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Methanol-to-Jet: *About Methanol*

Gregory Dolan, CEO

CAAFI Webinar -- 25 JULY 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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Methanol-to-Jet in Headlines

METHANOL INSTITUTE

SAF Investor NEWS LONDON 2024 TOPICS OPINIONS PROJECTS

MASDAR, TOTALENERGIES, SIEMENS ENERGY AND MARUBENI JOIN FORCES FOR METHANOL TO JET PATHWAY

NEWS BY ALASDAIR WHYTE JANUARY 25, 2023 0 PRINT THIS PAGE

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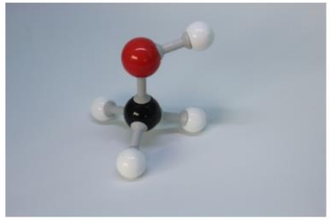

Airport Technology

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News | June 21, 2022

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.

Using its methanol to jet proprietary process technology and catalysts, ExxonMobil converts methanol derived from the gasification of biomass and waste, captured carbon dioxide or lower-carbon hydrogen into SAF.

The Way Point: Honeywell UOP's new methanol-to-jet tech might win it all

May 10, 2023 | Jim Lane

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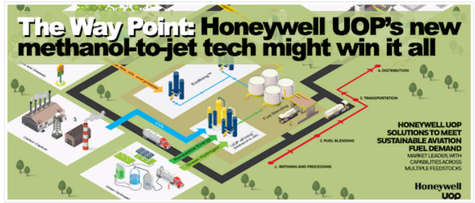

It may be that over the next few decades the most important feedstock for SAF will not be ethanol, or plant oils, but methanol. So it was big news last year when ExxonMobil announced a methanol-to-SAF technology, and even bigger news just now as Honeywell UOP announces a rival technology and a big customer with a tasty deployment timeline. Specifically, eFuels leader HIF Global intends to deploy the new technology to produce eSAF at its second U.S. eFuels facility.

The HIF eSAF project is expected to be the world's largest eSAF facility, recycling approximately 2 million tons of captured CO_2 to make approximately 11,000 barrels per day of eSAF by 2030, or just shy of 170 million gallons per year.

The boldest claim? An 88 percent reduction in GHGs, that's based on CO2 'captured from biomass processing' and green hydrogen.

Renewables Now

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

Danish renewables developer European Energy A/S said today it will partner with Swiss cleantech firm Metafuels AG to develop a methanol-to-jet fuel plant in Denmark.

The plant will use Metafuels' aerobrew technology for the conversion of green methanol to sustainable aviation fuel (SAF).

The Holmen energy park in Denmark. Source: European Energy.

Under a memorandum of understanding, the partners will establish the plant at one of European Energy's Power-to-X-sites in Denmark where the renewables company plans to build a power-to-methanol (e-methanol) production facility.

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

NEWS PROVIDED BY
HIF Global →
10 May, 2023, 07.00 ET

SHARE THIS ARTICLE

HIF intends to produce ~11,000 barrels per day of eSAF by 2030, decarbonizing ~12 billion air passenger miles per year in its second U.S. facility

HOUSTON, May 10, 2023 /PRNewswire/ -- HIF Global, the world's leading eFuels company, today announced agreements with Johnson Matthey and Honeywell to conduct preliminary engineering for HIF's first Sustainable Aviation Fuel (SAF) facility in the United States. The facility would produce approximately 11,000 barrels per day of eSAF, decarbonizing over 12 billion air passenger miles per year.[1]

SAF Investor NEWS LONDON 2024 TOPICS OPINIONS PROJECTS CONT

NACERO SHIFTS FOCUS TO METHANOL-BASED SAF WITH TOPSOE

NEWS BY CONOR FEASEY APRIL 4, 2023 0 PRINT THIS PAGE

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Green Car Congress

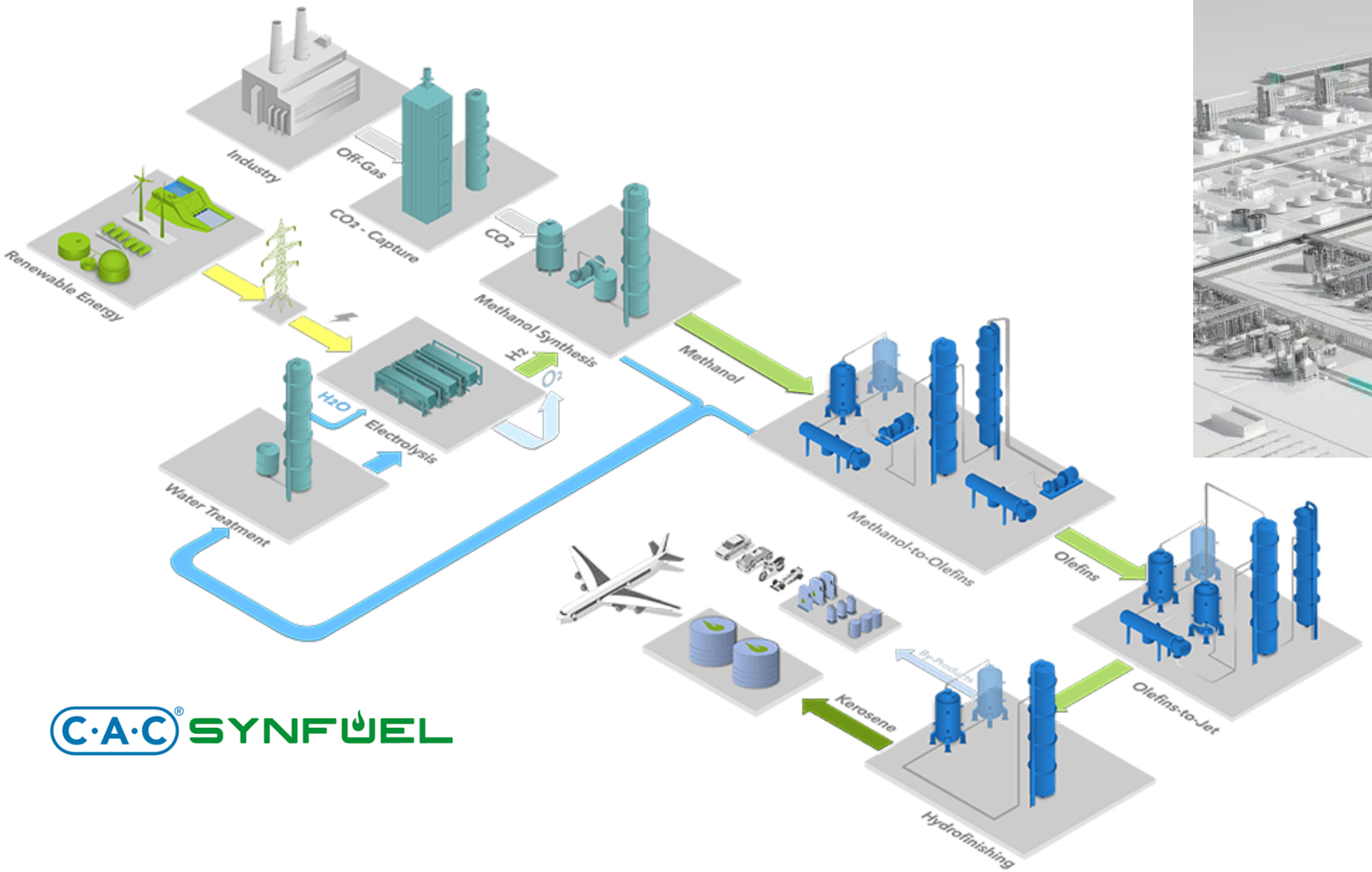
Energy, technologies, issues and policies for sustainable mobility

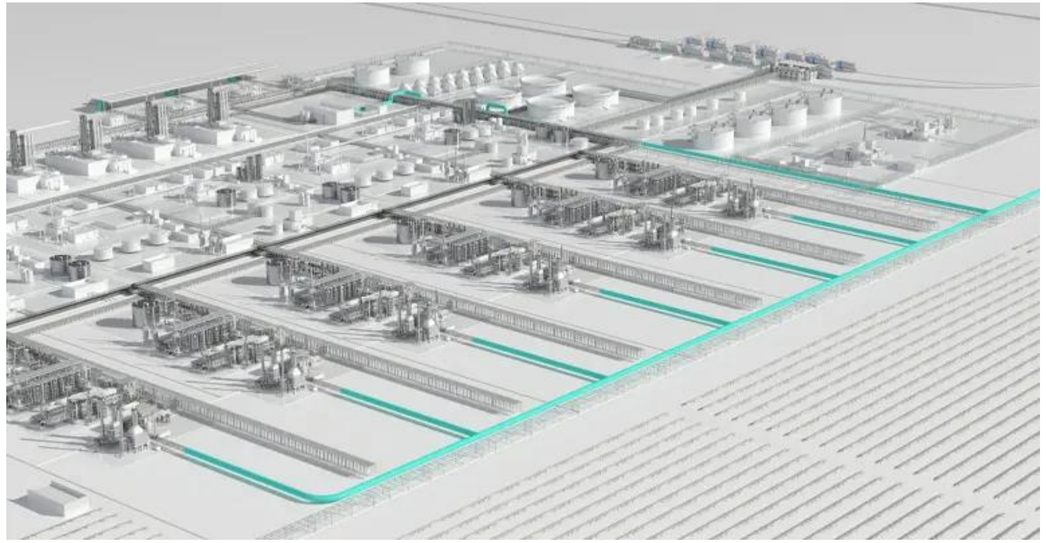
Arcadia eFuels selects Topsoe and Sasol G2L technology for the first commercial eFuels-for-aviation plant in Denmark

11 May 2023

Arcadia eFuels has selected Sasol and Topsoe technologies for its Vordingborg eFuels plant. The signing of the agreement represents a major milestone in maturing the project and ahead of the next major milestone being Arcadia's final investment decision.

Methanol-to-Jet Process



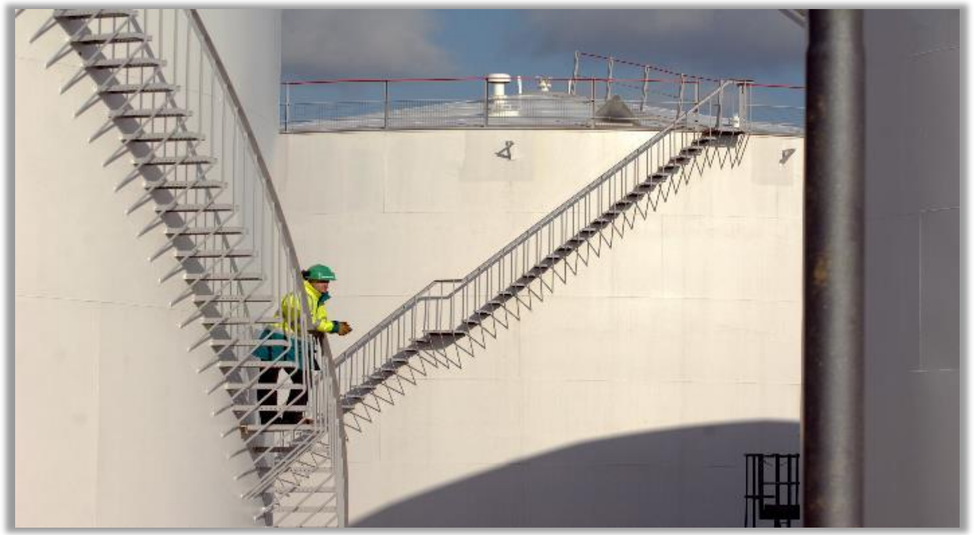


C·A·C SYNFUEL

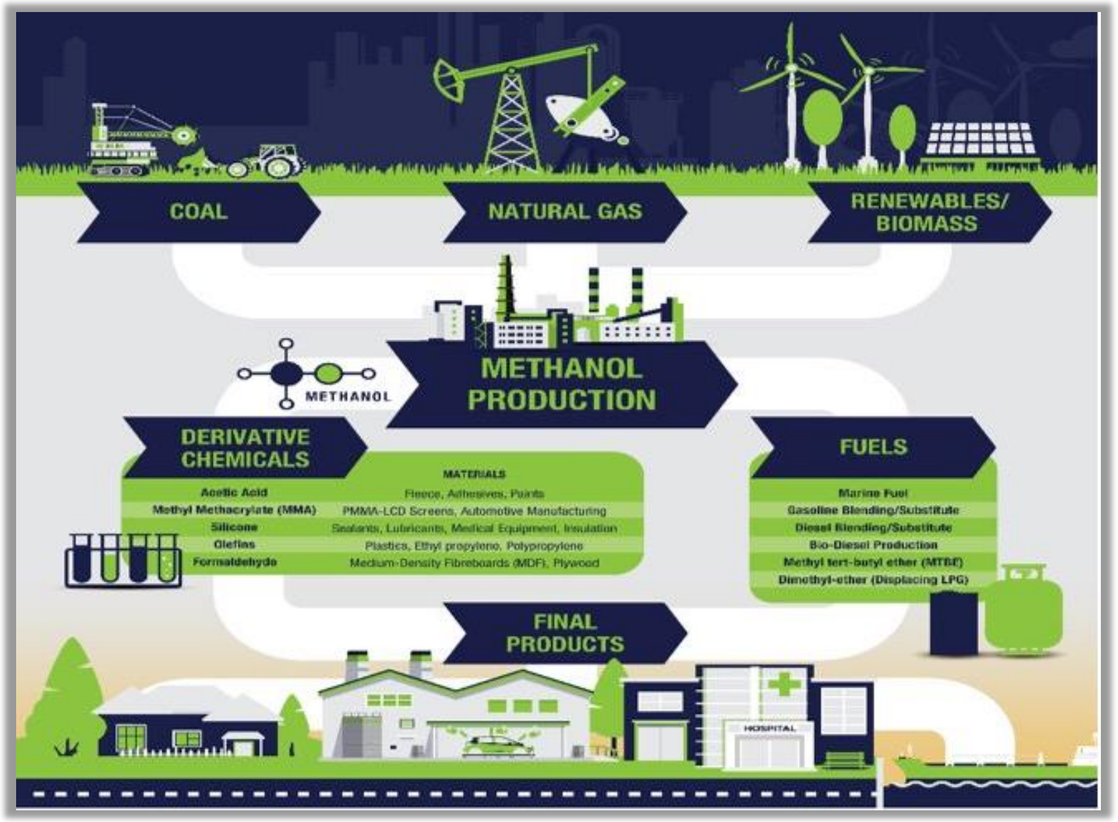
NACERO

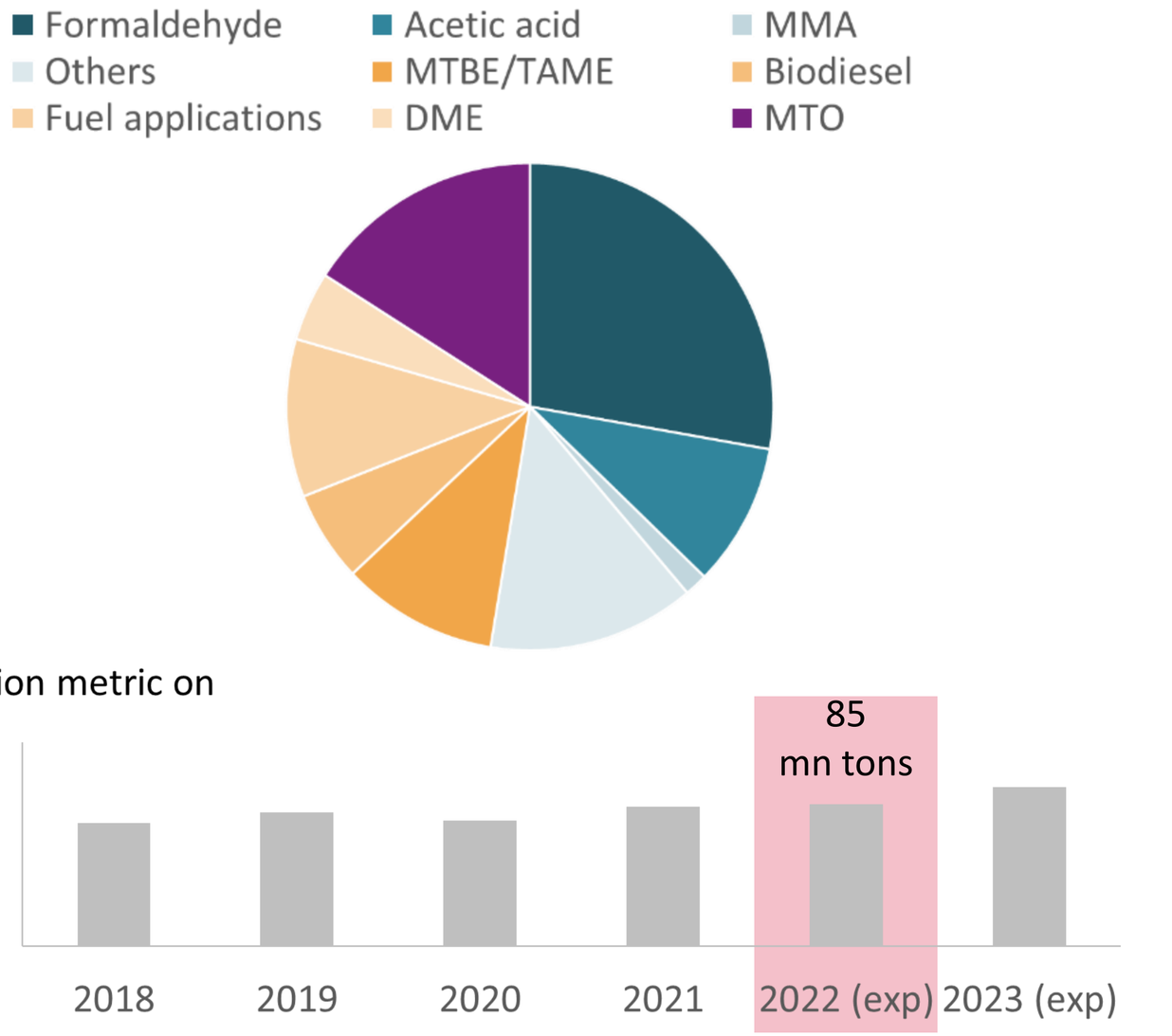
Bio-Methanol or
E-Methanol
to Olefins to SAF

Methanol Supply/Demand



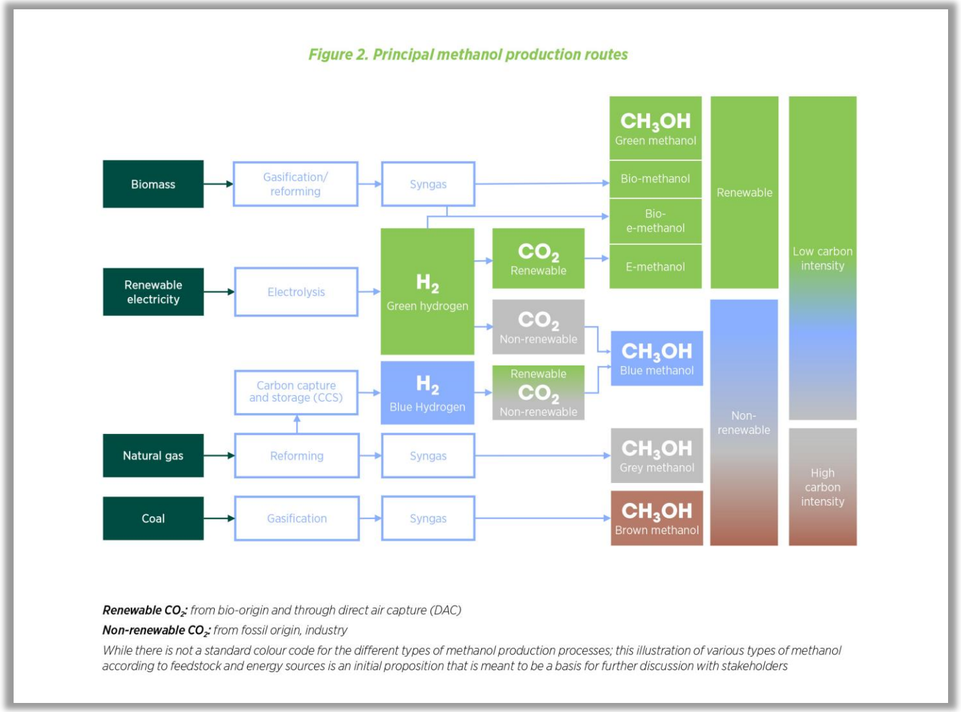
Essential Methanol





Source: S&P Commodity Insights

Low Carbon and Net Carbon-Neutral



https://www.irena.org/publications/2021/Jan/Innovation-Outlook-Renewable-Methanol

All globally traded methanol is produced to the IMPCA Methanol Specification Reference to a minimum purity of 99.85%
https://www.impca.eu/IMPCA/Technical/IMPCA-Documents

E-Methanol

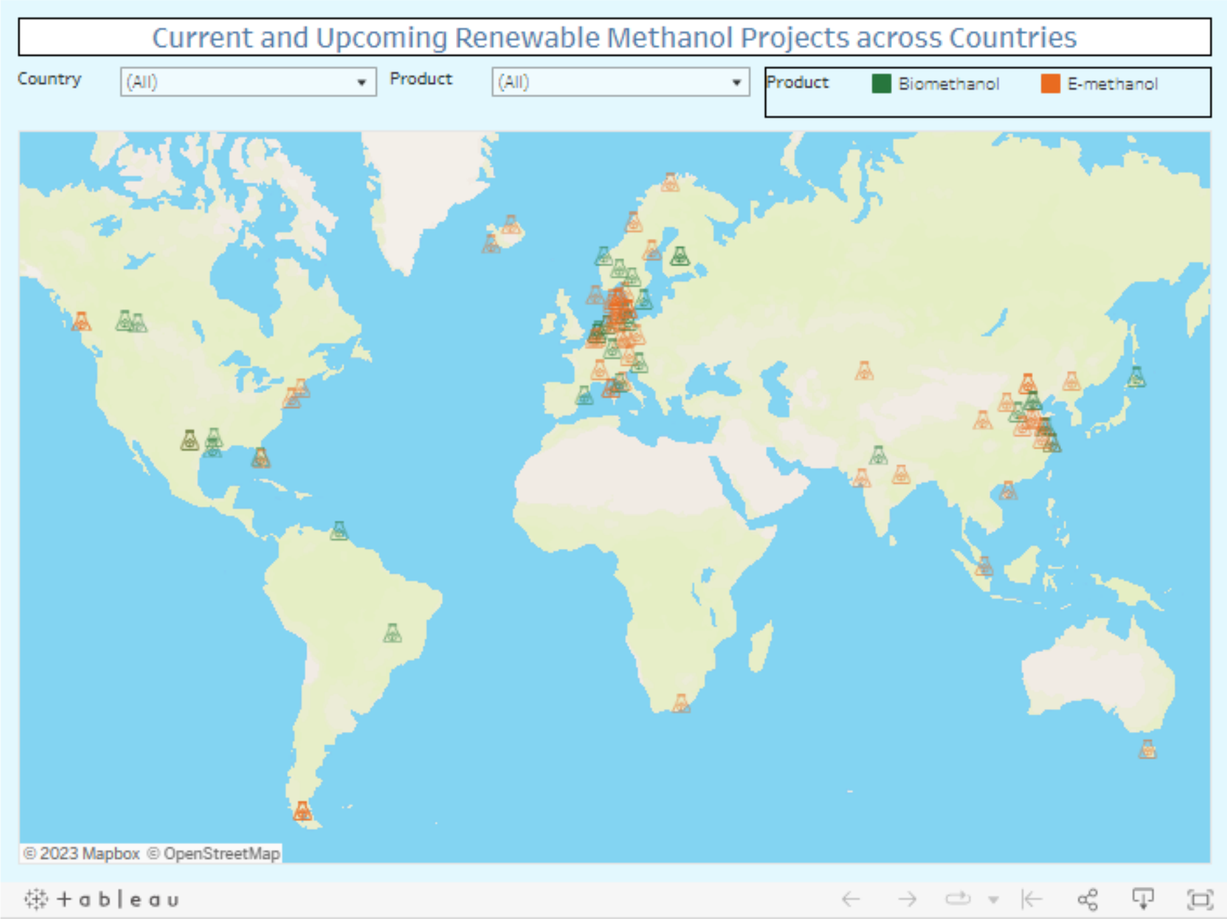
- Feedstocks: green hydrogen and captured CO_2
  - Green hydrogen produced from the electrolysis of water with renewable energy (e.g. solar, wind, geothermal etc.)
  - CO_2 from industrial flue gas (e.g. steel, cement, ethanol), biogenic sources, or direct air capture
- E-methanol is a very-low to net carbon-neutral fuel

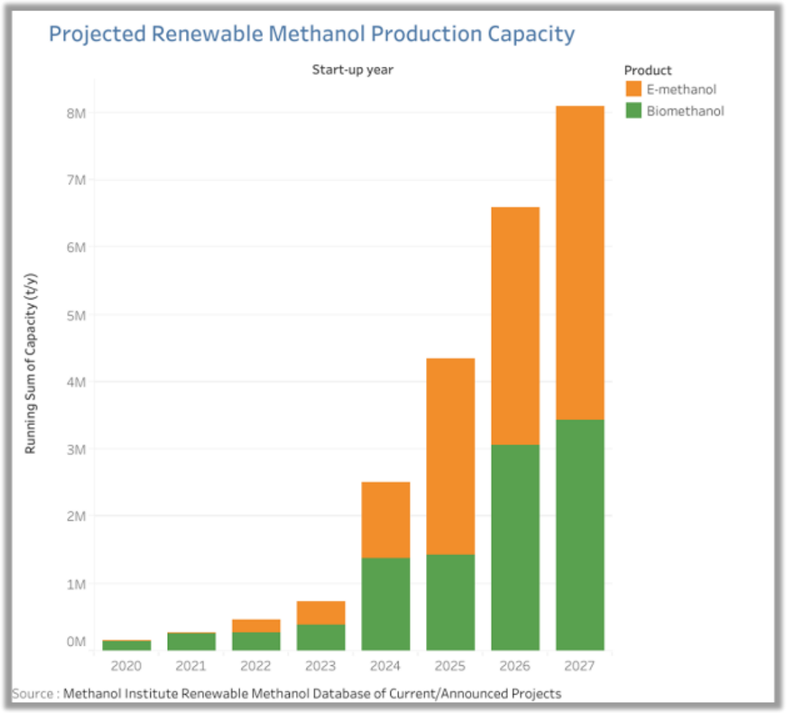
Bio-methanol

- 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

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." **Oct. 2022**
Gregory Dolan, CEO, Methanol Institute

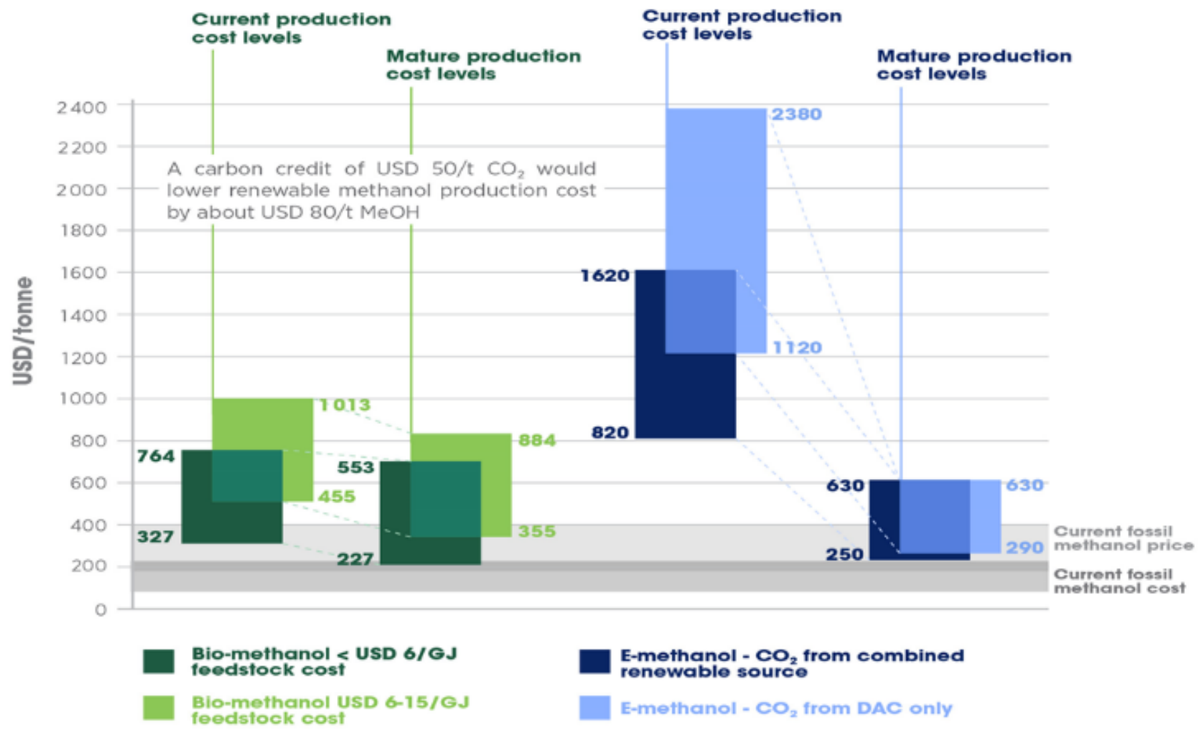
https://www.einpresswire.com/article/594328267/methanol-institute-sees-renewable-methanol-production-growth

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, TotalEnergies as well as Chevron, ExxonMobil, and Sinopec

Renewable Methanol Costs

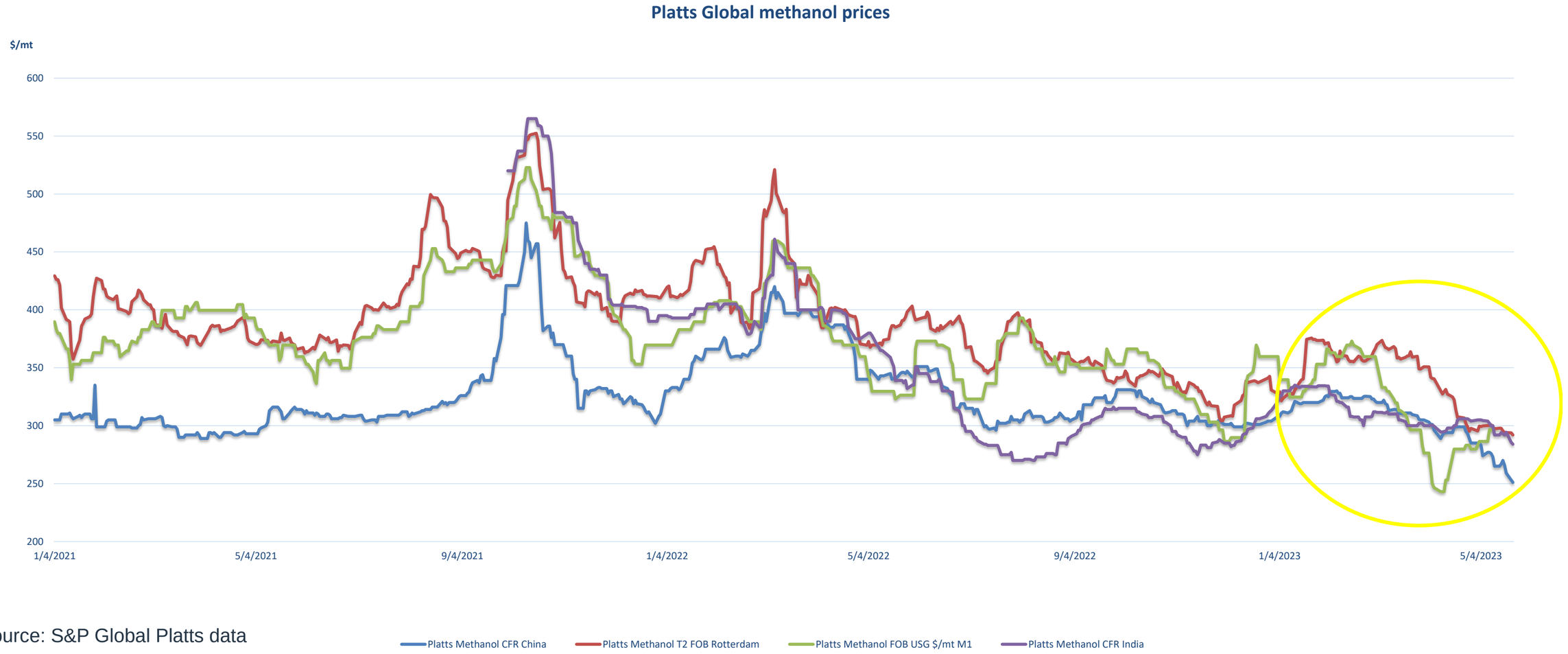
Figure 3. Current and future production costs of bio- and e-methanol



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.*

www.methanol.org/renewable/

Methanol Price Slide



- Source: S&P Global Platts data

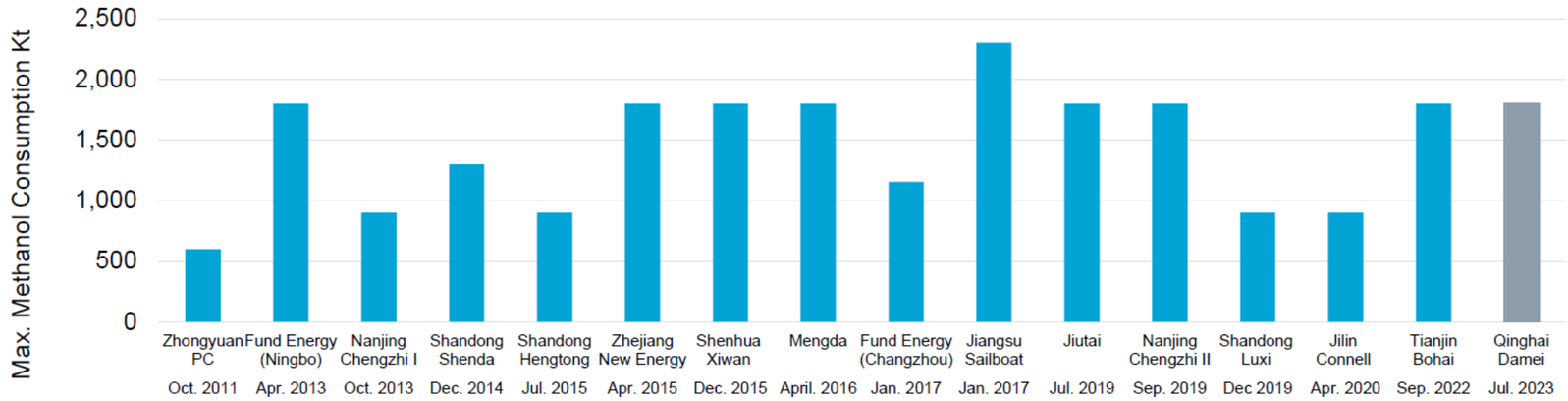
Friday 14 July – US Spot TX GC Barge = $229 mt = $0.69/gallon

Methanol-to-Olefins Plants

MTO Projects Latest Update - New Projects

CHEMICAL MARKET ANALYTICS
BY OPIS, A DOW JONES COMPANY

MTO Facilities 2022



Source: Chemical Market Analytics by OPIS

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

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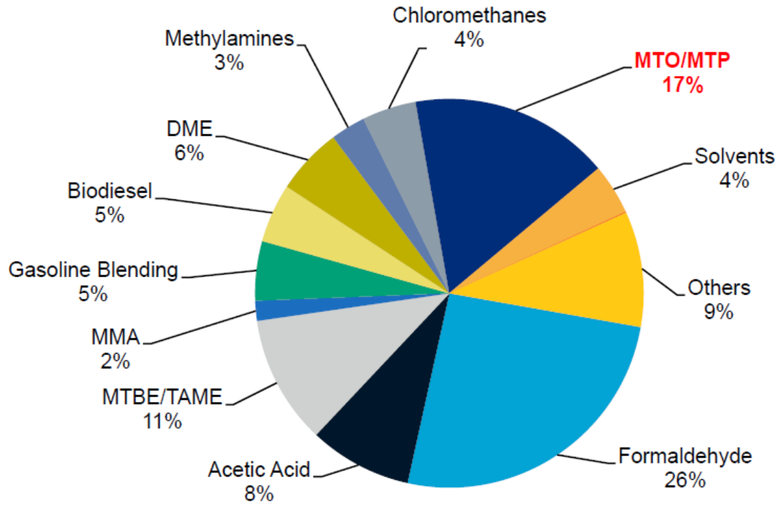
Methanol-to-Olefins Demand

1 in 6 tons of global methanol is consumed by the MTO sector

CHEMICAL MARKET ANALYTICS
BY OPIS, A DOW JONES COMPANY

World: 2022 Methanol Demand by End Use



Demand = 92 Million Metric Tons

Source: Chemical Market Analytics by OPIS

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5

In 2022, China imported 11 million metric tons of methanol – 3.7 billion gallons – largely to support MTO producers

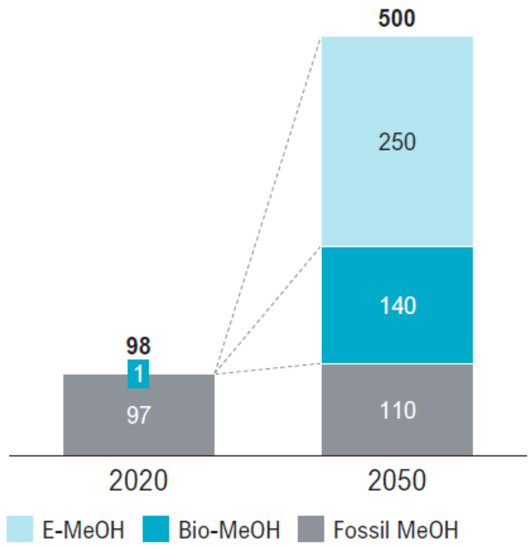
MtJ New Methanol Growth Segment

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

Forecast by IRENA

[million t]



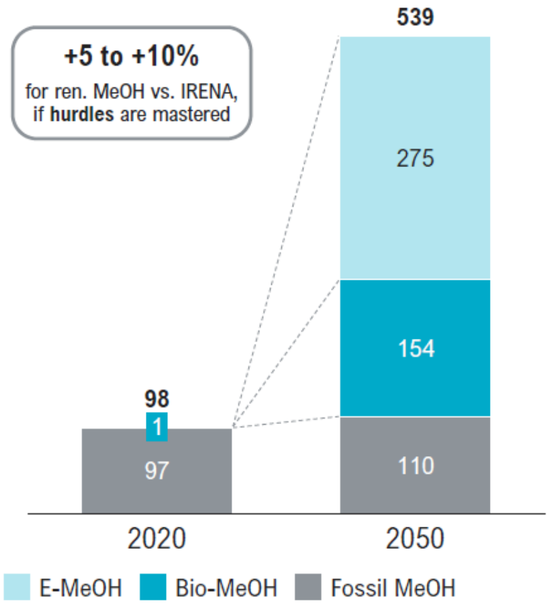
Growth drivers in key segments

Segment	Growth drivers	Outlook (vs. IRENA)
Maritime	• Decarb targets, e.g., IMO • Safe, infrastructure easy handling	↗
Auto	• FC-vehicles in PC limited use, but potential in long-haul HD transport	↗
Aviation	• ASTM approval for MtJ required • Potential for bio- and e-MeOH (PtL)	↗
Power	• Use for off-grid power & heat (direct of via FC solution) • Competes with diesel, LPG, EtOH wind & solar power solutions	→
H2 chain	• Build-up of H2 chains (US, EU, ME) • MeOH robust and safe H2 carrier • MeOH awareness fallen behind NH3	↗
Chemicals	• 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

Updated forecast by Roland Berger

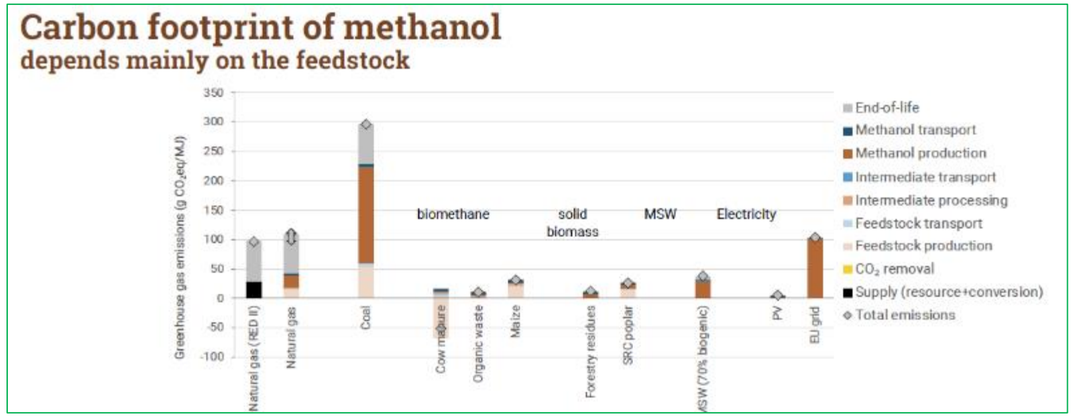
[million t]



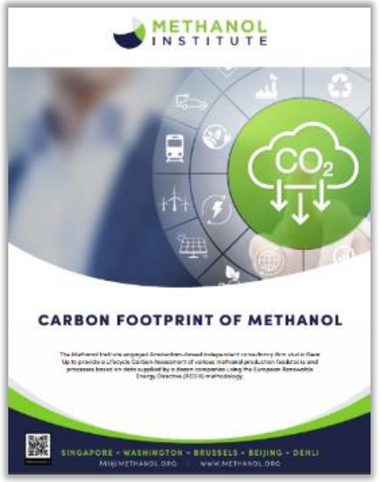
Source: IRENA, Roland Berger

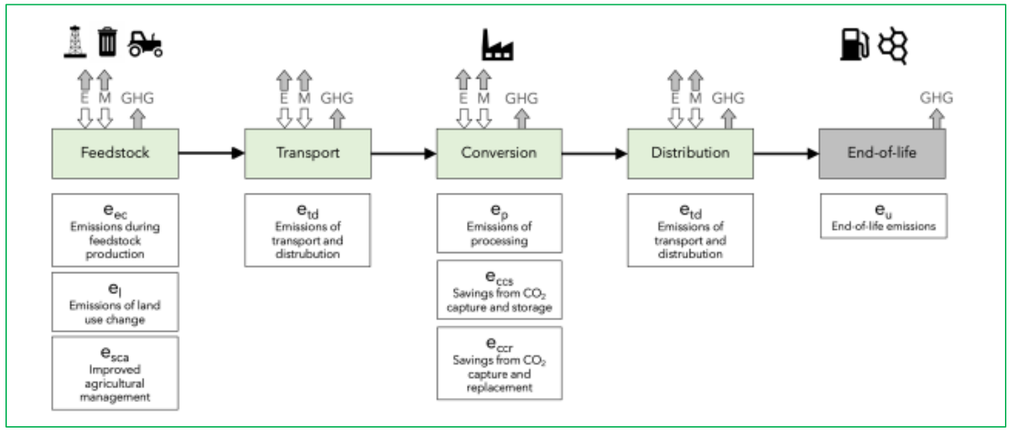
Carbon Intensity Accounting

- 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***

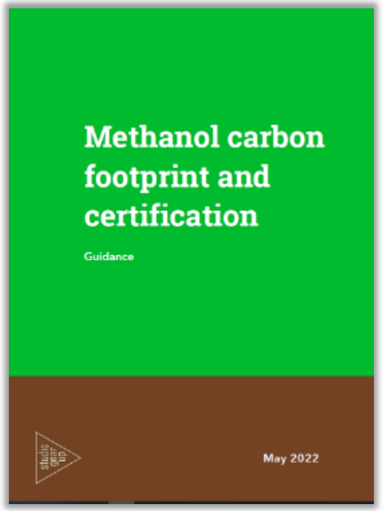


https://www.methanol.org/policy-initiatives/europe/





https://www.impca.eu/IMPCA/Technical/IMPCA-Documents



Marine


SUPERGREEN
Sustainable Shipping
Stena Line
STENA
SSPA
itu.se

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

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Algoma and CSL in for methanol-ready bulker newbuilds

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

Chinese Study Examining Methanol as a Marine Fuel

July 14, 2020

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

THE WALL STREET JOURNAL.

Methanol Takes Lead in Shipping's Quest for Green Fuel

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

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

TradeWinds

CRUISE AND FERRY

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

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

Maersk secures green e-methanol for the first container vessel operating on carbon fuel

Splash247.com

CMA CGM signs for $3bn worth of methanol and LNG powered boxships in China

HMM readies methanol-fuelled newbuilds

Sam Chambers · December 15, 2022

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

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

Methanol newbuilds elbow LNG out of the spotlight in October

08 Nov 2022 by John Snyder

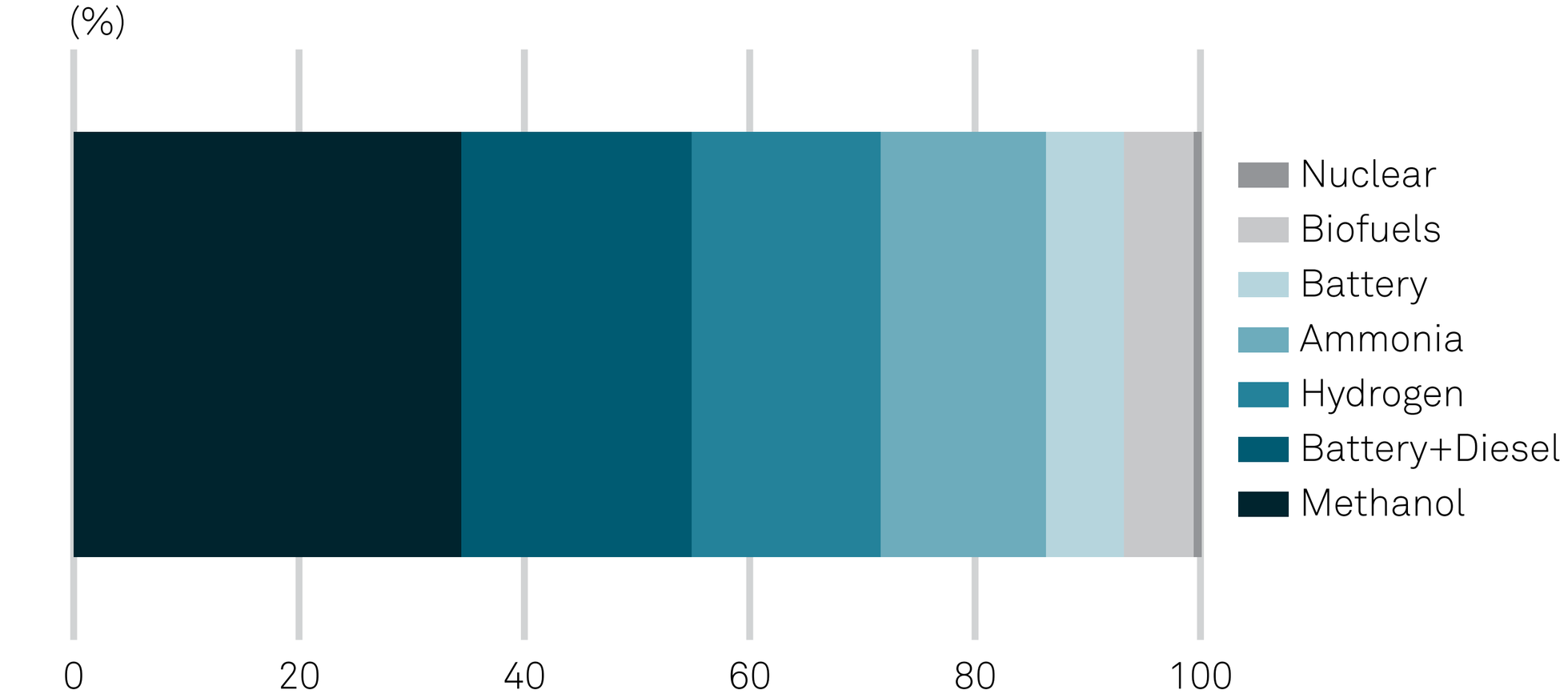
OOCL will add seven methanol dual-fuel container ships to its fleet (source: OOCL)

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.

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

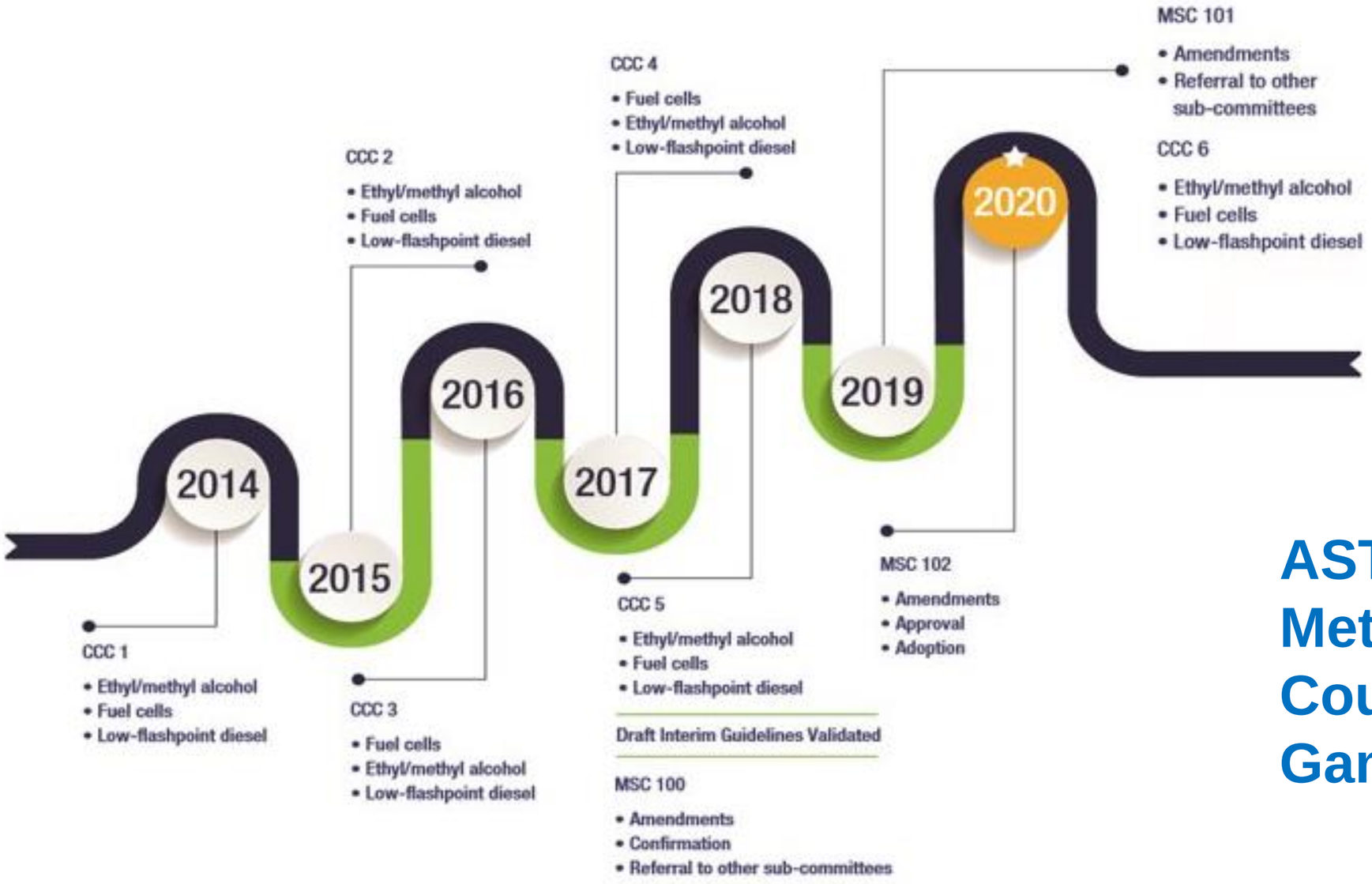
Methanol Leading Decade

Alternative shipping fuels outlook - 2030



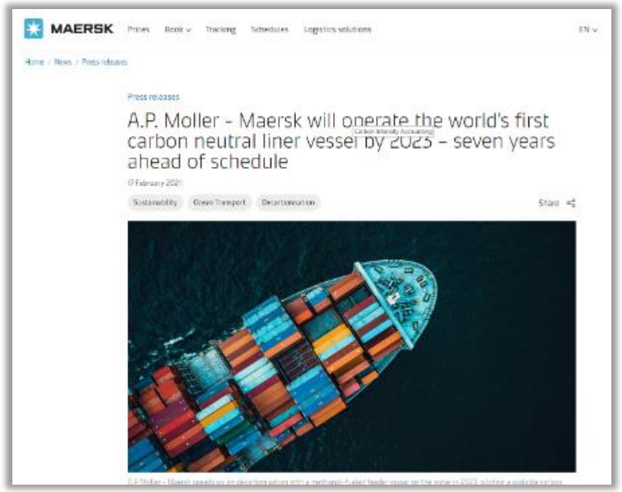
Source: S&P Global Commodity Insights

Game Changer 1: IMO IGF Code

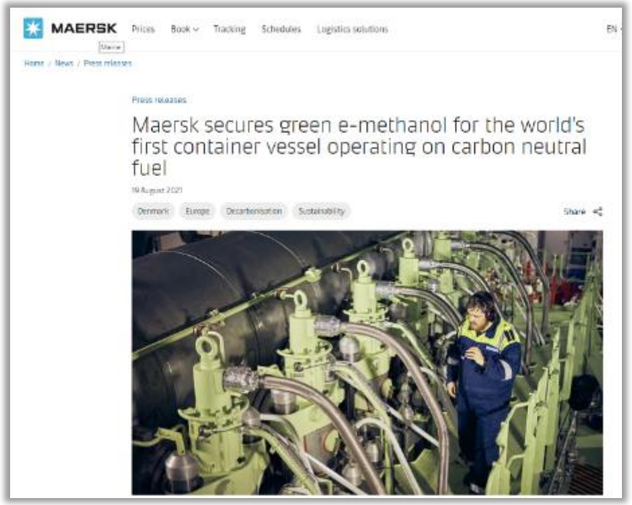


ASTM Inclusion of Methanol-to-Jet Could be SAF Game Changer

Game Changer 2.0: Maersk Vessel Orders



"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



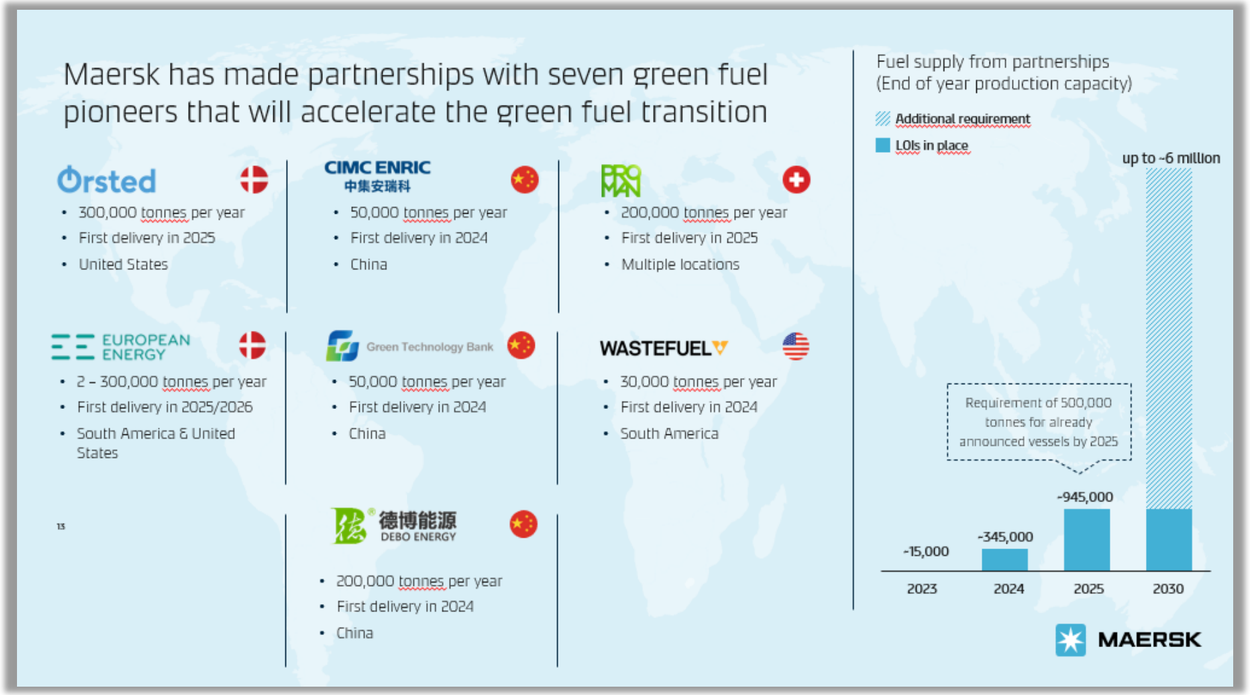
"That means that if we end up finding exactly the right solution then there will be a big retrofit opportunity for us." Maersk CEO Soren Skou speaking during Maersk's on 10 February earnings call

- **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
- $1.4 billion order each vessel $175 million 10-15% more expensive
- **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**

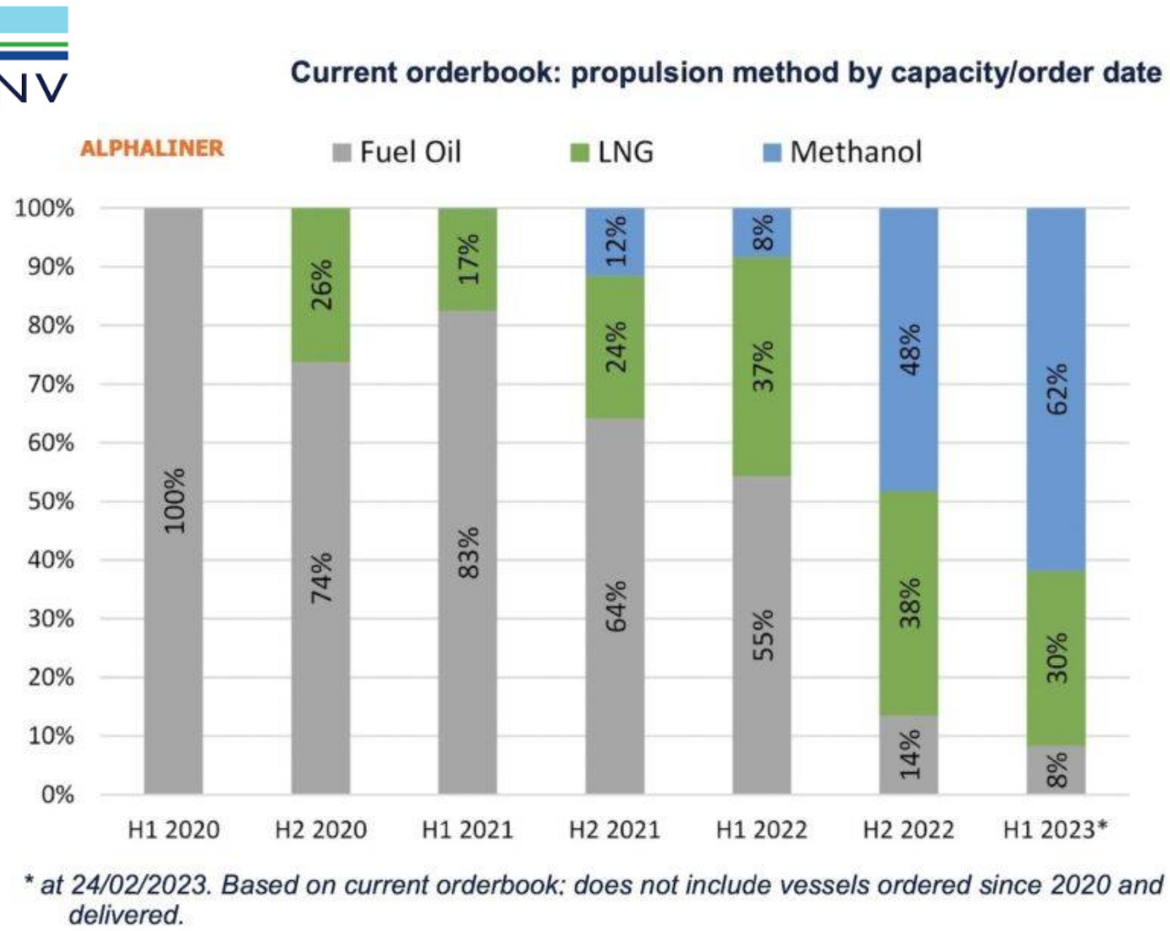
Game Changer 2.1: Maersk Methanol Supply

- **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

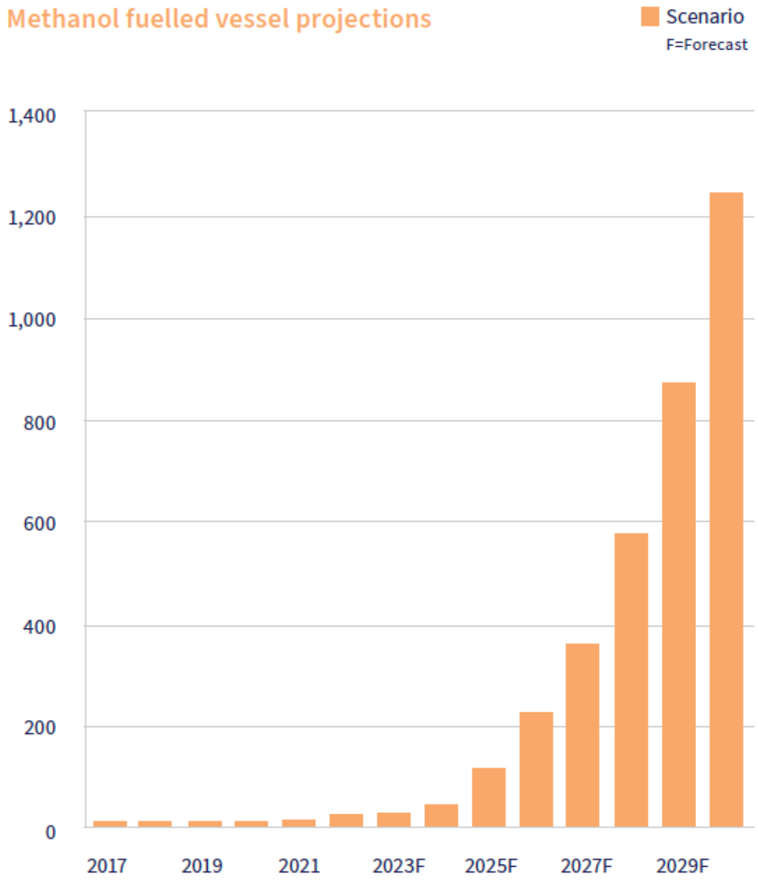
- Maersk estimates will need 6 million tons of renewable methanol by 2030 to fuel 25% of their 700-vessel fleet



Dominating Container Orderbook



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

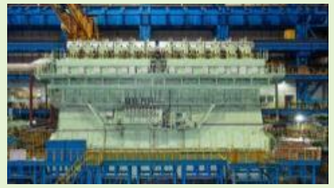


One 16,000 TEU container ship can consume 40,000 mt methanol year
1,200 vessels = 48 million tons methanol demand

On the Water and On the Way

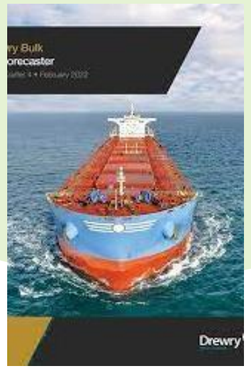
METHANOL INSTITUTE










METHANOL INSTITUTE SINGAPORE - WASHINGTON - BRUSSELS - BEIJING - DEHLI

Methanol Fuelled Vessels on the Water and on the Way

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

China (March 2023)

COSCO has placed orders for four 16,000 teu methanol-fueled ships at its affiliated yard in Yangzhou for an undisclosed price basis delivery in the second half of 2025.

Singapore (March 2023)

Singapore's Consort Bunkers has signed a contract with China Merchants Industry Holdings (CMHI) Jinling for a series of six 6,500-dwt methanol fuels new buildings, to be delivered in 2025

Denmark (March 2023)

FJ. Lauritzen has signed a letter of intent with Tsuneishi Shipbuilding, 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 vessels worth more than 21 billion yuan (about 3 billion U.S. dollars).

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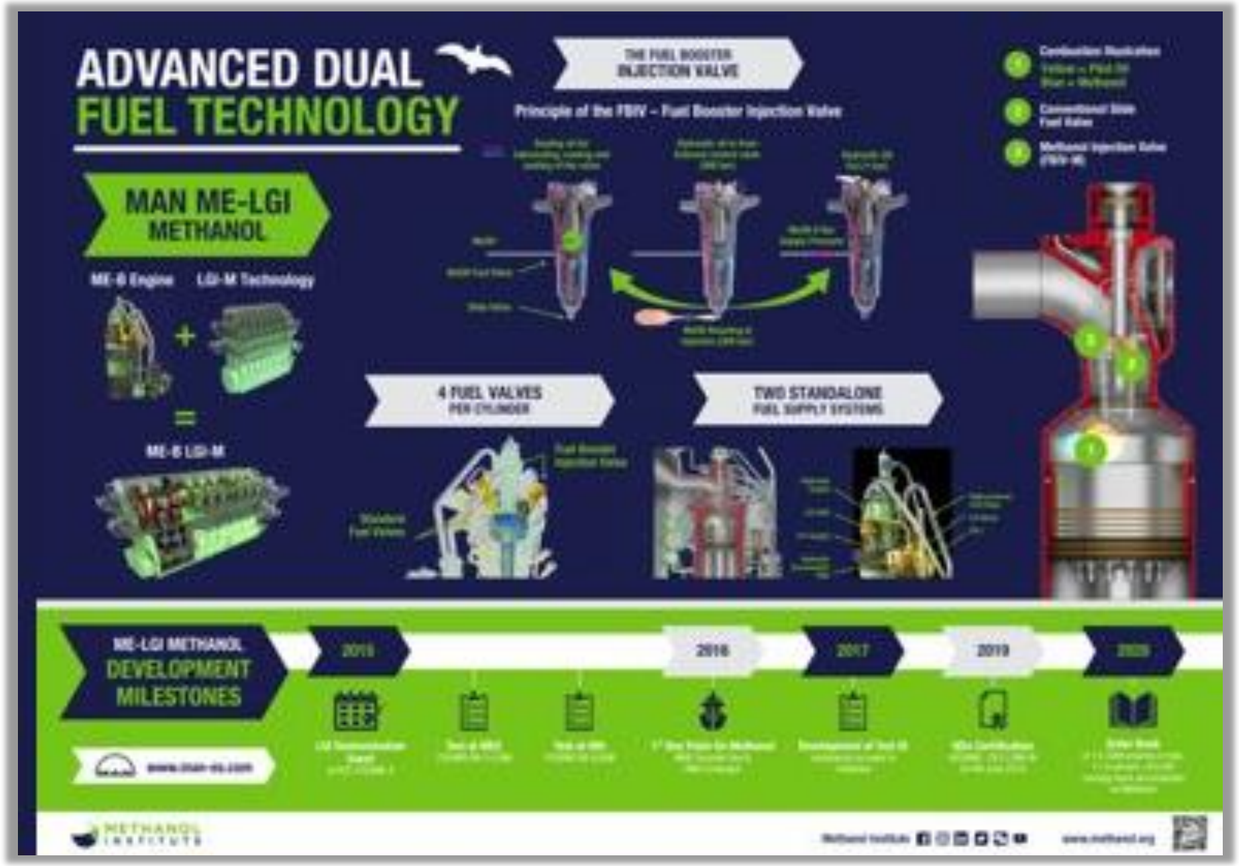
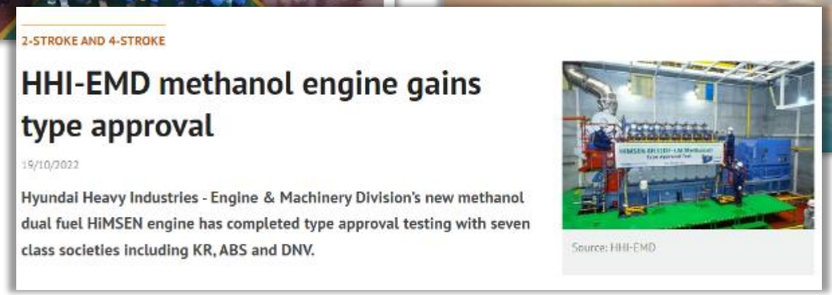
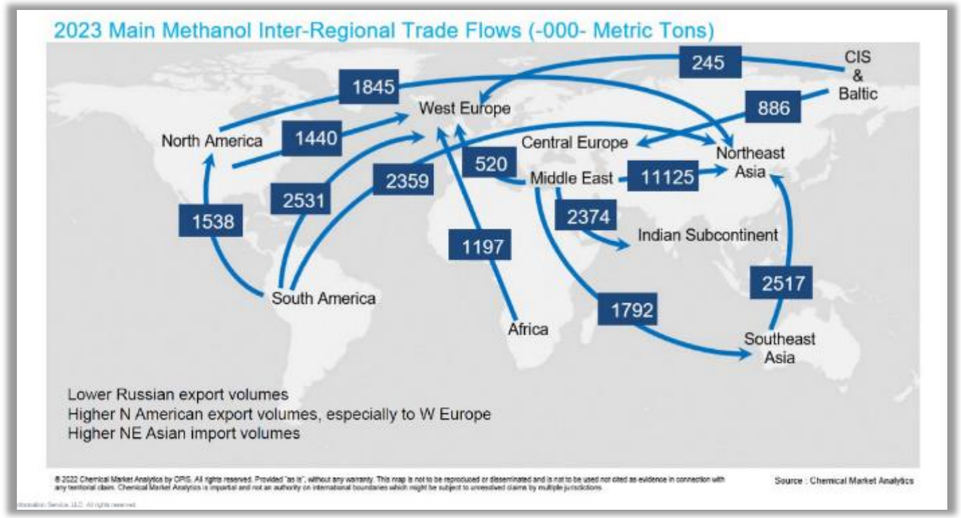
Engines Available and More Coming

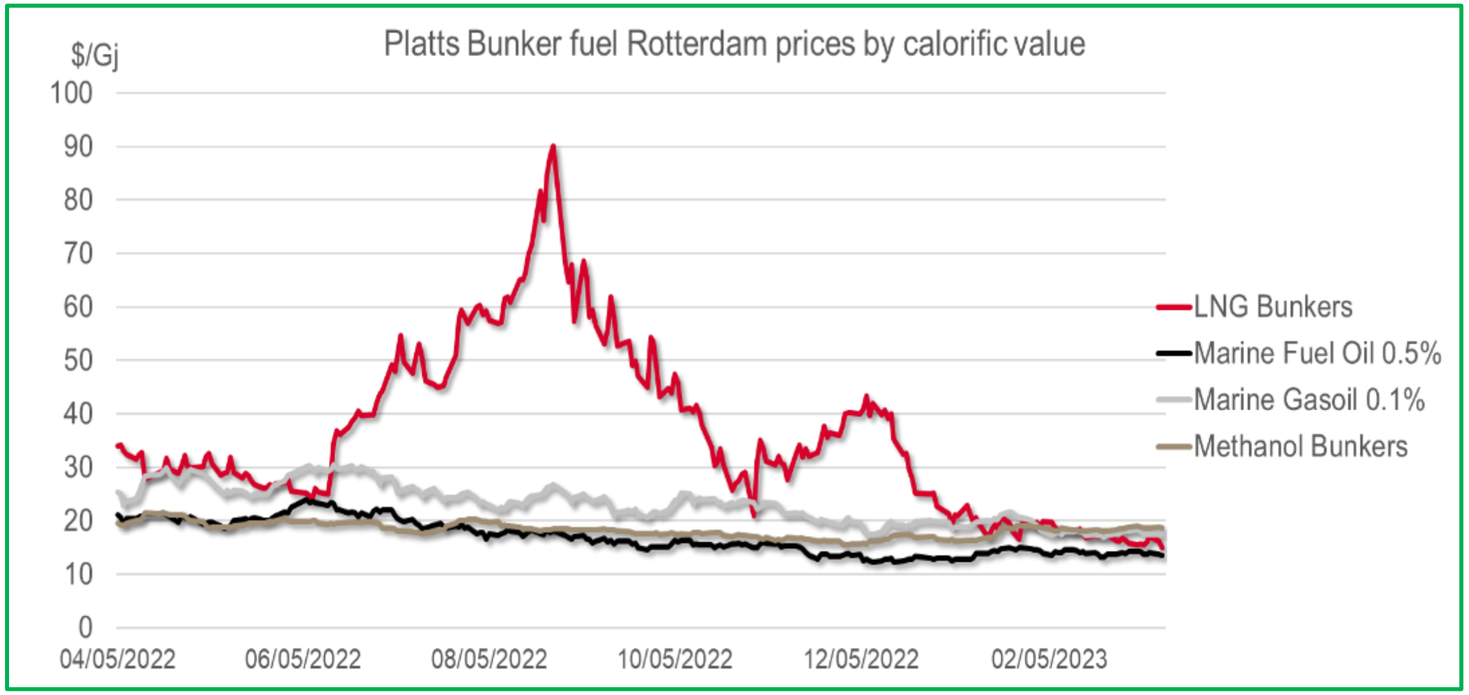




Since 2016, MAN has received orders for 120 large, two-stroke methanol engines, with 24 already in operation in chemical tankers operated by MI members. Another 100+ engine orders on the way!!!

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

Vingaren delivered in late 2020 expanded the company's Northern European bunkering oeprations (OljOla)

PUBLISHED NOV 9, 2022 7:06 PM BY **THE MARITIME EXECUTIVE**

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**

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.

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.

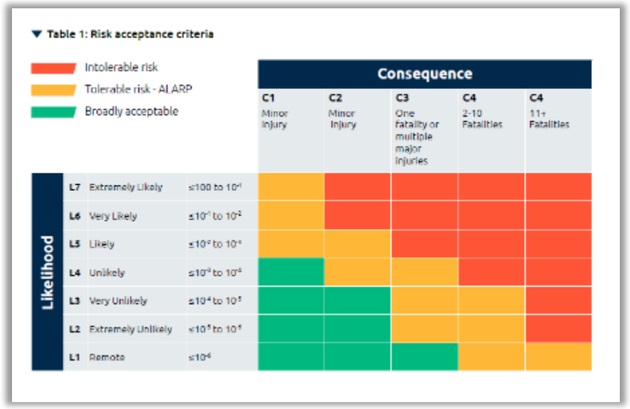


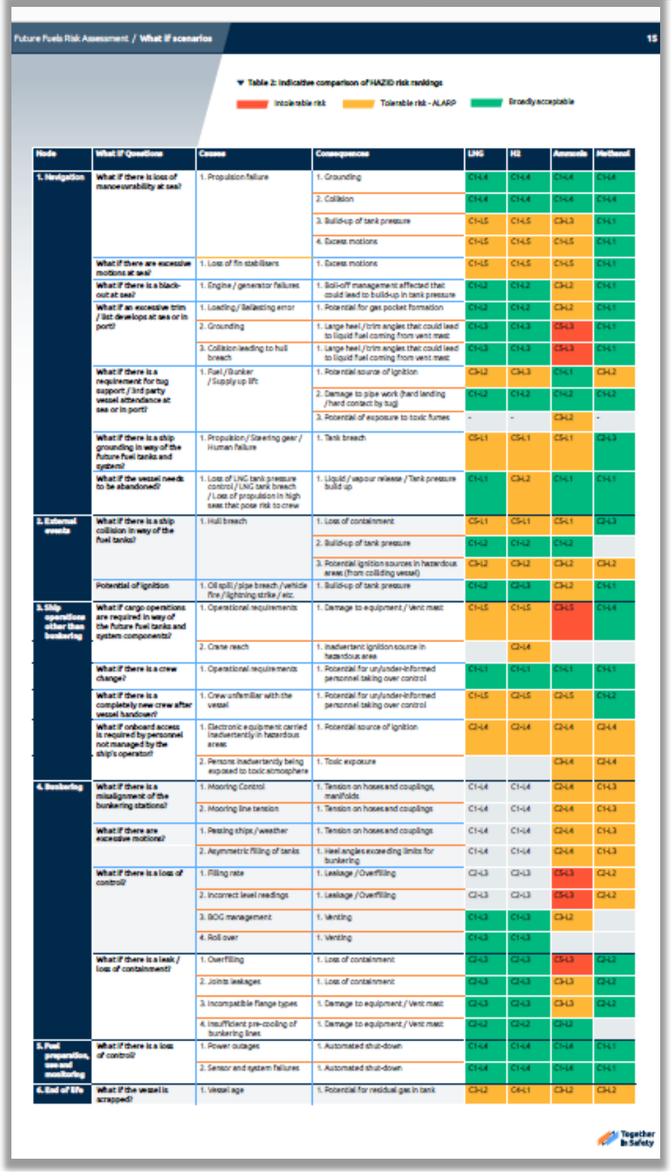
Table 1: Risk acceptance criteria

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		C2H-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

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