The Progress of Advanced Marine Fuels AMF Task 60

Participants

- Austria, LEC
- Canada, ECCC
- China, ESC of MVPA of MIIT
- Denmark, DTI, DTU
- Finland, VTT
- Korea, KIER
- Sweden, Trafikverket
- Switzerland, WinGD
- USA, Argonne National Lab

Policy Relevance

Global marine shipping is a sector which is hard to electrify and therefore in need of advanced motor fuels for a sustainable future. In short sea shipping battery electric propulsion can however be, and already is, an alternative.

The advanced motor fuels considered in this report are, bio-intermediates from catalytic pyrolysis or hydrothermal liquefaction, biodiesel blends, methanol, methane, hydrogen, ammonia, and propane.

Major Conclusion

Future marine engines need a combination of low carbon fuels and emission aftertreatment systems.

The choice of fuel is closely related to emission levels and the need for aftertreatment systems.

Two distinct pathways exist; drop-in fuels which use existing engines and fuel infrastructure, and novel fuels which require further modifications and investments.

Low Sulphur Fuel Oil has become widely available and represents the main solution for sulfur emission control on older ships. Wet scrubbers are the second most preferred solution.

NO_X emissions from any fuel can be handled with the right choice of engine and aftertreatment system.

The problem with Black Carbon emissions is not solved with wet scrubbers alone but can be effectively met with cleaner burning fuels such as e.g., hydrogen, methane, or methanol.

LNG as marine fuel has seen a major come back as a cleaner burning fuel alternative. With a low-pressure Gas Admission engine, ships can now fulfill all current emission regulations without aftertreatment systems. Only the greenhouse gas impact of LNG remains unsolved. Biomethane can be a good option when available, but methane slip still needs attention.

Methanol is moving to become the fuel of choice for many shipping segments including fishing boats and ferries with 4-stroke engines (China) and large box container ships with two-stroke dual fuel engines (Global). World production of green methanol needs to rise by several million tons per year to support this development.

Hydrogen remains a niche in marine fuels, mainly due to the relatively large space needed for storage. Engines for hydrogen, though still prototypes, are now emerging.

Hydrogen-derived fuels, on the other hand, can be produced as drop-in fuels.

Research is ongoing to finish the development of ammonia fueled marine engines for all segments.

Ammonia, together with hydrogen, are the only future fuels that are completely carbon-free, thus without direct CO_2 emissions. However, the true carbon footprint depends on a complete well-to-wake analysis, including upstream fuel processing steps and secondary emissions such as e.g. nitrous oxides.

Carbon capture technology either on board ships or in connection to marine fuel production may contribute significantly to decarbonization of the shipping sector.

Electrification can be a good option for short sea shipping.

Background

In 2013 IEA-AMF produced its first report on marine fuels (Annex 41). This report concluded that there was no alternative fuel option available for the shipping industry without major added cost or technical obstacles.

Since then, low Sulphur marine fuel has become widely available along with a number of other clean

technologies which allow most of the current pollution problems to be solved.

Especially LNG and scrubber installations has surged in recent years. Practically all large ships on order are now being built with some sort of alternative fuel option.

Methanol is becoming a widely accepted solution to reduce both air and water pollution and mitigate the climate effect of marine fuels.

In the near future, ammonia will have to stand the test as the first completely carbon free fuel offered for global mainstream shipping.

AMF is mainly concerned with the end-use aspects of advanced marine fuels. This includes engine technology, which is developing rapidly towards more fuel flexibility, but in particular the availability and cost of advanced fuels, the need for bunkering facilities in ports, and the proper handling of emissions from combustion remain our main concern.

Research Protocol

This report is the result of a multinational collaboration effort where researchers from different countries each submitted their findings and technological highlights from both national and global perspectives. This enables this report to address every marine segment from the smallest fishing boats on Yangtze River to the largest ocean-going container vessels.

The work process, coinciding with the Corona pandemic, has been carried out largely by remote meetings every two months. Each country has given both spoken and written presentations of their work. The entire report has been collated by the task manager and put up for review on a shared server.

The task was managed by Kim Winther, Technology Subcommittee Chair of IEA-Advanced Motor Fuels.

Key Findings

The key findings of this task are:

- Ultralow Sulphur marine fuel has become available in adequate quantities around the globe, contribution greatly to a reduction in marine sulfur emissions.
- LNG as a fuel has seen a big surge in both number ships and total amount of LNG used for shipping. This reduces both sulfur and Black Carbon emissions.
- Scrubber installations have also surged since the introduction of the IMO 2020 sulfur cap. Scrubbers effectively capture sulfur but, depending on operation, are less effective towards Black Carbon. Open loop scrubbers are not allowed in China.
- Emissions of Black Carbon can be met effectively with advanced fuels such as methane, ammonia, hydrogen, or methanol.
- The global NOx regulation applies only to new ships and has no effect on existing ships. To reduce NO_X pollution from older ships, local enforcement, differentiated harbor taxes, and incentivized retrofit programs are needed.
- Biofuels produced with fast catalytic pyrolysis or hydrothermal liquefaction are potentially promising drop-in fuels.
- Methanol dual-fuel engines are becoming an accepted option for new ships.
- Hydrogen engines are still new to the market.
- Ammonia engines are still in the research and development phase.
- The many different fuel production pathways are to be considered in the well-to-wake perspective when assessing climate impact.
- Carbon capture technology is important for the decarbonization of the shipping industry.
- Electrification may be the best option for short sea shipping.