GETTING TO ZERO COALITION

GLOBAL MARITIME FORUM

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INSIGHT BRIEFING SERIES

Methanol as a scalable zero emission fuel

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The Getting to Zero Coalition is committed to accelerating shipping decarbonization by getting commercially viable deep sea zero emission vessels powered by zero emission fuels into operation by 2030 to put shipping on a path for full decarbonization by 2050. To unpack the different fuels and technologies options that could support the transition to zero emission fuels, the workstream on Fuels & Technologies has hosted a series of webinars, gathering perspectives from experts across the maritime value chain - shipowners, operators, charterers, financial institutions, classification societies, and NGOs. The insight briefing paper series aims to reach a broader audience and build a common understanding of the fuels, engines, and storage technologies that will enable the decarbonization transition.

The Insight Brief is based on analysis by Global Maritime Forum for the Getting to Zero Coalition, a partnership between the Global Maritime Forum and the World Economic Forum, made possible with funding from Mission Possible Partnership.

MISSION POSSIBLE PARTNERSHIP

Date of the webinar: November 2021

Watch the webinar here.

Panelists:

- Dolf Gielen, Director, Innovation and Technology Centre, IRENA
- Robert L. Zeller III, Ph.D., P.E. Vice President, 1PointFive
- Caroline Båth Halldén, Public Policy & Business Development Manager, Liquid Wind
- Jacob Sterling, Head of Technical Innovation, A.P. Møller - Mærsk A/S

Moderator: Randall Krantz, Senior Project Advisor on Shipping Decarbonization, Global Maritime Forum/Getting to Zero Coalition

Executive Summary

Synopsis: This webinar explored the scalability potential of zero carbon methanol as a shipping fuel and the different feedstock options to source the carbon needed to produce methanol. Options include methanol synthesis from biomass, as well as using renewable hydrogen synthesised with carbon captured from point sources (including biomass combustion processes) and capturing carbon from the atmosphere using direct air capture technologies. The scope of this event excluded methanol produced from biomass.

Key takeaways:

> Different options are currently on the market to make methanol a fuel candidate on the shipping decarbonization transition pathway.

> Zero emission methanol is contingent on the production process, source of carbon feedstock (e.g. DAC, point source Bioenergy with Carbon Capture and Storage (BECCS)), as well as the scalability and cost of these carbon sources.

> Methanol is already available and used as shipping fuel today. So methanol has an edge on technology and safety issues that need to be considered for ammonia. In the long term, renewable methanol fuel production will be more expensive and the Total Cost of Ownership (TCO) will be higher than for clean ammonia.

> A strengthened dialogue between the demand and supply side actors will facilitate investment growth in methanol. The ordering of vessels to run on zero emission methanol is a demand signal to build additional production capacity.

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Opportunities and challenges of methanol being a zero emissions fuel candidate

The opportunities:

- **Safety & handling:** Methanol remains easy to handle and already meets operational safety and engine compatibility requirements.

- **Scalable:** For the direct air capture (DAC) pathway, there are no feedstock constraints regarding availability to scale methanol.

The challenges:

- **Feedstock:** High cost of DAC feedstock; long-term competition for bio-based CO2 feedstock (point source bio energy carbon capture).

- **Industry competition:** Methanol serves different industries and there may be medium- to long-term competition with sectors willing to pay more for clean fuel and clean feedstock.

- **Sustainability:** The production of methanol requires a framework with common standards in order to avoid negative environmental and social impacts upstream in production processes.

Detailed Summary

About methanol

Methanol's use as marine fuel has many advantages including being easy to handle and already meeting operational safety and engine compatibility requirements. However, as an alcohol, it includes carbon in its synthesis and, unlike options like liquid hydrogen and ammonia, this adds an extra question around how that carbon can be sourced at scale and in the long-run.

1. **The different types of methanol production and their key cost drivers**

The methanol production pathways vary depending on the technologies and feedstocks used. Two types of net zero carbon methanol exist, with the two e-methanol variants being the main topic of this webinar:

a. *Methanol types and production pathways*

The bio-methanol made from biomass. Key potential sustainable feedstocks include: forestry and agricultural waste and by-products, biogas from landfill, sewage, municipal solid waste and black liquor from the pulp and paper industry.

> Bio-methanol: biomass (gasification)

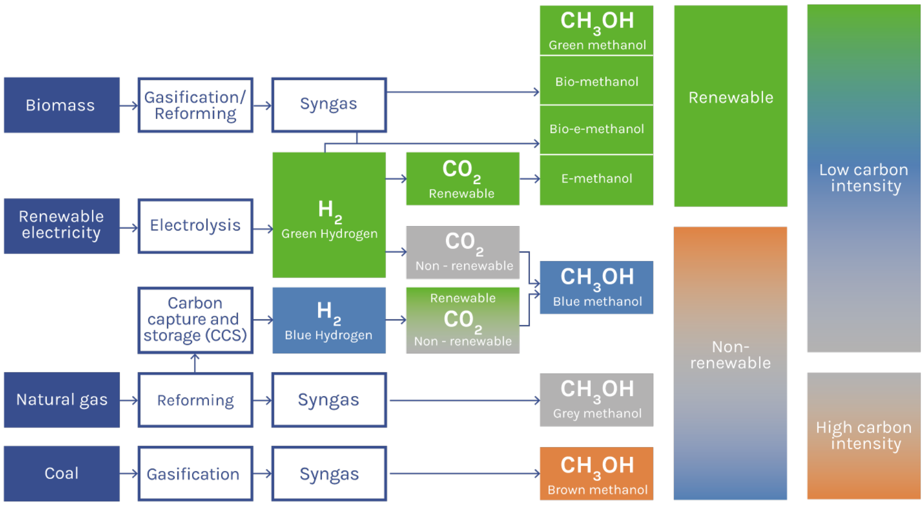
The E-methanol made from renewable hydrogen synthesised with a carbon (CO2) feedstock captured with renewable electricity.

> E-methanol = renewable hydrogen + CO2 from bioenergy with point source carbon capture and storage (BECCS)

> E-methanol = renewable hydrogen + CO2 from direct air capture (DAC)

Exhibit 1: *Principal methanol production route*

Source: IRENA (2021)



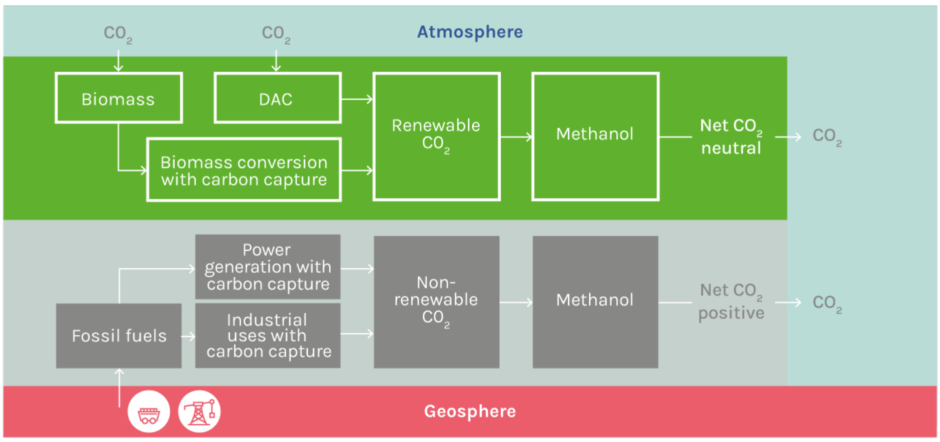
b. Technologies and CO2 feedstock

To produce net zero carbon methanol, the CO2 can be obtained directly by direct air capture (DAC) or from biomass. When the CO2 from bioenergy of various biomass production processes is captured for storage or utilisation, the process is usually referred to as bioenergy with carbon capture and storage (BECCS) or bio-energy with carbon capture and utilisation (BECCU) (Consoli, 2019). CO2 captured from the atmosphere is also becoming a possibility, known as direct air capture (DAC).[1]

1 IRENA. (2021). Innovation Outlook: Renewable Methanol

Exhibit 2: CO2 feedstock for the production of e-methanol

Source: IRENA (2021)



c. Key numbers for methanol

Today, the global production of methanol has reached 100 million tonnes. This methanol is produced from coal and from natural gas, its production and use is an important source of CO2 emissions.

To produce E-methanol, hydrogen supply and CO2 costs are key components of the overall cost. Indeed, if the cost of hydrogen decreases, the cost of methanol will also decrease.

The cost of methanol is driven by the production pathways such as the technologies and CO2 feedstock. In addition, large-scale production of e-methanol depends on the availability of inexpensive green hydrogen and CO2. Due to competition for bioenergy and the possibility of sequestering CO2 from BECCS, DAC technology cost decrease could drive an economy of scale.

The price of methanol today

According to IRENA [exhibit 3], large-scale production of e-methanol will depend on the availability of inexpensive green hydrogen and CO2, as well as the capital cost of the plant. According to the International and Renewable Energy Agency (IRENA) back-of-envelope calculation:

- The cost of renewable hydrogen today ranges from green hydrogen now costs USD 4-6/kg or USD 4000-6000/t
- CO2 at present 100-200 USD/t (BECCS) or 600-800 USD/t (DAC)
- 1 tonne of e-methanol requires 200kg of green hydrogen and 1.5tons of CO2 or:
- $800 H2 + $900 CO2 = 1700/t (feedstock only)

The price of methanol in 2050

Green hydrogen could fall below the USD 2 per kilogram mark – low enough to compete – within a decade. BECCS is generally deployed where biomass is used for energy, while DAC technology allows it to be deployed in deserts where hydrogen will be cheaper. The costs of e-methanol are projected to decline significantly and be on par with biomethanol, ranging from 250 to 630 USD/t by 2050.

- Long term H2 = 1.50/Kg or 1500/t
- Long term CO2 = 50-100 USD/t (BECCS) or 200 USD/T (DAC)
- 1 tonne of future e-methanol might cost, for example:

$300 H2 + $150 CO2 = 450 USD/t feedstock cost

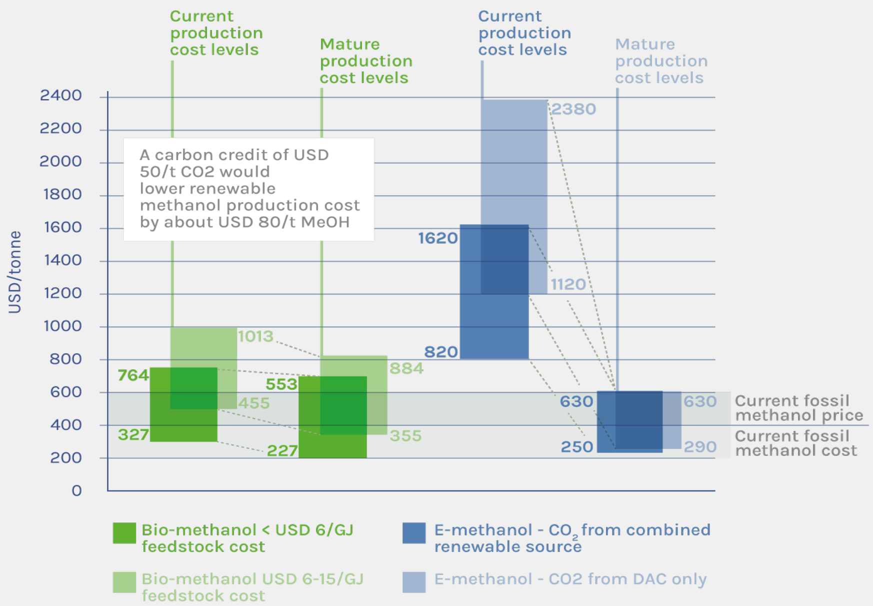


Exhibit 3: *Current and future production cost of bio and e-methanol*

Source: IRENA (2021)

2. The levers to scale methanol supply and demand

One of the levers for scalability is better understanding and transparency of the impact of methanol over its lifecycle. "Methanol has a high scalability potential," said Jacob Sterling from Maersk. He added, "To get production to scale, we will need to engage deeply with those suppliers. Part of that would be naturally to look at the full lifecycle analysis". The life cycle analysis aims at quantifying the potential impacts to the environment from all aspects of a fuel's life. As mentioned during the webinar, the transition pathway could be drawn by the blending of different fuel colours. In this case, a book and claim[2] system is useful to track the different origins and feedstocks of each fuel.

Another lever to scale methanol is to create a demand through cresting of an enabling policy framework. As Public Policy & Business Development Manager Caroline Båth Halldén mentioned, "We need policy instruments to speed up the transition such as Emission Trading Systems (ETS) and CO2 taxation". She added, "We need financial support to lower the gap between higher production costs and the willingness to pay". Indeed, a zero-emission fleet is only commercially viable and investable if zero-carbon energy sources are cost competitive with traditional fuels. Policy options, as explored in the GTZ Closing the Competitiveness Gap workstream, could help close the competitiveness gap and enable an equitable transition.[3]

A final barrier to scale up methanol is the need for infrastructure. Jacob Sterling mentioned that while some production infrastructure and procedures already exist, scale is needed through investments and development of bunkering infrastructure. All the panellists converge on the need for collaboration between the demand and supply side in order to move forward altogether.

2 RSB. (2022). Book & Claim

3 Rojon et al. (2021). Policy Options for Closing the Competitiveness Gap Between Fossil and Zero-Emission Fuels in Shipping

3. **Business cases and pilot projects**

In order to scale methanol, panellists offered some concrete examples of supply and demand that are already deployed on the market.

BUSINESS CASES

1PointFive is a development company formed to commercialise Carbon Engineering's DAC technology. CE's technology captures CO2 directly from the air with an engineered, mechanical system. CE's DAC technology pulls air into its systems and, through a series of chemical reactions, scrubs the air of pollutants and delivers CO2 in a pure, compressed form that can then be utilised to make fuels and other products, or stored permanently underground as a true CO2 removal from the biosphere. A Canadian project announced in October 2021, will use Carbon Engineering's AIR-TO-FUELTM technology, and is expected to produce 100 million litres of ultra-low carbon liquid fuels per year.[4]

4 Keith et al. (2018). A Process for Capturing CO2 from the Atmosphere: Joule

Liquid Wind produces e-methanol specifically for the maritime industry, using green hydrogen with CO2 from biogenic emitting sources. In this case, the CO2 is upcycled from bio-based point sources. Currently, a facility can produce up to 50,000 tonnes of methanol per annum, upcycling 70,000 tonnes of CO2. The upcycling system prevents 100,000 tonnes of CO2 emission per year per facility. In 2030, the company plans to have 10 plants operational, and to scale it to 500 by 2050.

PILOT PROJECT

This year, Maersk ordered eight vessels to run on dual fuel engines, with tanks and auxiliary systems to enable switching between two different fuels. It makes a clear signal for fuel producers. The shipping company has made an agreement for 10,000 tonnes of methanol with a fuel producer, the plant is already in construction.

The dual fuel capability accounts for 10% to 15% additional cost. According to Jacob Sterling, this extra cost is viewed as an insurance premium, bringing risk down of running on a stranded asset. The vision for Maersk is to be able to run at 95% green methanol and 5% of biodiesel. In this context, Maersk is exclusively considering green fuels as bio-methanol or e-methanol in order to build a new industry and send signals to those who produce green fuels.

Finally, Maersk has already made some projections and assumptions in terms of supply. By the end of 2024, the delivery of the eight new vessels will imply a need of 300,000 tonnes of methanol. For the entire Maersk fleet, the production of green methanol would need to increase 60 times in order to supply the 708 vessels [exhibit 4].

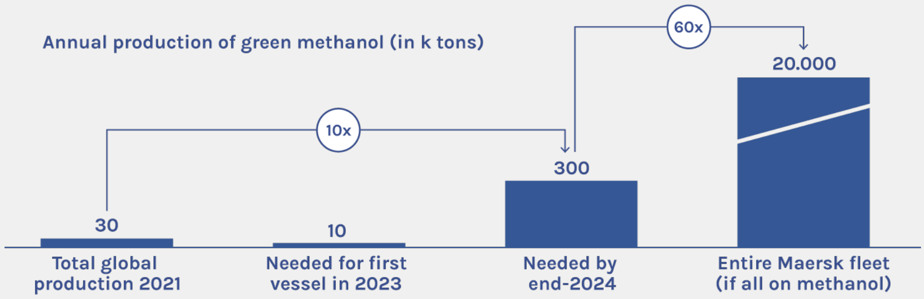


Exhibit 4: *Maersk projection for methanol need*

Source: *Maersk (2021)*

Conclusion

Different feedstocks and technology pathways can be deployed to produce renewable methanol. While clean ammonia has a long-term prospect of lower energy unit cost, renewable methanol remains attractive for its immediate availability. It remains easy to handle and already meets operational safety and engine compatibility requirements. For those reasons, E-methanol can play an increasing role in the coming decades. Indeed, it was agreed that methanol is easy to handle and already meets operational safety and engine compatibility requirements. The development of a book and claim system and lifecycle analysis are parameters to improve traceability and give insights and confidence to choose different fuel pathways. On various occasions, the panellists underscored the need for a dialogue between the demand and supply side in order to move forward altogether by creating demand and supply signals.