METHANOL INSTITUTE

Singapore | Washington | Brussels | Beijing | Delhi

# Methanol as a Marine Fuel

MARCH 2023

# MI History

- 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

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# Marine


SUPERGREEN
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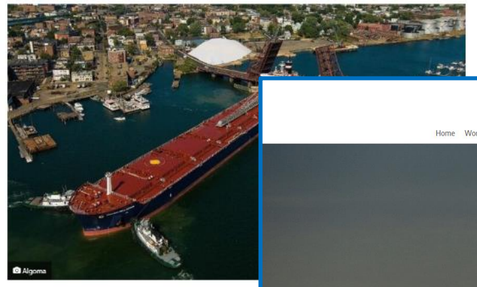
# 2022: "…the Year Methanol Went Global in the Shipping Industry"

METHANOL INSTITUTE

Algoma and CSL in for methanol-ready bulker newbuilds

Adis Ajdin · February 20, 2023 · 1 minute read



Canada's Algoma Central Corporation and CSL have ordered

China Merchants Orders Large, Methanol-Fueled Vehicle Ro-Ros

THE WALL STREET JOURNAL.

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JOURNAL REPORTS: ENERGY

Methanol Takes Lead in Shipping's Quest for Green Fuel

A successful shift to methanol, however, will require billions of dollars of investments in new ships and fueling infrastructure, as well as lower prices for methanol

Chinese Study Examining Methanol as a Marine Fuel

July 14, 2020

The Methanol Institute (MI) has joined a China Waterborne Transportation Research the think tank of the Chinese Ministry of consider the technical and operational req use of methanol as a marine fuel. The stu

Splash Extra

The future fuel race is over for this decade

Sam Chambers · February 22, 2023 · 0 · 42 · 2 minutes read

The problem with writing editorials is that they can come to look extremely misplaced predictions rather quickly. Not that that has ever stopped me before, so here goes!

I am calling the future fuel race over for this decade – methanol is the – again I am wary of writing the next word for how it might be viewed in posterity – clear winner.

methanol-operated fuel cell … 2021

COSCO Orders 12 Ultra-Large, Green Methanol Containerships for $2.9B

TradeWinds

Latest News · Tankers · Bulkers · Containerships · Gas · ESG · e-paper

CRUISE AND FERRY

LATEST JOBS · Technical Superintendent / Fleet Manager

Norwegian Cruise Line's $1.3bn methanol bet a 'great signal'

Chemical tankers and container ships are already using alternative fuel for propulsion

Norwegian Cruise Line Holdings Proceeding with Methanol Tests

Norwegian Cruise Line discussed its future fuel plans during the premier of Norwegian Prima in New York (NCL)

PUBLISHED OCT 12, 2022 5:14 PM BY THE MARITIME EXECUTIVE

The shipping industry is under increasing pressure from regulators and consumers to

CMA CGM will spend another $1bn on methanol container ships, says Saade

French liner giant is ready to double order for green vessels in China

9 November 2022 10:05 GMT · UPDATED 9 November 2022 12:07 GMT

Hyundai Engine & Machinery Division, HHI-EMD, will build the engines. The order contains an option for a f

HMM readies methanol-fuelled newbuilds

Sam Chambers · December 15, 2022 · 1 · 1,024 · 1 minute read

2022 is rapidly shaping up as the year methanol went global in the shipping industry.

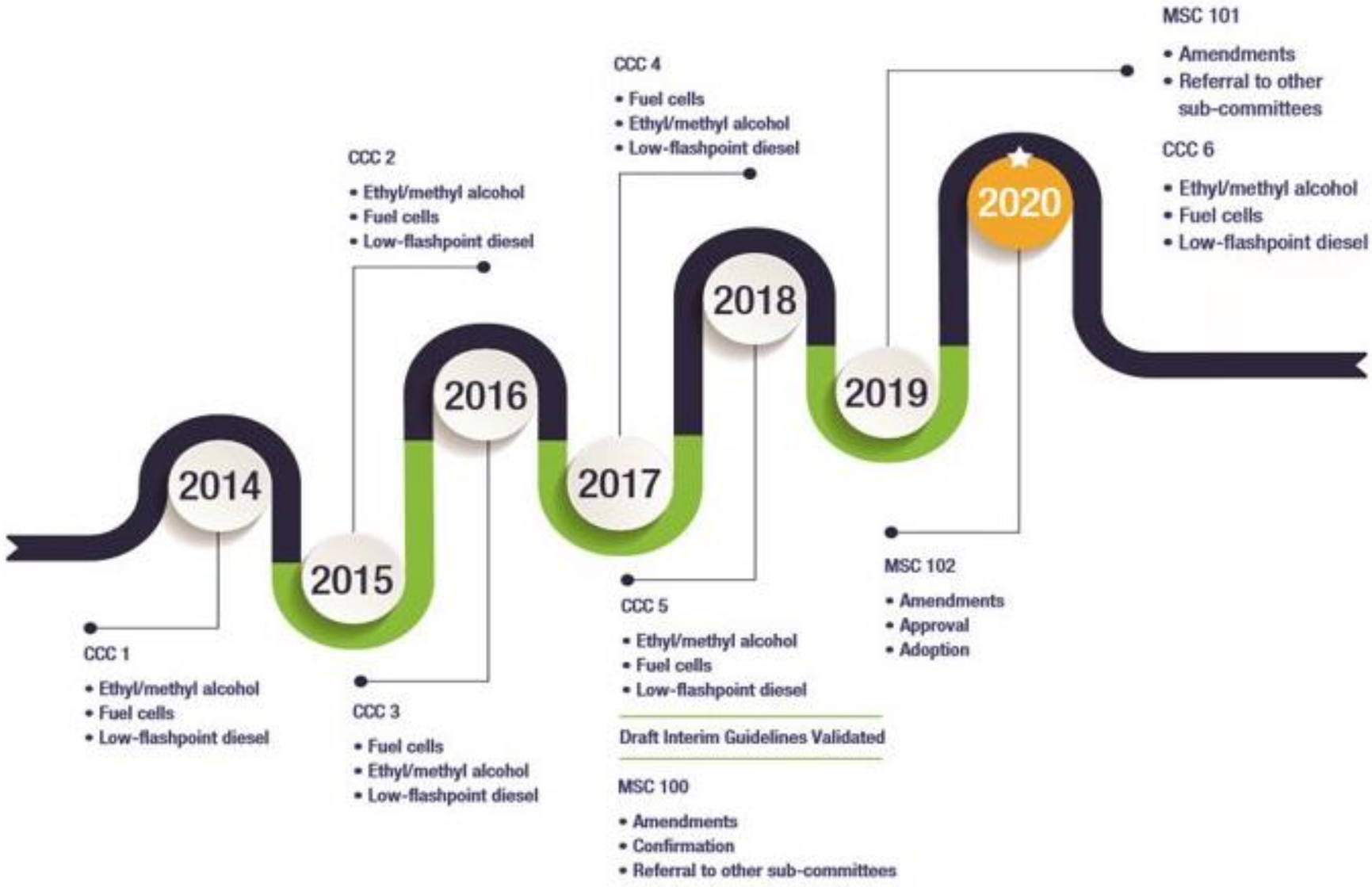
OOCL will add seven methanol dual-fuel container ships to its fleet (source: OOCL)

Methanol newbuilds elbow LNG out of the spotlight in October

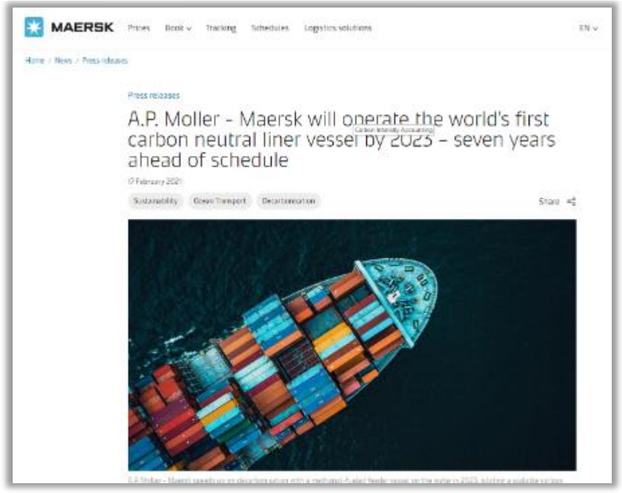
08 Nov 2022 by John Snyder

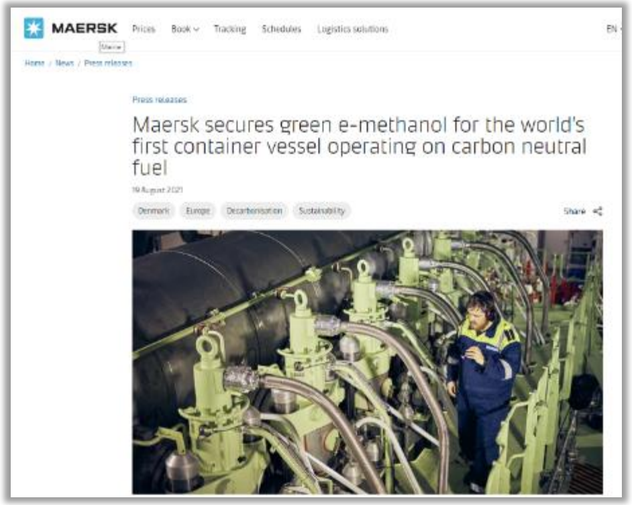
The use of alternative fuels in the shipping industry has been receiving increasing attention as a method of complying with low sulphur requirements for fuels and reduced emissions of sulphur oxides. As methanol and ethanol are sulphur-free, they would ensure compliance with the European Commission Sulphur Directive.

# Game Changer 1: IMO IGF Code



# Game Changer 2.0: Maersk Vessel Orders

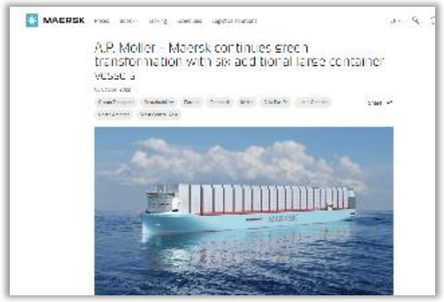



"The reason that we have gone for methanol on the first one is that it is the most mature from the technology perspective; we can get an engine that can burn it." Morten Bo Christiansen, head of decarbonization at Maersk

"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

https://www.maersk.com/news/articles/2022/10/05/maersk-continues-green-transformation

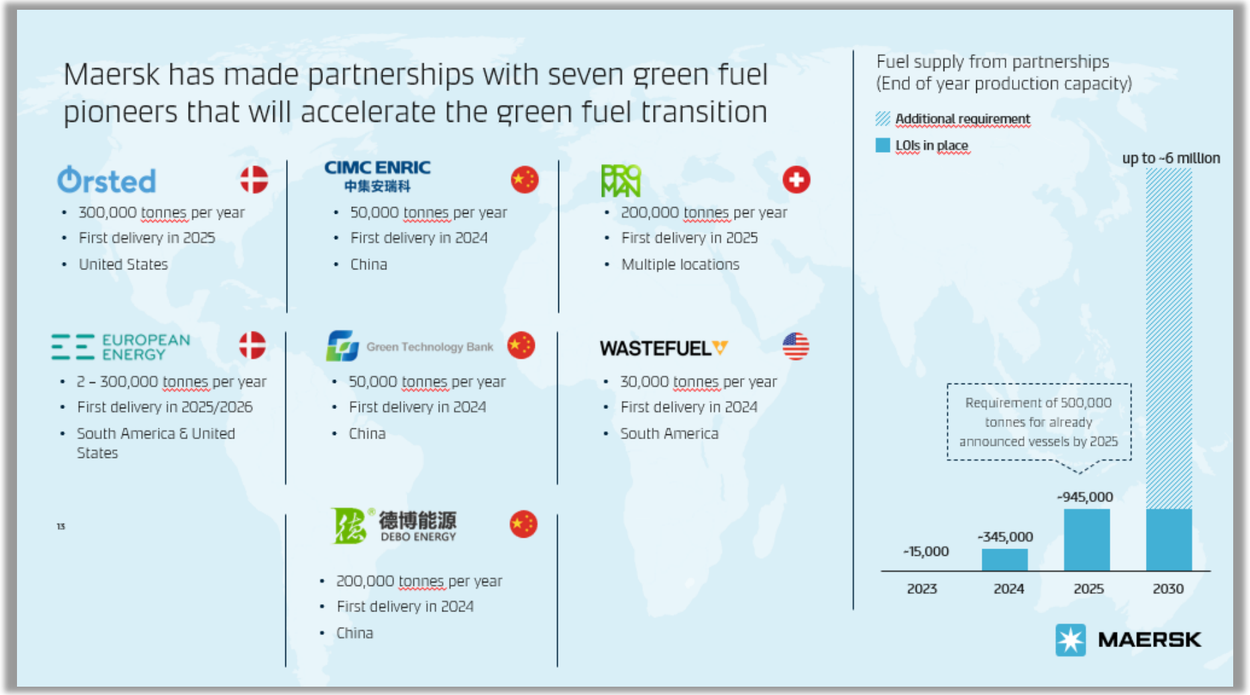



- **21 Feb 2021**: Maersk announces that the world's first carbon neutral container vessel by 2023 will operate on dual-fuel methanol
- Maersk has now ordered 2,100 TEU methanol dual-fueled feeder vessels from Korean shipyard
- **24 Aug 2021**: "Maersk accelerates fleet decarbonization with 8 large ocean-going vessels to operate on carbon neutral methanol"
- 16,000 container (Twenty Foot Equivalent – TEU) vessels
- $1.4 billion order each vessel $175 million 10-15% more expensive
- ***5 Oct 2022:*** Maersk orders additional six 17,000 TEU methanol dual-fuel vessels, in total now ordered 19 vessels to be delivered by 2025
- ***Each ship will require 35,000-40,000 tons of methanol annually or a total of 500,00 tons of methanol***
- *Customer Pull:* Maersk's 200 largest customers asking for carbon neutral transport

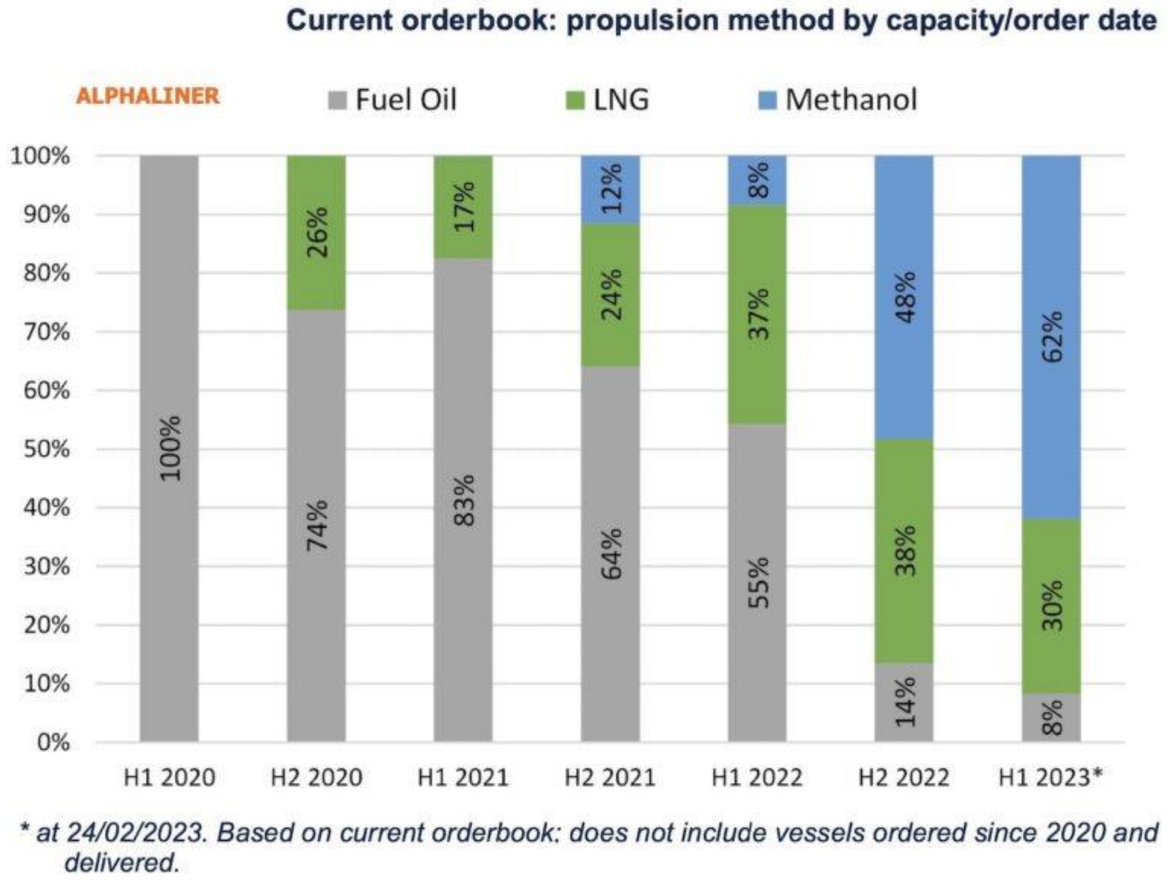
# Game Changer 2.1: Maersk Methanol Supply

- **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

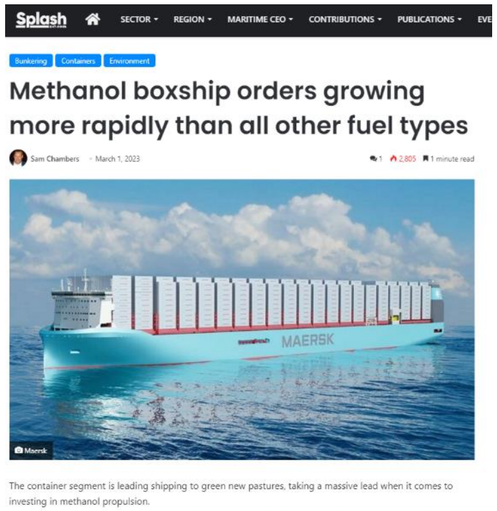
- Maersk estimates will need 6 million tons of renewable methanol by 2030 to fuel 25% of their 700-vessel fleet



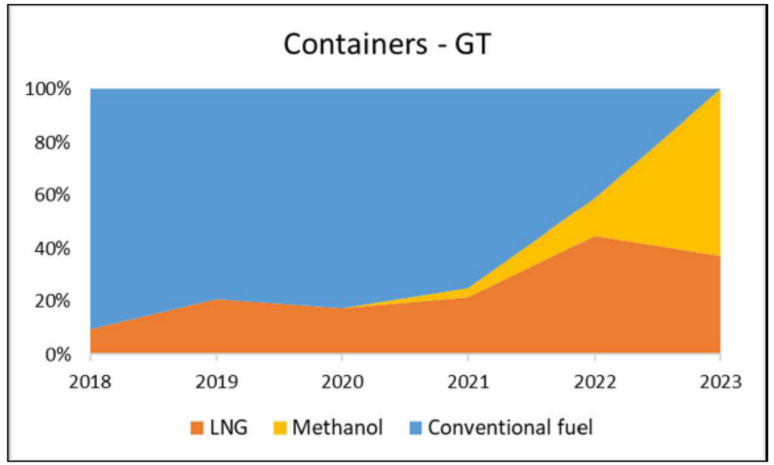

# Dominating Container Orderbook



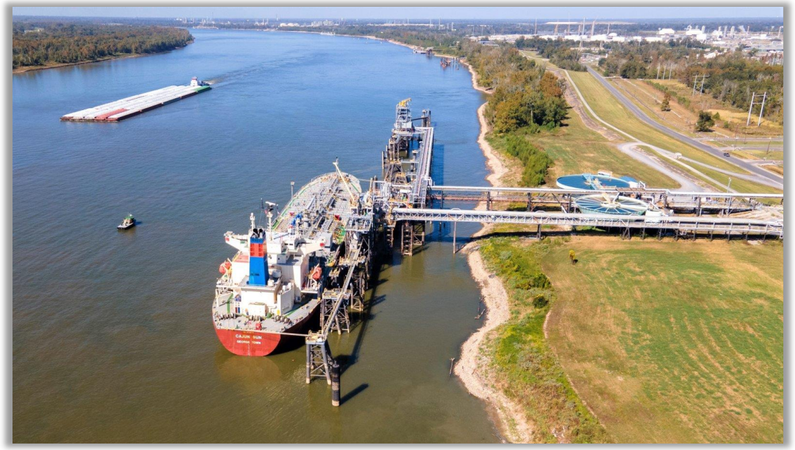

** at 24/02/2023. Based on current orderbook: does not include vessels ordered since 2020 and delivered.*




https://splash247.com/methanol-boxship-orders-growing-more-rapidly-than-all-other-fuel-types/



# Leading by Example - Tankers



- In 2016, **Methanex** subsidiary **Waterfront Shipping** launched first methanol dual-fuel 50,000-DWT chemical tanker, the Cajun Sun
- WFS now has 18 methanol dual-fuel vessels in its fleet, with over 140,000 hours of operating hours
- In December 2022, **Proman Stena Bulk** took delivery of its fourth methanol-fueled tanker, and has two more methanol vessels on the way
- In February 2023, the dual-fuel vessel *Cajun Sun*, operated by WFS and chartered from MOL, completed the first-ever net-zero voyage fuelled by bio-methanol. By blending ISCC-certified bio-methanol that has negative carbon intensity with natural gas-based methanol, net-zero greenhouse gas emissions on a lifecycle basis were achieved for the 18-day trans-Atlantic voyage. This innovative fuel solution, produced at our ISCC-certified plant in Geismar, offers shipping companies the ability to achieve net-zero carbon emissions today, supporting the industry's transition to a low-carbon future.

https://www.methanex.com/news/release/methanex-and-mol-complete-first-ever-net-zero-voyage-fuelled-by-bio-methanol/

# On the Water and On the Way

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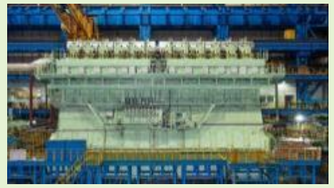





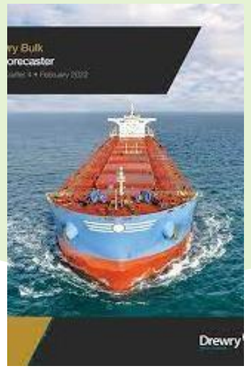


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## Methanol Fuelled Vessels on the Water and on the Way

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

**Netherlands (February 2023)**

Dutch fuel producer OCI and barge operator Unibarge have developed a dual-fuel methanol bunker barge, which will be deployed at the Port of Rotterdam in the second half of 2024.

**USA (February 2023)**

Advent Technologies will develop a 50kW-500kW marine fuel cell solution for a range of superyachts, providing a sustainable and reliable source of auxiliary power and improving power density.

**Netherlands (February 2023)**

Dutch short sea shipping company Vertom Group has ordered two dry cargo vessels with a modular electric propulsion system ready for methanol-electric operation.

**France (February 2023)**

French liner giant CMA CGM has ordered an additional six 15,000 TEU container ship dual-fuel methanol newbuidings for delivery in 2025 and 2026, this brings CMA CGM's total order to 12 methanol ships.

**Switzerland (February 2023)**

Proman and HMMsign MOU explore future methanol supply for HMM's new order of nine methanol dual-fuel 9,000-teu newbuildings.

MI@methanol.org | www.methanol.org

@MethanolToday





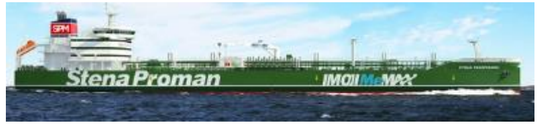








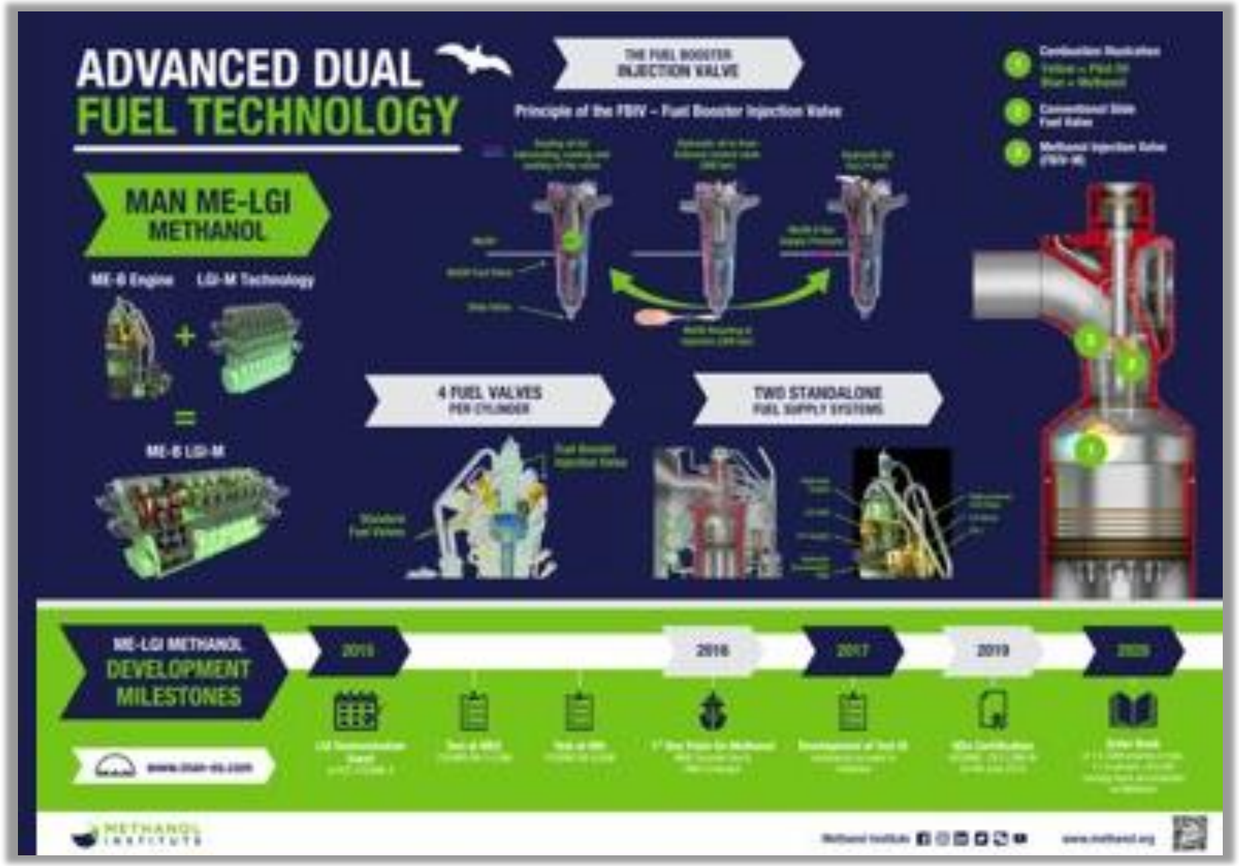




www.methanol.org/join-us

www.methanol.org/marine/

# Engines Available and More Coming



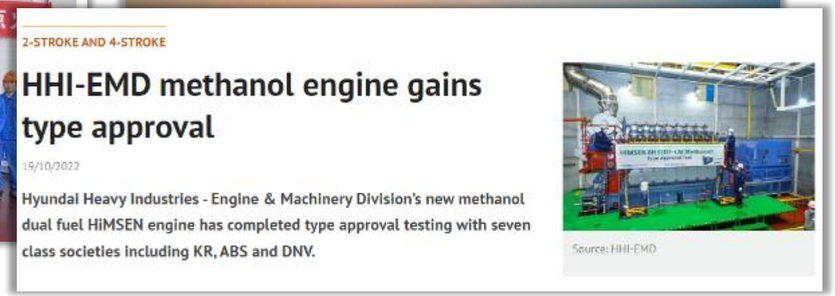












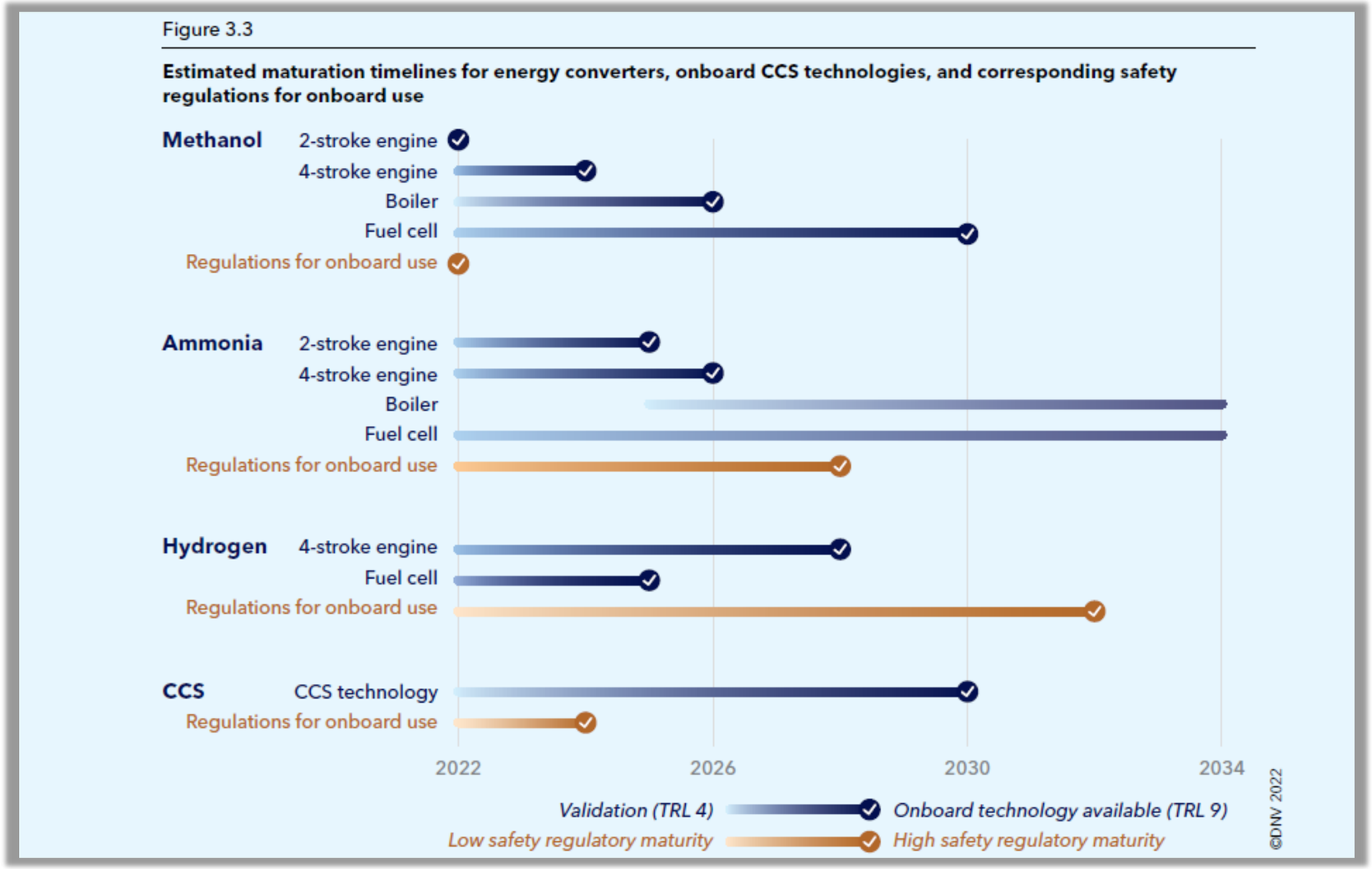

*Since 2016, MAN has received orders for 110 large, two-stroke methanol engines, with 24 already in operation in chemical tankers operated by MI members. Another 100+ engine orders on the way!!!*

# Maritime Partners/E1 Marine



- The world's first methanol-fueled towboat is set to join the fleet of Metairie, La., based Maritime Partners LLC and become available for charter in 2023 to meet the pressing demand for sustainable towboat operations.
- The vessel, the M/V Hydrogen One, will be IMO 2030 compliant, meet the USCG's Subchapter M requirements, and have an operational range of 550 miles before refueling. It is being developed by Maritime Partners in cooperation with Elliott Bay Design Group, e1 Marine, and ABB.
- Decarbonizing the towboat sector poses substantial challenges, particularly due to towboats' inherent size, space, and weight limitations. Batteries are only suitable for boats that operate on fixed routes and can recharge daily, and a towboat's limited storage capacity restricts the use of pressurized or cryogenically stored gases as fuels. There are also very few dockside facilities to load such marine fuels, which severely constrains a vessel's range and functionality.
- The ship has been designed by Elliott Bay Design Group using proven, efficient technology throughout, from ABB's electrical power distribution and automation to e1 Marine's methanol-to-hydrogen fuel cell.

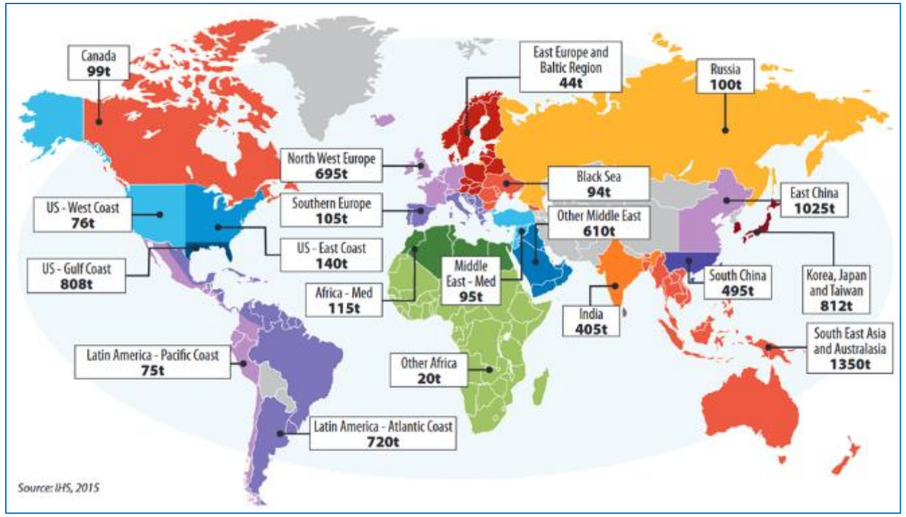
# Technology Readiness



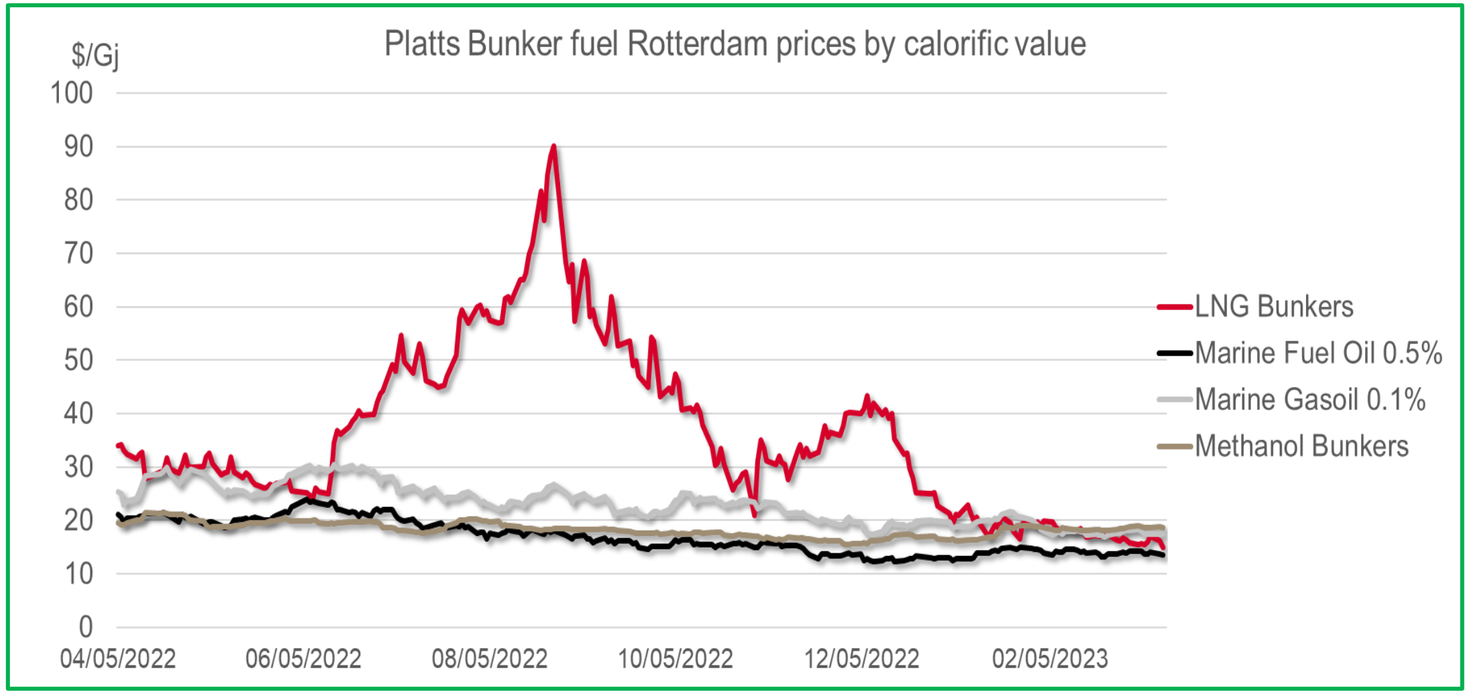

https://www.dnv.com/maritime/publications/maritime-forecast-2022/index.html

# Available and Affordable

*Methanol Trading Hubs – Storage Capacity*








*Friday 17 March – S&P Methanol*

**Rotterdam Spot = €335/tonne**

# Easily Bunkered



First dual-fuel methanol bunker barge headed for Rotterdam

by Mariska Buitendijk | Feb 3, 2023 | Emissions, Energy transition, Inland navigation, Marine fuels, News, Ports, Shipping

OCI and Unibarge have joined forces to develop Europe's first dual-fuelled green methanol bunker barge, driving cleaner shipping. The vessel will be deployed at the Port of Rotterdam in 2024.

## Global Energy Group orders first methanol bunkering tanker for Singapore

Japanese newbuilding could pave the way to a new generation of versatile bunkering tankers

3 November 2022 5:41 GMT *UPDATED 3 November 2022 8:47 GMT*

By Jonathan Goonzaier in Singapore

# Marine Spills Still Happen….

**Methanol [5]**
**15,400 mg/l**

- Methanol is a more environmentally-benign fuel in marine environments
- In a waterbody, nearly 200 times more methanol is needed to kill half the number of fish than marine heavy fuel oil

## LC 50: Lethal Dose: Fish

| Gasoline [1] | Methane [2] | Diesel [3] | Heavy Fuel Oil [4] | Ammonia[6] |
|---|---|---|---|---|
| 8,2 mg/l | 49,9 mg/l | 65 mg/l | 79 mg/l | 0.068 mg/l |

Sources:
[1] Petrobras/Statoil ASA, Safety Data Sheet, ECHA registration dossier Gasoline
[2] ECHA, European Chemicals Agency, registration dossier Methane
[3] ECHA, European Chemical Agency, registration dossier Diesel
[4] GKG/ A/S Dansk Shell, Safety Data Sheet
[5] ECHA, European Chemical Agency, registration dossier Methanol
[6] ECHA, European Chemical Agency, registration dossier Ammonia

# 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.

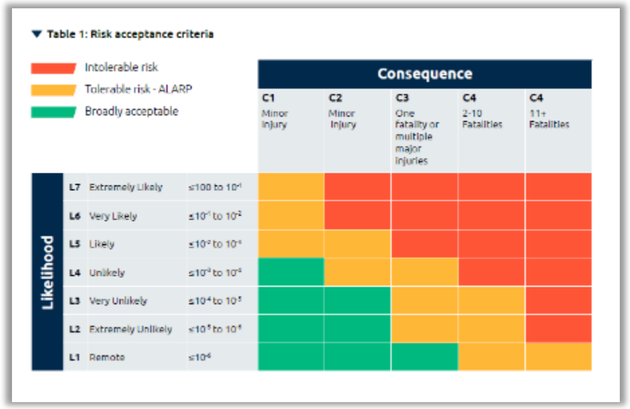


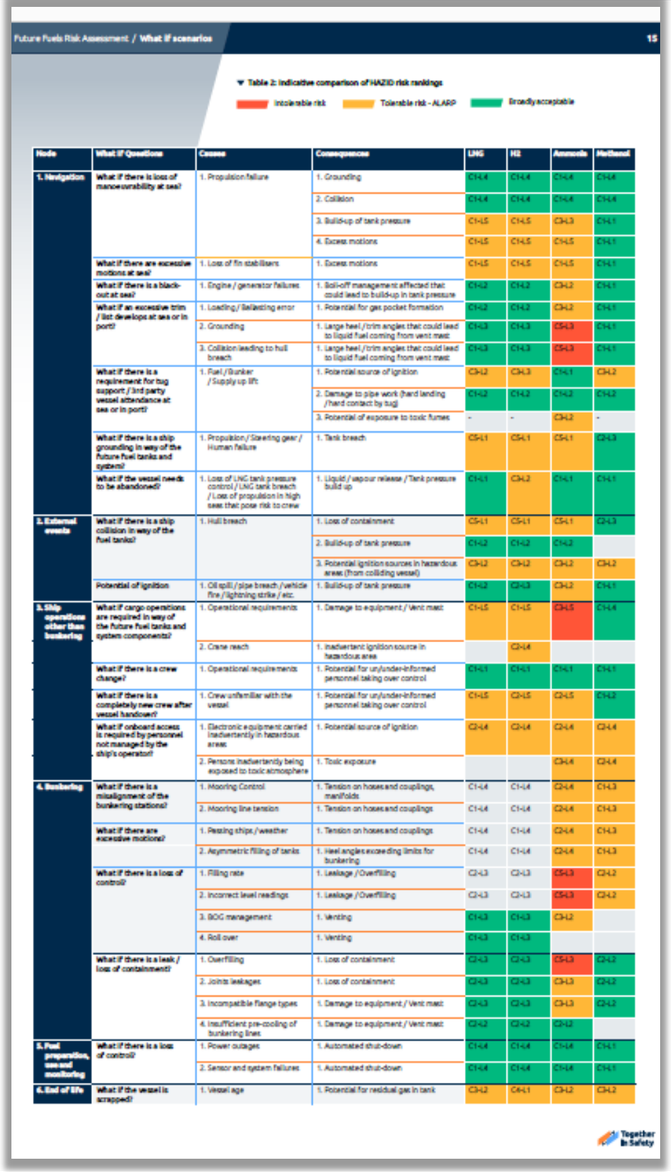
Table 1: Risk acceptance criteria

Intolerable risk
Tolerable risk - ALARP
Broadly acceptable

| Likelihood | | | Consequence C1 Minor injury | C2 Minor injury | C3 One fatality or multiple major injuries | C4 2-10 Fatalities | C4 11+ Fatalities |
|---|---|---|---|---|---|---|---|
| L7 | Extremely Likely | ≤100 to $10^{-1}$ | | | | | |
| L6 | Very Likely | ≤$10^{-1}$ to $10^{-2}$ | | | | | |
| L5 | Likely | ≤$10^{-2}$ to $10^{-3}$ | | | | | |
| L4 | Unlikely | ≤$10^{-3}$ to $10^{-4}$ | | | | | |
| L3 | Very Unlikely | ≤$10^{-4}$ to $10^{-5}$ | | | | | |
| L2 | Extremely Unlikely | ≤$10^{-5}$ to $10^{-6}$ | | | | | |
| L1 | Remote | ≤$10^{-6}$ | | | | | |

**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



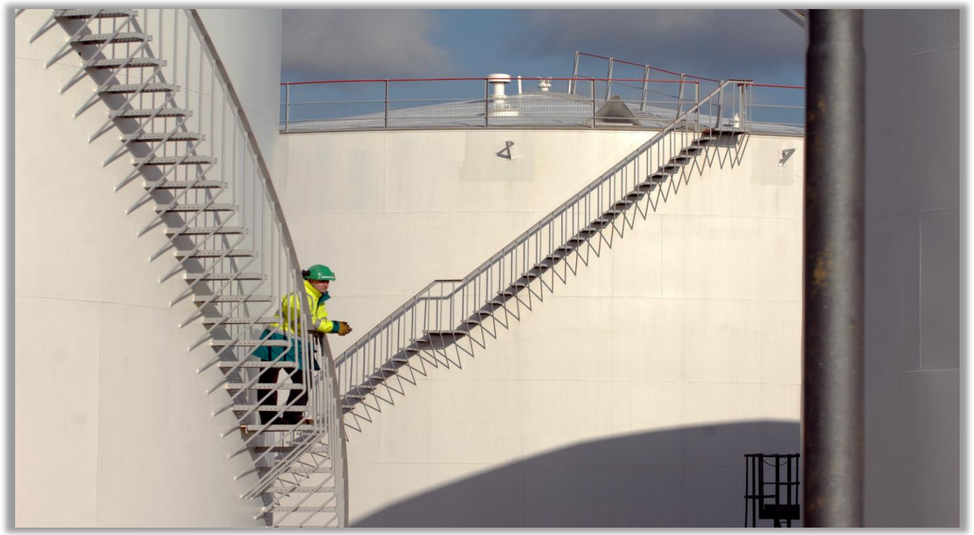
Future Fuels Risk Assessment / What if scenarios 15

Table 2: Indicative comparison of HAZID risk rankings

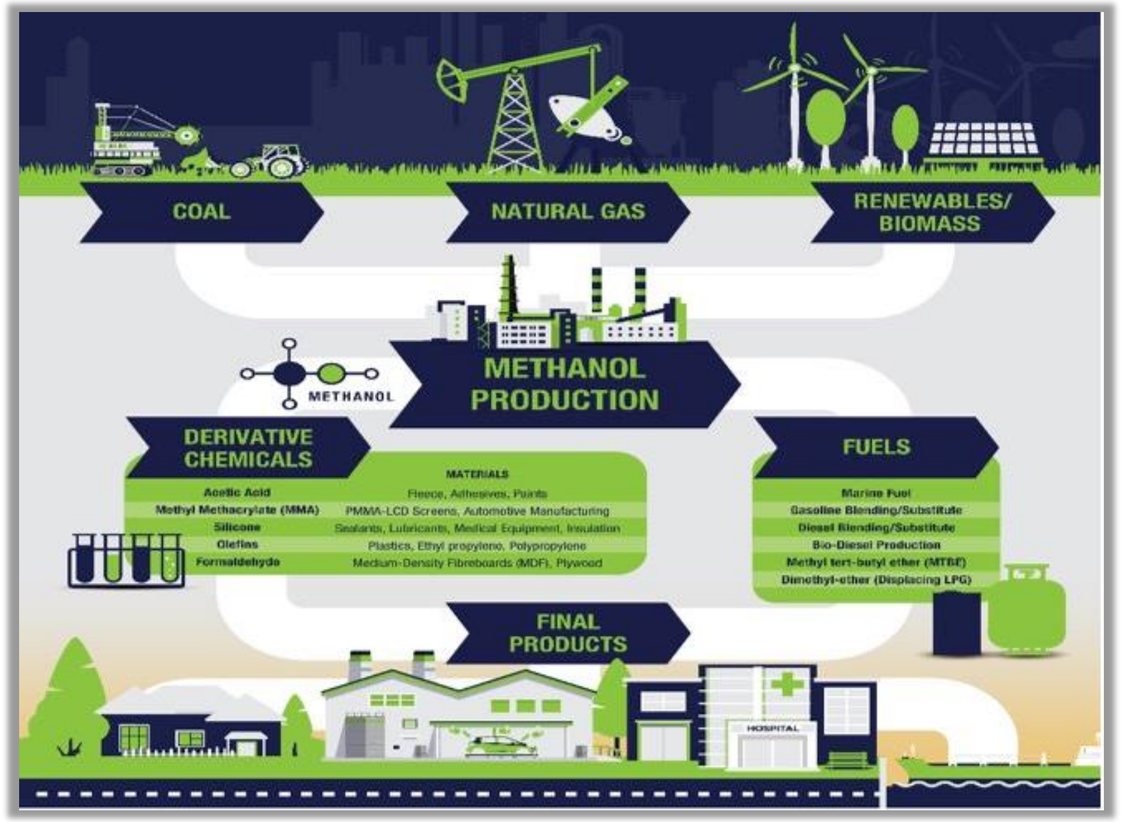
Intolerable risk | Tolerable risk - ALARP | Broadly acceptable

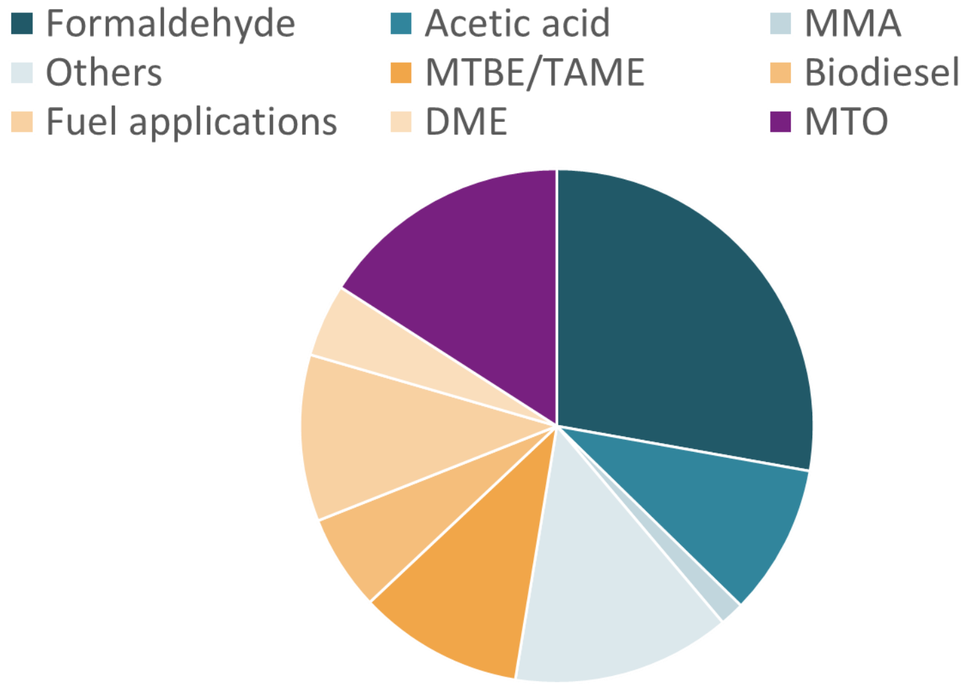
| Node | What if Question | Causes | Consequences | LNG | H2 | Ammonia | Methanol |
|---|---|---|---|---|---|---|---|
| 1. Navigation | What if there is loss of manoeuvrability at sea? | 1. Propulsion failure | 1. Grounding | C1-L4 | C1-L4 | C1-L4 | C1-L4 |
| | | | 2. Collision | C1-L4 | C1-L4 | C1-L4 | C1-L4 |
| | | | 3. Build-up of tank pressure | C1-L5 | C1-L5 | C3-L3 | C1-L1 |
| | | | 4. Excess motions | C1-L5 | C1-L5 | C1-L5 | C1-L1 |
| | What if there are excessive motions at sea? | 1. Loss of fin stabilisers | 1. Excess motions | C1-L5 | C1-L5 | C1-L5 | C1-L1 |
| | What if there is a black-out at sea? | 1. Engine / generator failures | 1. Sol-off management affected that could lead to build-up in tank pressure | C1-L2 | C1-L2 | C3-L2 | C1-L1 |
| | What if an excessive trim / list develops at sea or in port? | 1. Loading / Ballasting error | 1. Potential for gas pocket formation | C1-L2 | C1-L2 | C3-L2 | C1-L1 |
| | | 2. Grounding | 1. Large heel / trim angles that could lead to liquid fuel coming from vent mast | C1-L3 | C1-L3 | C3-L3 | C1-L1 |
| | | 3. Collision leading to hull breach | 1. Large heel / trim angles that could lead to liquid fuel coming from vent mast | C1-L3 | C1-L3 | C3-L3 | C1-L1 |
| | What if there is a requirement for tug support / 3rd party vessel attendance at sea or in port? | 1. Fuel / Bunker / Supply up lift | 1. Potential source of ignition | C3-L2 | C3-L3 | C3-L1 | C3-L2 |
| | | | 2. Damage to pipe work (hard landing / hard contact by tug) | C1-L2 | C1-L2 | C1-L2 | C1-L2 |
| | | | 3. Potential of exposure to toxic fumes | - | - | C3-L2 | - |
| | What if there is a ship grounding in way of the future fuel tanks and systems? | 1. Propulsion / Steering gear / Human failure | 1. Tank breach | C5-L1 | C5-L1 | C5-L1 | C2-L3 |
| | What if the vessel needs to be abandoned? | 1. Loss of LNG tank pressure control / LNG tank breach / Loss of propulsion in high seas that pose risk to crew | 1. Liquid / vapour release / Tank pressure build up | C1-L1 | C3-L2 | C1-L1 | C1-L1 |
| 2. External events | What if there is a ship collision in way of the fuel tanks? | 1. Hull breach | 1. Loss of containment | C5-L1 | C5-L1 | C5-L1 | C2-L3 |
| | | | 2. Build-up of tank pressure | C1-L2 | C1-L2 | C1-L2 | |
| | | | 3. Potential ignition sources in hazardous areas (from colliding vessel) | C3-L2 | C3-L2 | C3-L2 | C3-L2 |
| | Potential of ignition | 1. Oil spill / pipe breach / vehicle fire / lightning strike / etc. | 1. Build-up of tank pressure | C1-L2 | C2-L3 | C3-L2 | C1-L1 |
| 3. Ship operations other than bunkering | What if cargo operations are required in way of the future fuel tanks and system components? | 1. Operational requirements | 1. Damage to equipment / Vent mast | C1-L5 | C1-L5 | C3-L5 | C1-L4 |
| | | 2. Crane reach | 1. Inadvertent ignition source in hazardous area | | C2-L4 | | |
| | What if there is a crew change? | 1. Operational requirements | 1. Potential for un/under-informed personnel taking over control | C1-L1 | C1-L1 | C1-L1 | C1-L1 |
| | What if there is a completely new crew after vessel handover? | 1. Crew unfamiliar with the vessel | 1. Potential for un/under-informed personnel taking over control | C1-L5 | C2-L5 | C2-L5 | C1-L2 |
| | What if onboard access is required by personnel not manage d by the ship's operator? | 1. Electronic equipment carried inadvertently in hazardous areas | 1. Potential source of ignition | C2-L4 | C2-L4 | C2-L4 | C2-L4 |
| | | 2. Persons inadvertently being exposed to toxic atmosphere | 1. Toxic exposure | | | C3-L4 | C2-L4 |
| 4. Bunkering | What if there is a misalignment of the bunkering stations? | 1. Mooring Control | 1. Tension on hoses and couplings, manifolds | C1-L4 | C1-L4 | C2-L4 | C1-L3 |
| | | 2. Mooring line tension | 1. Tension on hoses and couplings | C1-L4 | C1-L4 | C2-L4 | C1-L3 |
| | What if there are excessive motions? | 1. Passing ships / weather | 1. Tension on hoses and couplings | C1-L4 | C1-L4 | C2-L4 | C1-L3 |
| | | 2. Asymmetric filling of tanks | 1. Heel angles exceeding limits for bunkering | C1-L4 | C1-L4 | C2-L4 | C1-L3 |
| | What if there is a loss of control? | 1. Filling rate | 1. Leakage / Overfilling | C2-L3 | C2-L3 | C3-L3 | C2-L2 |
| | | 2. Incorrect level readings | 1. Leakage / Overfilling | C2-L3 | C2-L3 | C3-L3 | C2-L2 |
| | | 3. BOG management | 1. Venting | C1-L3 | C1-L3 | C3-L2 | |
| | | 4. Roll over | 1. Venting | C1-L3 | C1-L3 | | |
| | What if there is a leak / loss of containment? | 1. Overfilling | 1. Loss of containment | C2-L3 | C2-L3 | C3-L3 | C2-L2 |
| | | 2. Joints leakages | 1. Loss of containment | C2-L3 | C2-L3 | C3-L3 | C2-L2 |
| | | 3. Incompatible flange types | 1. Damage to equipment / Vent mast | C2-L3 | C2-L3 | C3-L3 | C2-L2 |
| | | 4. Insufficient pre-cooling of bunkering lines | 1. Damage to equipment / Vent mast | C2-L2 | C2-L2 | C3-L2 | |
| 5. Fuel preparation, use and monitoring | What if there is a loss of control? | 1. Power outages | 1. Automated shut-down | C1-L4 | C1-L4 | C1-L4 | C1-L1 |
| | | 2. Sensor and system failures | 1. Automated shut-down | C1-L4 | C1-L4 | C1-L4 | C1-L1 |
| 6. End of life | What if the vessel is scrapped? | 1. Vessel age | 1. Potential for residual gas in tank | C3-L2 | C4-L1 | C3-L2 | C3-L2 |

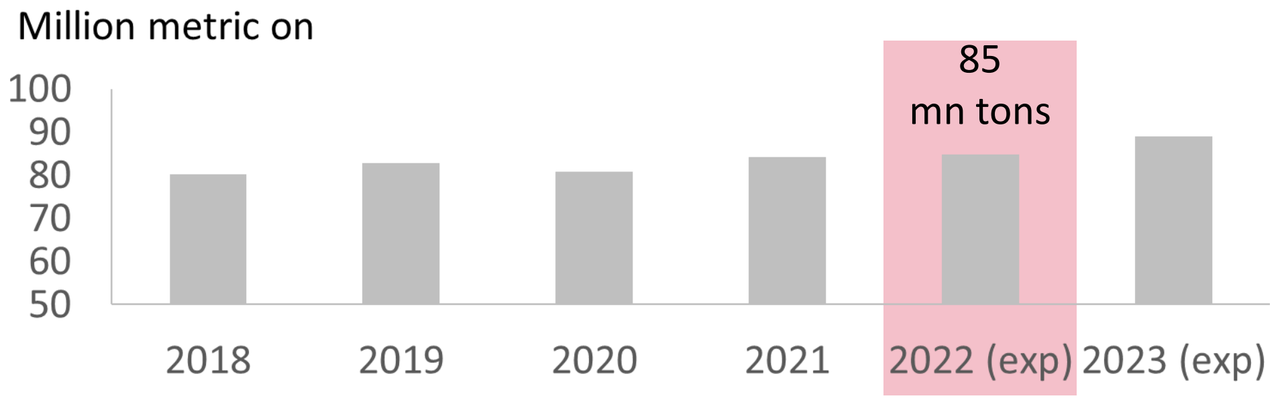
# Methanol Supply



# Essential Methanol

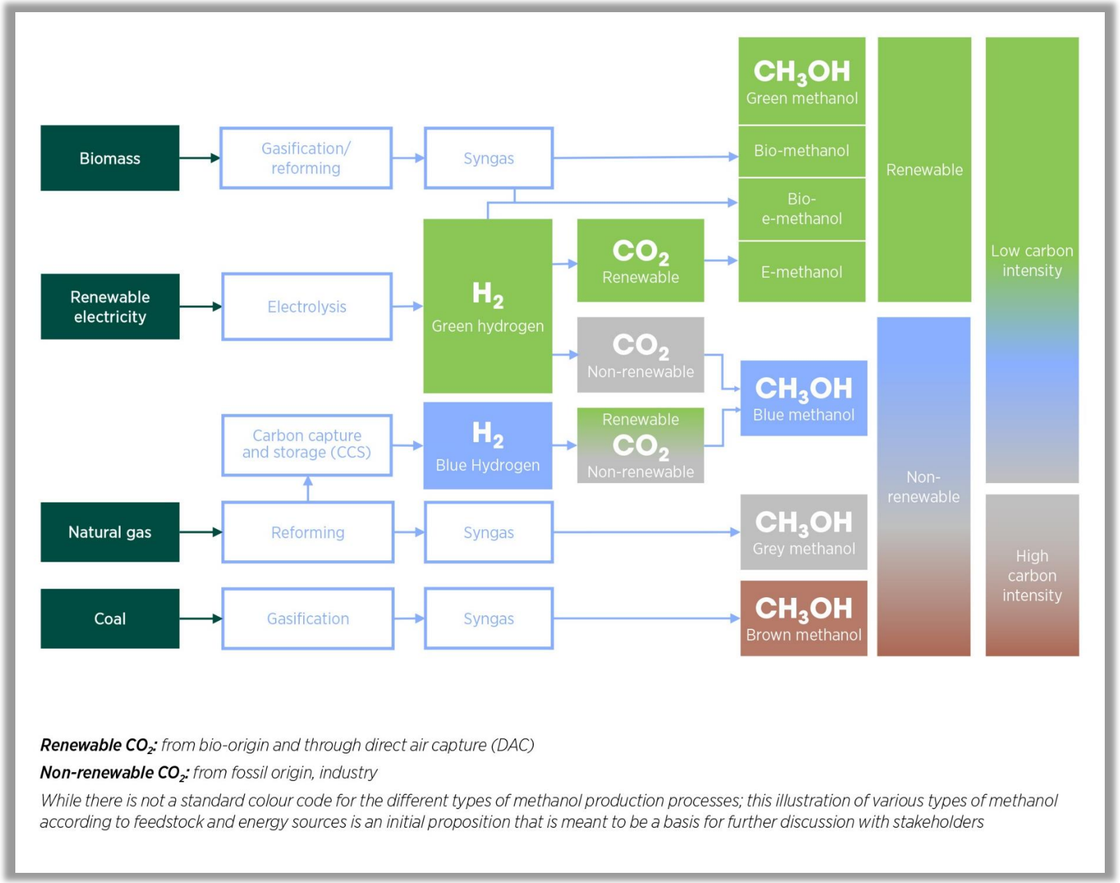



Source: S&P Commodity Insights

# Grey, Blue and Green




***Renewable $CO_2$:*** *from bio-origin and through direct air capture (DAC)*

***Non-renewable $CO_2$:*** *from fossil origin, industry*

*While there is not a standard colour code for the different types of methanol production processes; this illustration of various types of methanol according to feedstock and energy sources is an initial proposition that is meant to be a basis for further discussion with stakeholders*


## 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

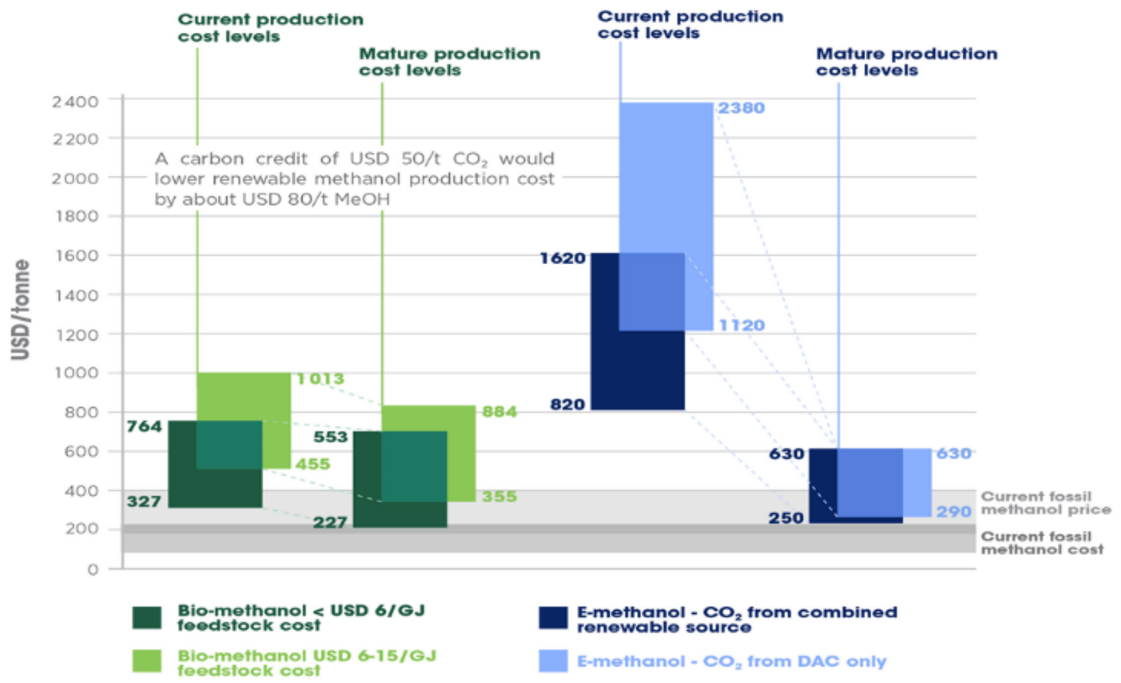
## Bio-methanol

- 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

# MI-IRENA Renewable Methanol

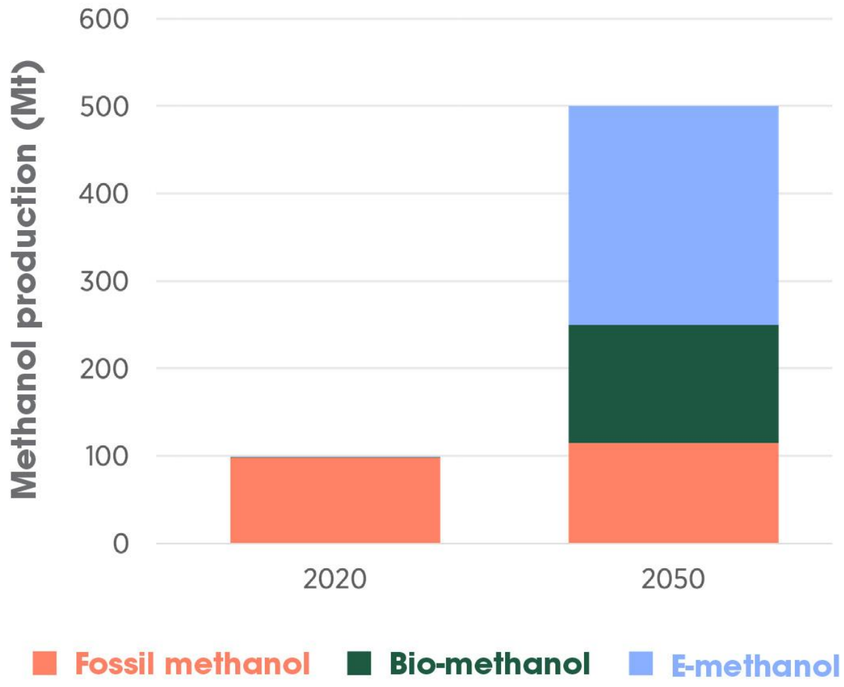
www.methanol.org/renewable/

*Figure 3. Current and future production costs of bio- and e-methanol*



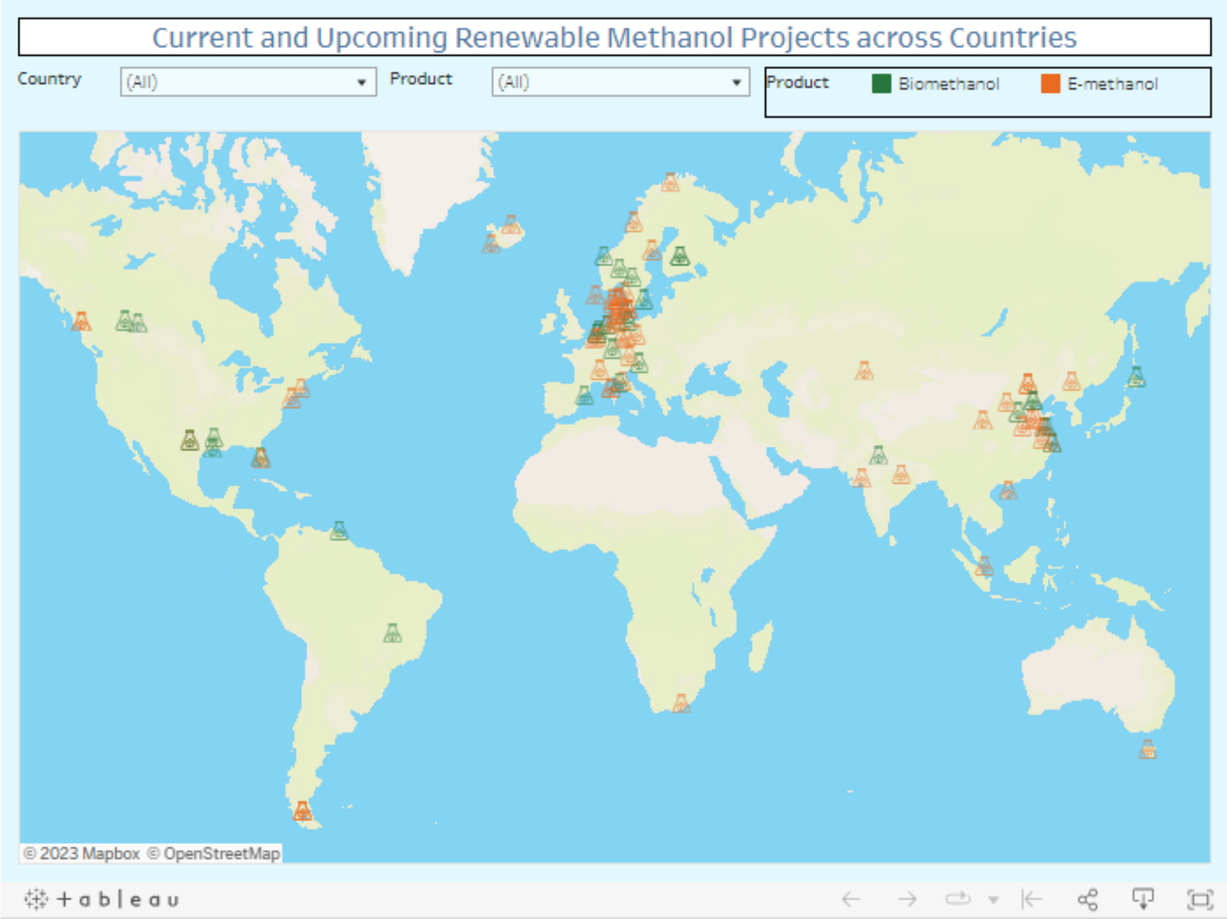

***Notes:*** *MeOH = methanol. Costs do not incorporate any carbon credit that might be available. Current fossil methanol cost and price are from coal and natural gas feedstock in 2020. Exchange rate used in this figure is USD 1 = EUR 0.9.*

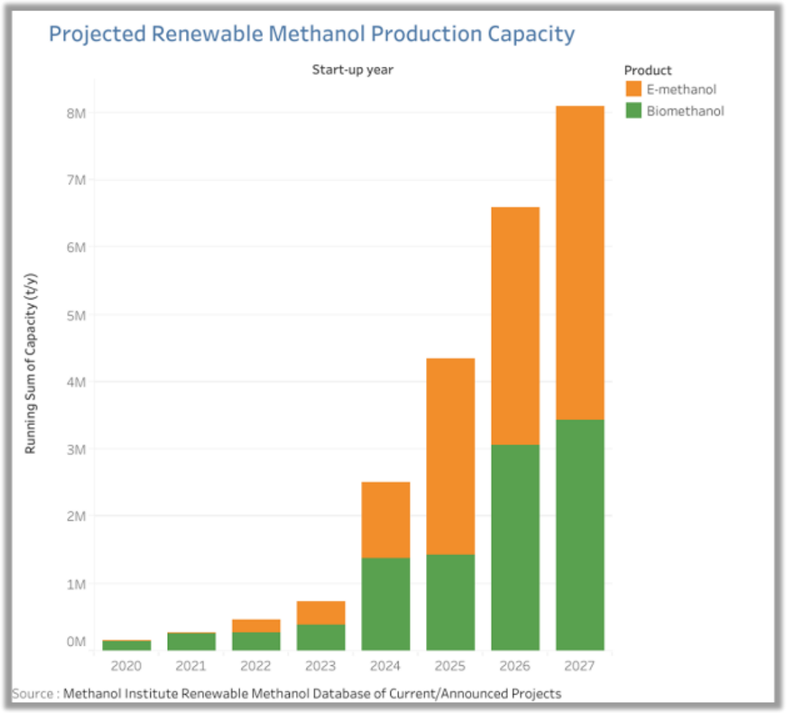
*Figure 47. Current and future methanol production by source*



# Renewable Methanol Tidal Wave

www.methanol.org/renewable/



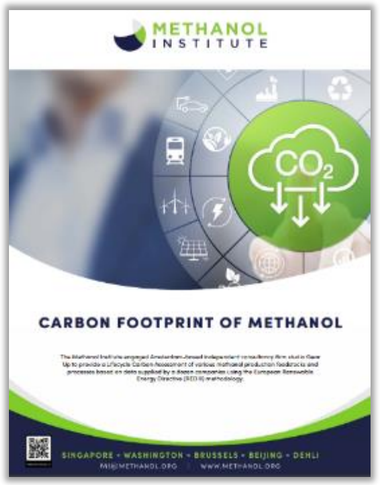

***"With 80 renewable methanol projects already announced, we are seeing clear signs of an incoming wave of bio-methanol and e-methanol production"***
**Gregory Dolan, CEO, Methanol Institute**

https://www.einpresswire.com/article/594328267/methanol-institute-sees-renewable-methanol-production-growth

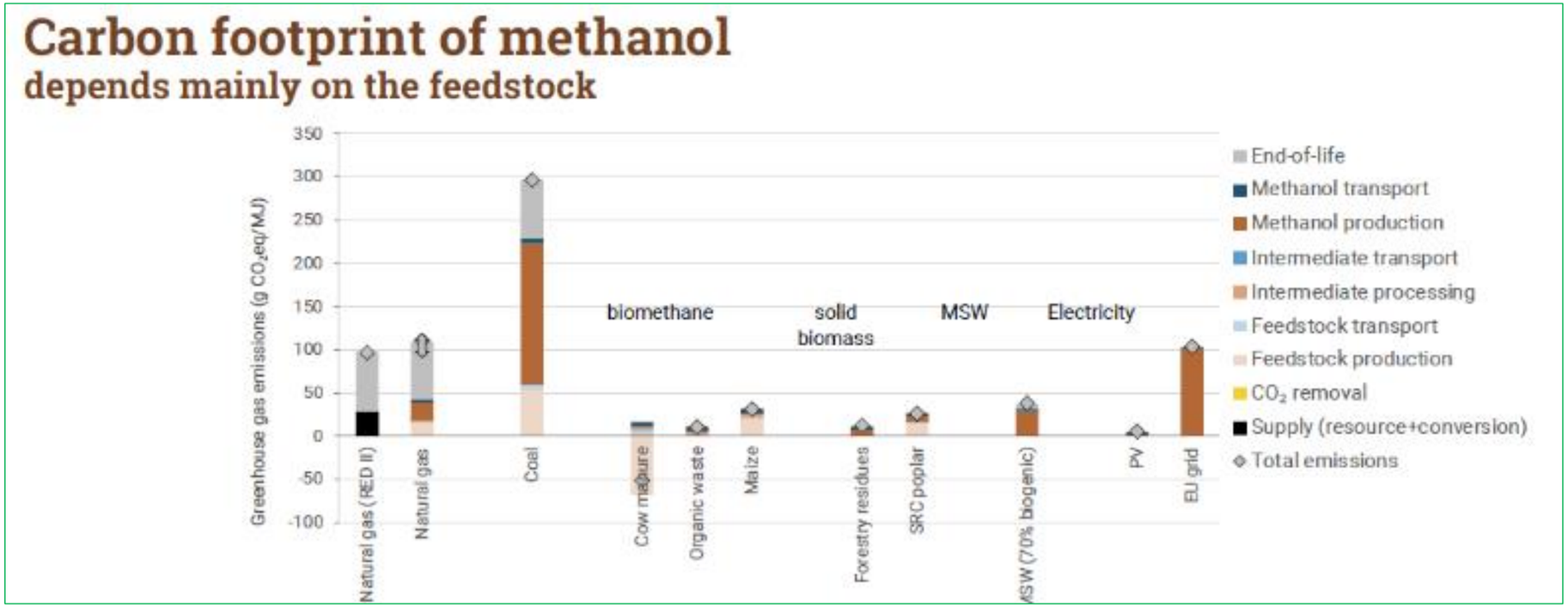
# Increasing Scale – Bigger Players

- 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, TotalEngines as well as Chevron, ExxonMobil, and Sinopec

# GHG Intensity Accounting




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




- In January 2022, 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 65-95%, and even negative CI score from cow manure
- ***Call to Action: Need to develop a common platform for GHG intensity accounting***

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