Methanol-to-Jet: About Methanol

Gregory Dolan, CEO

CAAFI Webinar -- 25 JULY 2023
The Methanol Institute (MI) was established in 1989. More than three decades later, MI is recognized as the trade association for the global methanol industry. We facilitate methanol’s increased adoption from our Singapore headquarters and regional offices in Washington DC, Brussels, Beijing and Delhi.
Methanol-to-Jet in Headlines

Methanol-to-Jet technology is gaining traction as a sustainable aviation fuel (SAF) alternative. Here are some headlines highlighting recent developments in this field:

**ExxonMobil introduces new technology to convert methanol to SAF**

The company aims to use the new technology to grow its lower-emission fuel business.

ExxonMobil has unveiled its new process technology to produce sustainable aviation fuel (SAF) from renewable methanol.

**HIF Global initiates engineering for U.S. Sustainable Aviation Fuel facility, selects Johnson Matthey & Honeywell technologies**

HIF Global is proceeding with its plan to build a sustainable aviation fuel (SAF) production facility in the United States.

**European Energy, Metafuels plan methanol-to-jet fuel plant in Denmark**

Danish renewables developer European Energy AG (EU Energi) and Metafuels AG will develop a methanol-to-jet fuel plant in Denmark.

**Green Car Congress**

Arcadia eFuels selects Topsoe and Saudi GIL technologies for its commercial eFuels for aviation plant in Denmark.

These developments underscore the growing interest in methanol-to-jet technology as a potential solution to reduce the carbon footprint of the aviation industry.
Methanol-to-Jet Process

Bio-Methanol or E-Methanol to Olefins to SAF
Methanol Supply/Demand
Essential Methanol

Source: S&P Commodity Insights

Million metric on

<table>
<thead>
<tr>
<th>Year</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022 (exp)</th>
<th>2023 (exp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>50</td>
<td>60</td>
<td>70</td>
<td>80</td>
<td>85</td>
<td>90</td>
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85 mn tons
Low Carbon and Net Carbon-Neutral

E-Methanol
- Feedstocks: green hydrogen and captured CO$_2$
  - Green hydrogen produced from the electrolysis of water with renewable energy (e.g. solar, wind, geothermal etc.)
  - CO$_2$ from industrial flue gas (e.g. steel, cement, ethanol), biogenic sources, or direct air capture
- E-methanol is a very-low to net carbon-neutral fuel

Bio-methanol
- Feedstocks: Municipal Solid Waste (MSW), Agricultural Waste, Black Liquor, Bio-Methane from wastewater treatment, landfills, or animal husbandry
- Feedstocks can be gasified or anaerobically digested to produce syngas used in methanol production
- Avoided emissions from landfills, incinerators, or dairy farms potentially allow bio-methanol to be a net carbon-negative fuel

All globally traded methanol is produced to the IMPCA Methanol Specification Reference to a minimum purity of 99.85%


“With 80 renewable methanol projects already announced, we are seeing clear signs of an incoming wave of bio-methanol and e-methanol production.” Oct. 2022
Gregory Dolan, CEO, Methanol Institute

Increasing Scale – Bigger Players

• Increasing scale: To date, e-methanol and biomethanol plants have been in range of 4,000-10,000 tons/year, and we are now seeing announced plants with planned capacity of 50,000, 100,000, 250,000 tons/year

• Expanding from project developers like Carbon Recycling International, Enerkem, Liquid Wind and Gidara, we are seeing major utilities like European Energy, Orsted, Iberdola, SunGas Renewables, and Engie

• We are also seeing interest in methanol from oil/gas majors including new MI members Aramco, BP, ENI/Ecofuel, TotalEnergies as well as Chevron, ExxonMobil, and Sinopec
Renewable Methanol Costs

A carbon credit of USD 50/t CO₂ would lower renewable methanol production cost by about USD 80/t MeOH.

Notes: MeOH = methanol. Costs do not incorporate any carbon credit that might be available. Current fossil methanol cost and price are from coal and natural gas feedstock in 2020. Exchange rate used in this figure is USD 1 = EUR 0.85.

www.methanol.org/renewable/
Methanol Price Slide

Platts Global methanol prices

- Platts Methanol CFR China
- Platts Methanol FOB Rotterdam
- Platts Methanol FOB USG $/mt M1
- Platts Methanol CFR India

Source: S&P Global Platts data

Friday 14 July – US Spot TX GC Barge = $229 mt = $0.69/gallon
Methanol-to-Olefins Plants

MTO Projects Latest Update - New Projects

<table>
<thead>
<tr>
<th>MTO Company</th>
<th>Location</th>
<th>Time on stream</th>
<th>Max. Methanol Consumption</th>
<th>MTO technology Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tianjin Bohai Chemical</td>
<td>Tianjin</td>
<td>Sep-2022</td>
<td>Phase 1: 1,800</td>
<td>Dalian Institute of Chemical Physics</td>
</tr>
<tr>
<td>Qinghai Damei</td>
<td>Xining, Qinghai</td>
<td>July-2023</td>
<td>1,800</td>
<td>Dalian Institute of Chemical Physics</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Total extra demand by 2023</td>
<td>3,600</td>
</tr>
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</table>

Source: Chemical Market Analytics by OPIS

© 2022 Oil Price Information Service, LLC.
In 2022, China imported 11 million metric tons of methanol – 3.7 billion gallons – largely to support MTO producers.
MtJ New Methanol Growth Segment

The outlook for methanol into 2050 is very promising. Strong additional potential in aviation and H2 long-distance transport – but only if key hurdles are mastered.

Methanol and green methanol forecast by IRENA and Roland Berger

<table>
<thead>
<tr>
<th>Forecast by IRENA [million t]</th>
<th>Growth drivers in key segments</th>
<th>Updated forecast by Roland Berger [million t]</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Segment</td>
<td>&lt;+5 to +10% for ren. MeOH vs. IRENA, if hurdles are mastered</td>
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<tr>
<td></td>
<td>Growth drivers</td>
<td>+5 to +10% for ren. MeOH vs. IRENA, if hurdles are mastered</td>
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<td>Aviation</td>
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<td></td>
<td>Power</td>
<td>+5 to +10% for ren. MeOH vs. IRENA, if hurdles are mastered</td>
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<tr>
<td></td>
<td>H2 chain</td>
<td>+5 to +10% for ren. MeOH vs. IRENA, if hurdles are mastered</td>
</tr>
<tr>
<td></td>
<td>Chemicals</td>
<td>+5 to +10% for ren. MeOH vs. IRENA, if hurdles are mastered</td>
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</table>

+ Decarb targets, e.g., IMO
+ Safe, infrastructure easy handling
+ FC-vehicles in FC limited use, but potential in long-haul HD transport
+ ASTM approval for MtJ required
+ Potential for bio- and e-MeOH (PtL)
+ Use for off-grid power & heat (direct of via FC solution)
+ Competes with diesel, LPG, EIOH wind & solar power solutions
+ Build-up of H2 chains (US, EU, ME)
+ MeOH robust and safe H2 carrier
+ MeOH awareness fallen behind NH3
+ Chemicals to decarbonize replacing fossil with green MeOH as feed
+ CCS solutions in MeOH production drive robustness (blue-MeOH)

well covered by Irena  strong upside potential, but hurdles

Source: IRENA, Roland Berger
Carbon Intensity Accounting

• In January, MI released a report from Amsterdam-based consulting firm studio Gear Up on “Carbon Footprint of Methanol”

• Depending on feedstock and production process methanol’s carbon footprint can be reduced by 65-90%

• In May, International Methanol Producers and Consumers Association working with sGU released a “backpack” calculator can help determine the carbon footprint of methanol depending on feedstock, conversion technologies, and the fate as either fuel or chemical

• **Call to Action: MI and IMPCA working together assist the methanol industry in developing a common platform for carbon intensity accounting**

https://www.methanol.org/policy-initiatives/europe/

https://www.impca.eu/IMPCA/Technical/IMPCA-Documents
2022: “…the Year Methanol Went Global in the Shipping Industry”
Methanol Leading Decade

Alternative shipping fuels outlook - 2030

Source: S&P Global Commodity Insights
Game Changer 1: IMO IGF Code

ASTM Inclusion of Methanol-to-Jet Could be SAF Game Changer
Game Changer 2.0: Maersk Vessel Orders

• 21 Feb 2021: Maersk announces that the world's first carbon neutral container vessel by 2023 will operate on dual-fuel methanol

• 24 Aug 2021: Maersk accelerates fleet decarbonization ordering eight 16,000 TEU ocean-going vessels to operate on methanol

• 23 June 2023: Maersk orders additional six methanol dual-fuel vessels, in total now ordered 24 vessels to be delivered 2025-2027

• 16 July 2023: Maersk’s first methanol dual-fueled feeder vessel (2,100 TEU) bunkered 1,000 metric tons bio-methanol at Ulson, Korea

• Customer Pull: Maersk’s 200 largest customers asking for carbon neutral transport

“The reason that we have gone for methanol on the first one is that it is the most mature from the technology perspective; we can get an engine that can burn it.” Morten Bo Christiansen, head of decarbonization at Maersk

“That means that if we end up finding exactly the right solution then there will be a big retrofit opportunity for us.” Maersk CEO Soren Skou speaking during Maersk’s on 10 February earnings call
10 March 2022: Maersk began announcing a series strategic partnerships with now ten leading companies -- including MI members Proman, Orsted, European Energy, Wastefuel, and SunGas Renewables -- with the intent of sourcing at least 730,000 tons/year of green methanol by end of 2025

Maersk estimates will need 6 million tons of renewable methanol by 2030 to fuel 25% of their 700-vessel fleet

Maersk has made partnerships with seven green fuel pioneers that will accelerate the green fuel transition

Orsted
- 500,000 tonnes per year
- First delivery in 2025
- United States

CIMC ENRIC
- 70,000 tonnes per year
- First delivery in 2024
- China

European Energy
- 2 – 300,000 tonnes per year
- First delivery in 2025/2026
- South America & United States

Proman
- 30,000 tonnes per year
- First delivery in 2024
- China

SunGas Renewables
- 200,000 tonnes per year
- First delivery in 2024
- China

Wastefuel
- 30,000 tonnes per year
- First delivery in 2024
- South America
Dominating Container Orderbook

One 16,000 TEU container ship can consume 40,000 mt methanol year
1,200 vessels = 48 million tons methanol demand
On the Water and On the Way

Methanol Fuell ed Vessels on the Water and on the Way

To learn more about each project, click on the project title.

China (March 2023)
CSSC has placed orders for four 16,000 teu methanol-fuelled ships at its affiliated yard in Yanshou for an undisclosed price basis delivery in the second half of 2023.

Singapore (March 2023)
Singapore's Consent Bunkers has signed a contract with China Merchants Industry Holdings (CMIH) Jining for a series of six 6,500-dwt methanol fuels new buildings, to be delivered in 2023.

Denmark (March 2023)
FJ Lauritzen has signed a letter of intent with Kawasaki Heavy Industries for the construction of at least two methanol dual-fuel 81,200 dwt Kamsarmax bulk carriers. The vessels have been ordered in partnership with Cargill, which will operate the vessels for a period of at least seven years.

China (March 2023)
China State Shipbuilding Corporation has signed a cooperation agreement with France's CMA CGM Group to produce 16 large methanol dual-fuel container vessel s worth more than 21 billion yuan (about 3 billion US dollars).
Since 2016, MAN has received orders for 120 large, two-stroke methanol engines, with 24 already in operation in chemical tankers operated by MI members. Another 100+ engine orders on the way!!!
Available and Affordable

Friday 14 July

**US GC Methanol** = $229 mt

**Ship and Bunker**

**Houston VLSFO** = $587 mt

**Houston MGO** = $768 mt
Easily Bunkered

Methanol Bunker Vessel Planned for Northern Europe

Published Nov 9, 2023 7:56 PM by THE MARITIME EXECUTIVE

First dual-fuel methanol bunker barge headed for Rotterdam

By Daniel Kroon | Feb 1, 2023 | Energy, Environment, Renewable energy, Methanol, Methane, Power, Ports, Shipping

Global Energy Group orders first methanol bunkering tanker for Singapore

Published Dec 20, 2022 8:17 PM by THE MARITIME EXECUTIVE

Stepa Line

www.methanol.org/join-us
Safety Assessment

• June 2022: Together in Safety, a non-regulatory shipping industry consortium initiated the “Future Fuels Risk Assessment,” a cross-industry study to evaluate the potential operational risks of LNG, methanol, hydrogen and ammonia.

• The study, which involved a series of hazard identifications (HAZID) workshops across a set of operational scenarios, found of the four fuels reviewed, methanol poses the least overall risk, followed by LNG, hydrogen and ammonia.

• Methanol scored the lowest risk ratings within navigation-related scenarios, as well as in scenarios related to ship operations.

• Methanol also scored the lowest risk ranking in the external event scenario of hull breach from ship collision.

• The study identified some ‘intolerable’ risks associated with ammonia that need to be resolved before it can be used at scale as a bunker fuel.

Bud Darr, Executive Vice President, Maritime Policy, MSC Group: “Without the safety issues being thoroughly identified and properly addressed, we will not reach the end state we need. Safety and net zero GHG operations must go hand-in-hand in a world powered by future fuels at sea.”

https://togetherinsafety.info