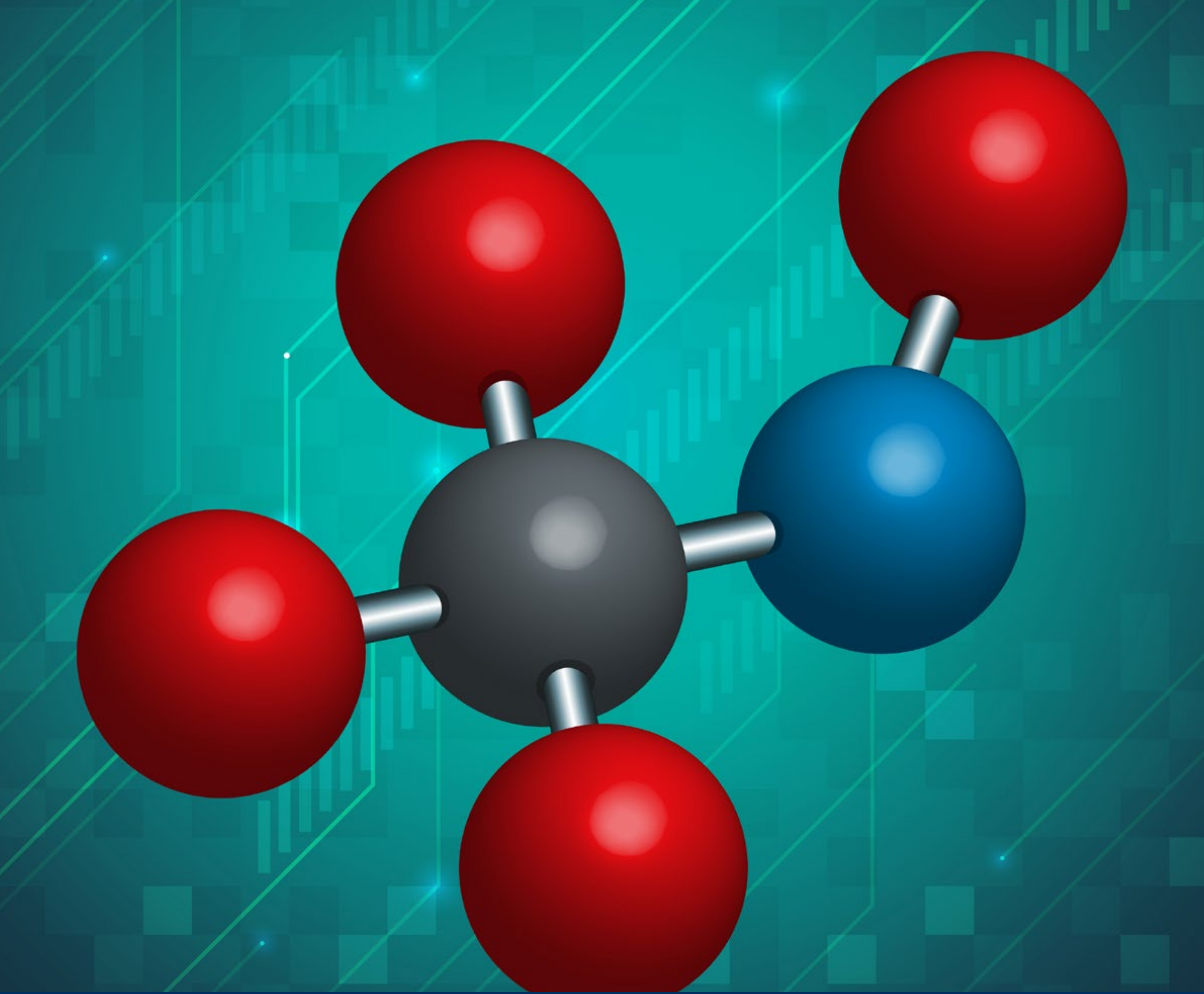

Methanol - liquid fuel to implement in the maritime industry

Green Deal Validation

Netherlands Maritime Technology | IRO | TNO innovation for life | MARIN | Koninklijke Vereniging van Nederlandse Reders | Ministerie van Infrastructuur en Waterstaat | Ministerie van Economische Zaken en Klimaat

Description

Methanol (CH3OH) is a liquid fuel with about half the energy content of diesel fuel (16 versus 36 MJ/dm3). Methanol is produced in large quantities from fossil feedstock, namely natural gas (98 Mton globally in 2022), but there are also good options to produce it from renewable feedstock. The produced quantity of renewable methanol in 2021/2022 is very small and totals 0.2 Mton. In addition to biomass feedstock, methanol can also be produced as E-fuel with (green) H2 and CO_2.

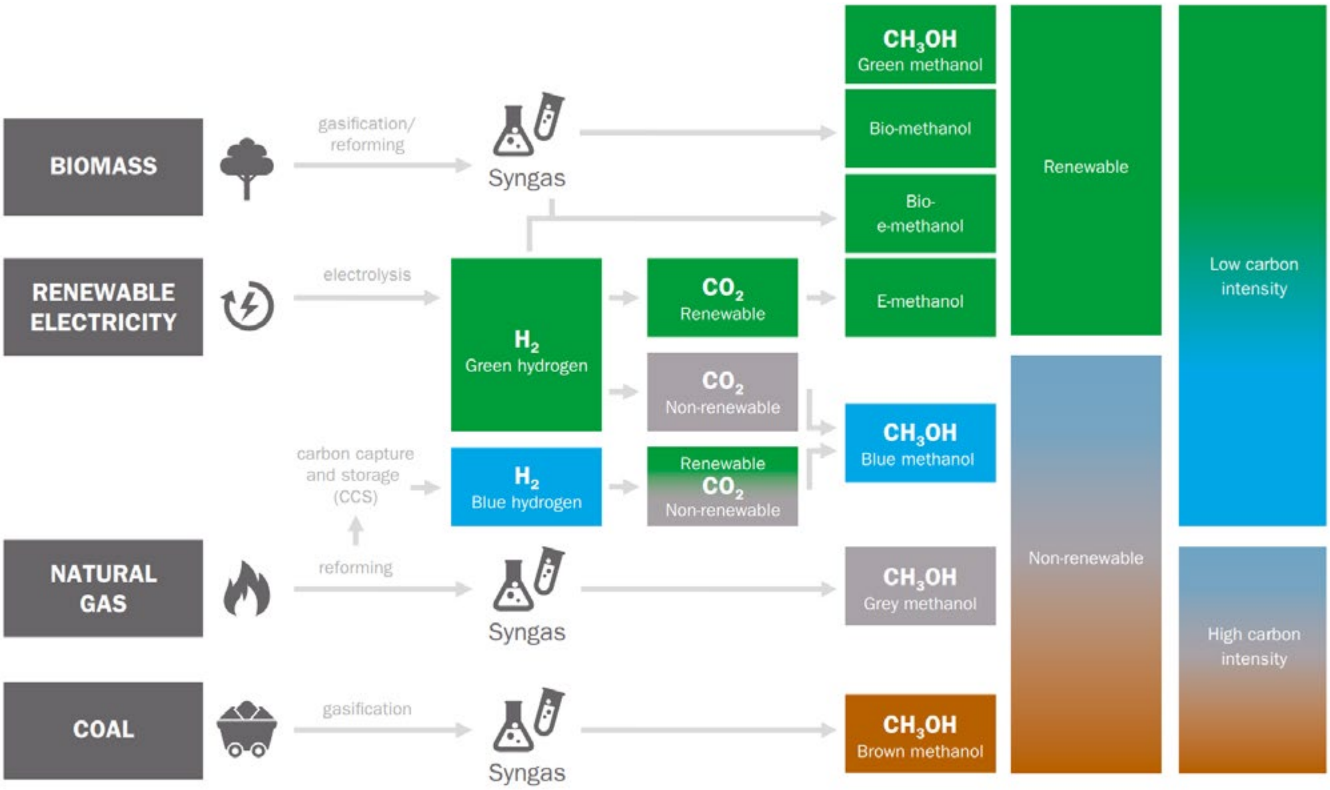

Figure 1: High level overview of methanol production methods (grey: fossil; blue: carbon-recycled; green: renewable) source: IREA and Methanol institute, "Innovation Outlook Renewable Methanol" IRENA, Abu Dhabi, 2021

Methanol can be used in different types of combustion engines or different types of fuel cells, although regarding the latter, the associated power (<0.5 MW) currently only supports rather small marine vessels. From a practical perspective, methanol lacks the energy density of HFO, but is a better option than ammonia or hydrogen gas (<10 MJ/dm3). Hence, the usage of methanol is limited by fuel tank capacity and energy requirements. Methanol deviates strongly from diesel fuel, because it has a high auto-ignition temperature. To overcome this limitation and combine it with an ICE, three main principles can be used

- Dual fuel or diesel pilot. a certain amount of diesel fuel (2% - 20%) is used to initiate the combustion
- Spark ignition, Otto principle
- Methanol with an ignition improver: a chemical liquid (e.g. 5%) is used to lower the auto-ignition temperature such that it can be burned in an (adapted) diesel engine.

Market readiness & availability

As of 2023, two engine manufacturers have delivered methanol engines for marine shipping. Wärtsilä's 32 (3480 – 5220 kW) and, MAN B&W ME-LGI Series. Both engines are dual fuel and fuel-flexible engines, in which methanol is ignited with a diesel pilot. They can also run on diesel fuel only. Similarly, Anglo Belgian Corporation has introduced a series of dual-fuel methanol engines (DZD MeOH) (1326 – 4810 kWe). Other methanol engines are currently in development. Caterpillar has announced the launch of new methanol engine (Cat 3500E-series). Hence, the market size for methanol engines is slowly expanding.
ABC has announced a dual-fuel methanol engines based on their DHZ series (1326 – 4810 kW), but not yet introduced. Caterpillar, Mitsubishi, MTU and Scania/Scandinaos are investigating the possibilities of converting engines towards methanol use. Some have announced, but no real products are available yet.

The infrastructure associated with the production and distribution of fossil methanol as chemical feedstock has been well established. Tank storage capacity is available at 88 of the world's top 100 ports. Unfortunately, this almost solely accounts for the fossil methanol options. Nevertheless, the established infrastructure and experience can be re-used for the distribution of renewable methanol and bunkering strategies. The latter is already being done for several ship operations. There is some experience with ship bunkering. Nevertheless ship-to-ship and shore-to-ship bunkering infrastructure needs to be build up.

Applicability for reference ships

The current availability of methanol engines is limited to one medium speed type (Wärtsilä) and one slow-speed type (MAN). Development of a high-speed engines has been announced, but actual availability in the future is uncertain. For that reason, the applicability is rated lower for the reference ships with high-speed engines. Apart from the engine, the installation of the tank onboard of the ship can be a challenge, because currently cofferdams are required. This may change in the future.

General cargo	Tug boat	Offshore supply	Crew tender	Dredger vessel	Super yacht
+	0	O	O	+	0

The impact on the design of the ship is heavily influenced by the engine type. A dual-fuel system requires two bunker tanks (methanol and diesel) which is more challenging in terms of packaging and costs for small ship types.

In order to be allowed to transport or use methanol as engine fuel, a number of requirements from the IMO must be met. These include regulations covered by the MARPOL Annex VI and Marpol Annex II and SOLAS Ch. VII, which refer to the IBC code. This code provides an international standard for the safe carriage in bulk by sea of dangerous chemicals, of which methanol is one of the listed items. Additionally, the regulations regarding the use of methanol as bunker fuel on board are also covered in the IGF code of the IMO (MSC.391(95)).

Emission reduction effectiveness

Depending on the feedstock, using methanol in an ICE has the potential to eliminate all CO_2 emissions. From a WTW perspective, gray methanol can lead to a CO_2 increase, whereas green methanol produced from sustainable biomass feedstock cuts these emissions up to 90% and e-methanol potentially completely eliminates the CO_2 emissions.

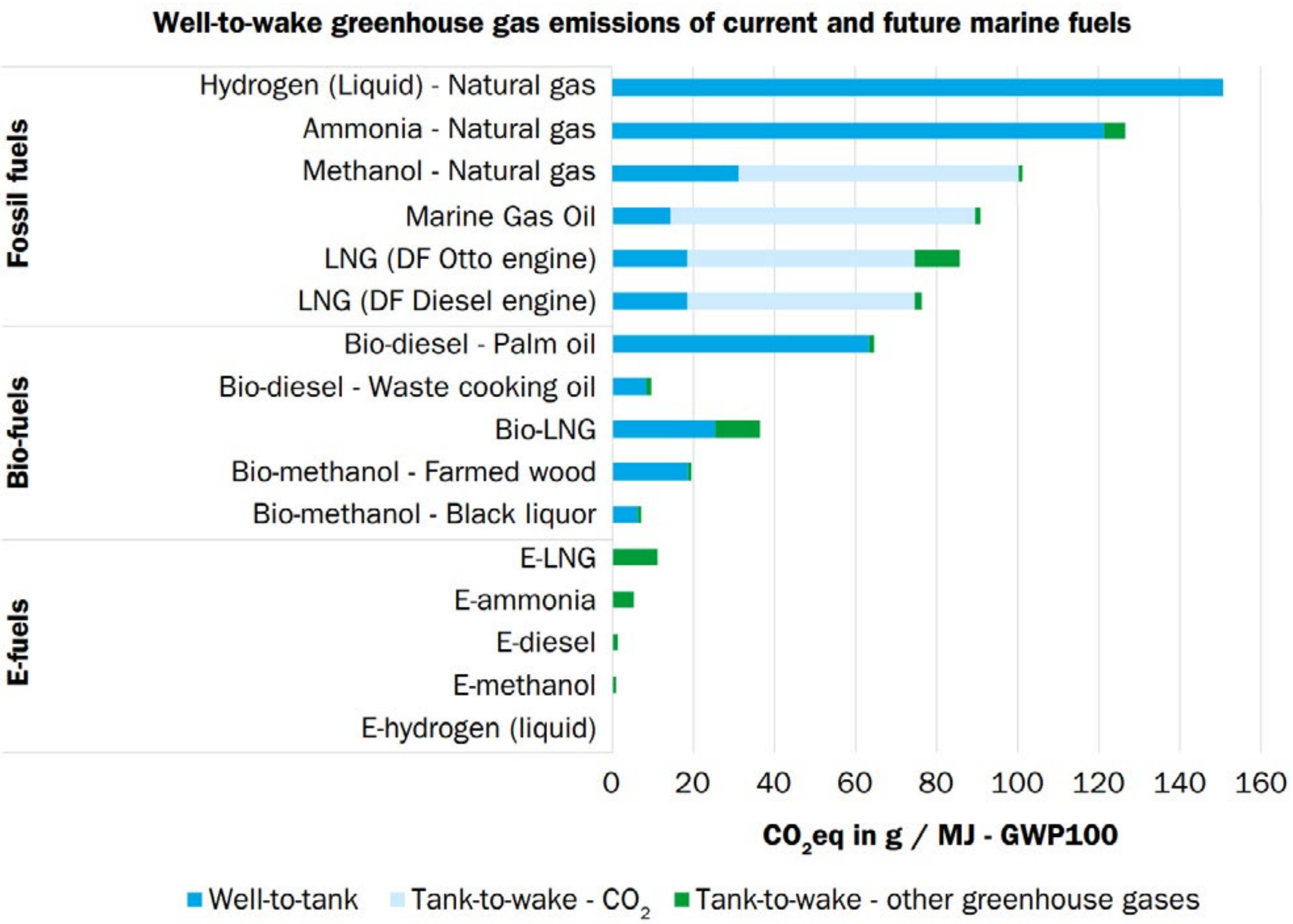

Figure 2: Overview of the well-to-wake CO_2-equivalent emissions (split in well-to-tank (WTT) and tank-to-wake (TTW)) for methanol variants in comparison to conventional marine fuels.Source: TNO, "Green Maritime Methanol: A call to action", 2023

Due to the absence of Sulphur in the fuel and the pre-mix combustion principle, both SOx and PM emissions will be a lot lower than with the conventional marine fuels. Methanol as marine fuel is compliant with the IMO's 2020 regulations regarding the emission of SOx. To achieve the IMO Tier III NOx emission requirements, Additional NOx emission reduction is necessary. This can be done with SCR deNOx aftertreatment, methanol-water blending or possibly EGR (exhaust gas recirculation).

Operation and safety

Since methanol is classified as a low flashpoint fuel (below 60 degrees Celsius), the IGF code (chp. 2.3) describes a risk assessment approach has to be taken according to SOLAS Ch. II-2 Reg. 17 before it can be introduced on a merchant vessel. This regulation has the goal to ensure the altered system has an equivalent level of safety, from a fire safety perspective, as a conventional fuel oil arrangement.

Methanol has very different chemical properties to diesel fuel, giving rise to increased health hazards. Methanol vapor is toxic and poisonous, it burns at relatively low temperatures with an invisible flame, and has a wide explosion range. The eminent health hazard is induced by methanol leakages. As such, methanol

should be treated with care by introducing an additional barrier, an appropriate ventilation system and assigning the safety zone distances from the system upfront.
Material choices are critical in order to avoid corrosion and leakages. Methanol is corrosive to frequently used materials in the engine system, such as aluminum and titanium alloys. Also methanol resistant elastomers and packings must be used.

Costs

Indicative values are:

- Investment costs:
  - Retrofit cost from diesel fuel to dual-fuel: 250 – 350 euro/kW [10-25 MW engines]
  - Newbuild: 270/KW [2x 10 MW engines]
- Operation & maintenance costs
- Fuel costs (market price may vary a lot due to supply-demand issues):
  - Green methanol: 90 – 110 euro/MWh or 500 - 600 euro/tonne, MeOH
  - Fossil methanol: 60 – 75 euro/MWh or 340 – 410 euro/tonne MeOH
  - E-methanol: estimated at 145 – 290 euro/MWh or 800 – 1600 euro/tonne MeOH

Development prospect

Several engine manufacturers have started the development of methanol engines. For the relatively small Dutch reference vessels, the future availability of high speed single and dual-fuel engines or methanol fuel cell system are the most important development aspects.

Maersk has organized a scaling of capacity to at least 730.000 tonnes per year in 2025. This is a joint effort with CIMC ENRIC, European Energy, GTB, Orsted, Proman and Wastefuel to increase bio- and e-methanol production.
Also in the port of Rotterdam, scaling operations have been announced. In the Port of Rotterdam, GIDARA Energy is currently constructing an advanced biofuels facility to annually produce 90.000 tonnes of MeOH from 2025 onwards.