaled up significantly to provide substantial amounts of green methanol for shipping. Policy makers therefore should implement straight forward regulation as soon as possible.

These could include GHG reduction targets, a price tag on GHG emissions, green fuel quotas, and mechanisms to encourage the use of methanol, such as through accounting and reporting mechanisms. Regional regulation and infrastructure improvements can also help promote the adoption of RFNBOs.

Also support for investments in environmentally friendly methanol production facilities, early adaptation of land use planning and infrastructure at ports, or the use of CCfDs (Carbon Contracts for Difference) are key instruments to ramp up the supply. At the same time, the demand side should be supported by the European Union and the World Shipping Organization (IMO), which have to set decisive levers for more climate-friendly shipping.

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