METHANOL INSTITUTE

Methanol: An Emerging Marine Fuel

August 2020

Singapore | Washington | Brussels | Beijing | India

Our History

- The Methanol Institute (MI) was established in 1989
- 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, Singapore, Beijing and Delhi

Our Members

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Tier 1

MHTL · methanex the power of agility · سابك sabic · OCI

Tier 2

Qatar Fuel Additives Company Limited · MITSUBISHI GAS CHEMICAL · ATLANTIC METHANOL · MITSUI & CO., LTD · PETRONAS · Oman Methanol Company S.A.O.C.

Tier 3

eni ecofuel · Sipchem EXCELLENCE everywhere · GX G2XENERGY · OQ · JM Johnson Matthey Inspiring science, enhancing life · Mitsubishi International Corporation

Tier 4

FiTech · Advent · HELM PROMAN METHANOL · OMAN TRADING INTERNATIONAL · MOL Mitsui O.S.K. Lines · Blue World Technologies · CARBON RECYCLING INTERNATIONAL · Element 1 Powering Innovation · SCC Southern Chemical Corporation · bse engineering · YCI METHANOL ONE · FUELSAVE GREEN TECHNOLOGY · GasTechno ENERGY AND FUELS · mma Global Insight, Asian Perspective · neo-H2 · IMTT · Palcan · Double Green Bridge NW INNOVATION WORKS · Advanced Chemical Technologies Inc. · TRICON ENERGY · GANE ENERGY · Ser energy The Power of Simplicity · CLARIANT · OLAHMOTORS · IGPMethanol · HALDOR TOPSOE · solvadis we do chemistry · Nebraska Public Power District Always there when you need us

The Simplest of Alcohols

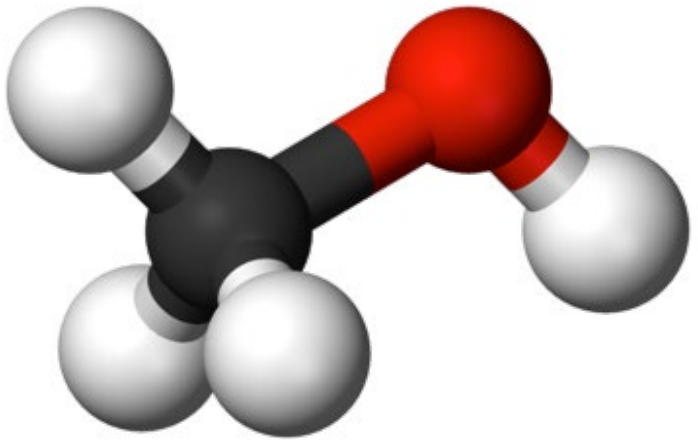
- A simple molecule rich in hydrogen, with only a single carbon bond
- Clear and colorless liquid at room temperature and ambient pressure
- Sometimes known as ‘wood alcohol’ methanol can be produced from a wide range of feedstocks

Formula: CH_3OH

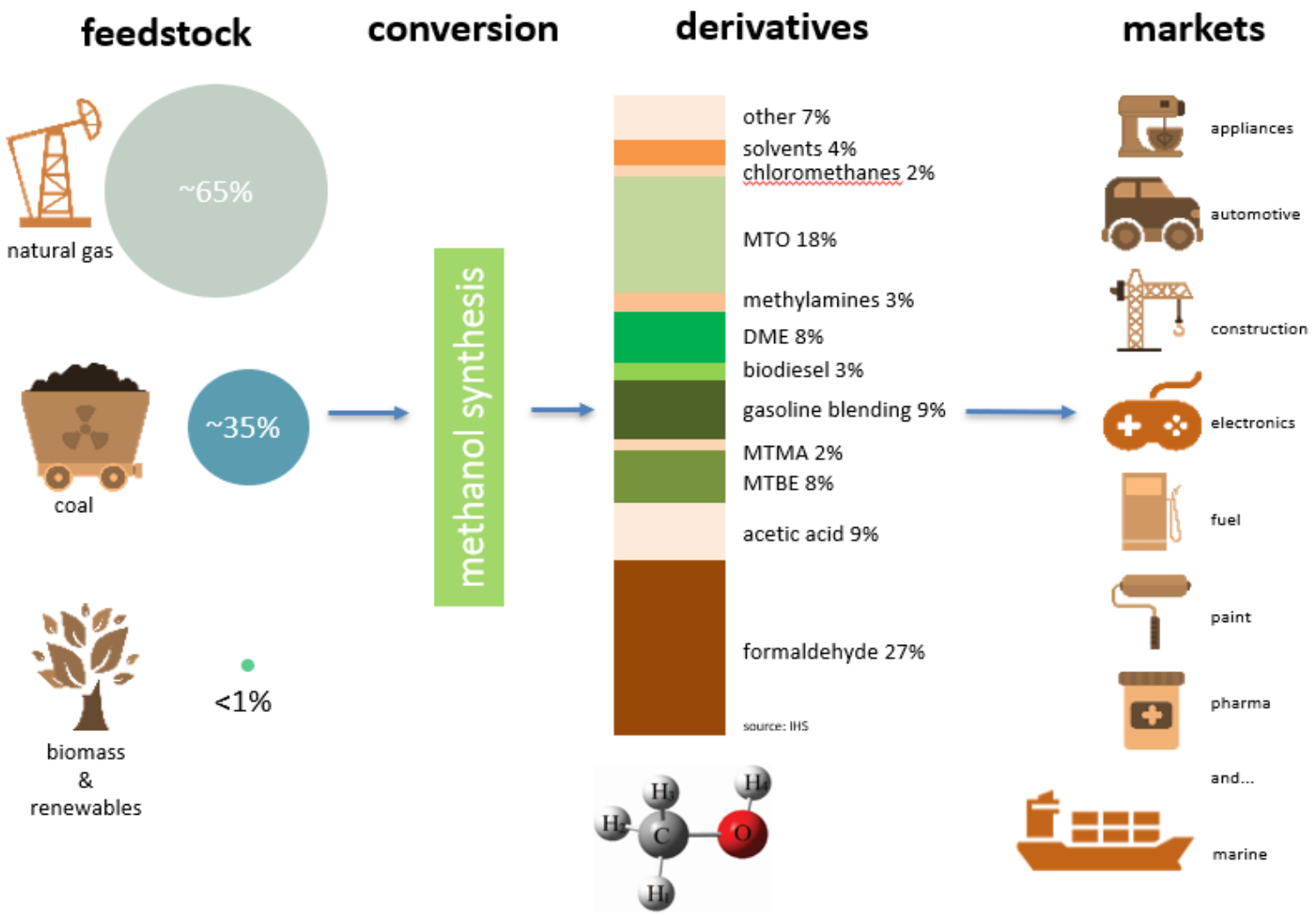
Density: 0,792 $g.cm^{-3}$

Molar mass: 32,04 $g\ mol^{-1}$

Appearance: colorless liquid

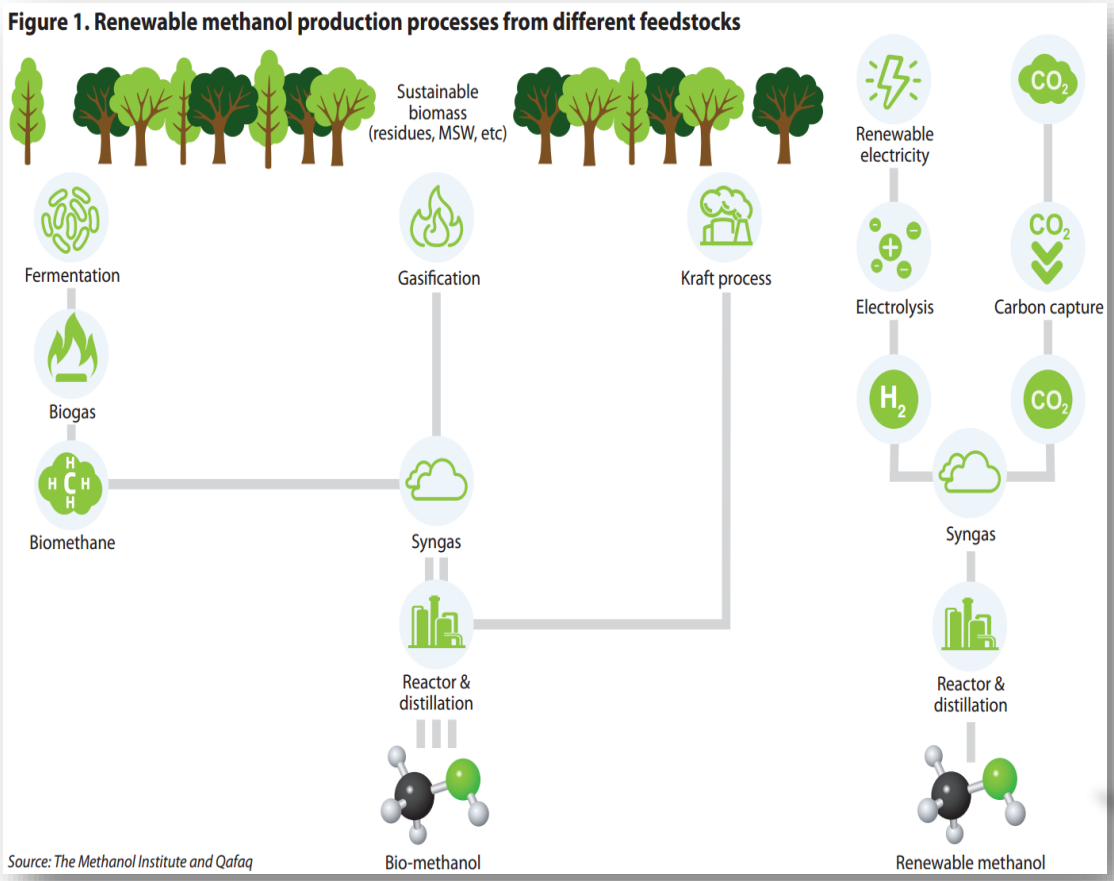


Feedstocks and Markets



2019: Global Methanol Demand = 86 Million Metric Tons or 28.6 billion gallons

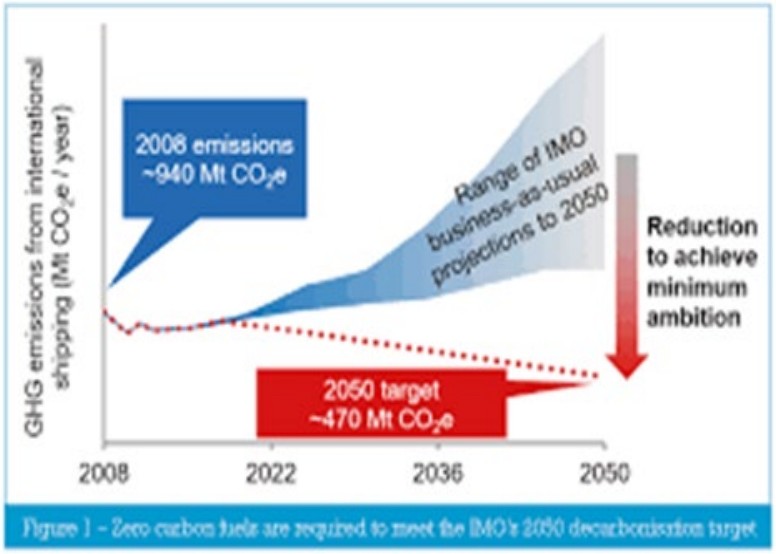
Net Carbon-Neutral Pathways



> *Renewable methanol is an ultra-low carbon chemical produced from sustainable biomass, often called bio-methanol, or from carbon dioxide and hydrogen produced from renewable electricity.*

Renewable Methanol Emission Reductions: CO2 by up to 95%; NOx by 80%; virtually eliminating SOx and Particulate Matter (PM)

IMO Emission Rules



- The International Maritime Organization has adopted emission regulations transforming the shipping industry
- In 2020, global SOx reductions took effect
- By 2030, interim requirements targeting 40% reduction of carbon intensity from shipping
- By 2050, greenhouse gas emissions must be cut in half

Reducing Conventional Pollutants

Methanol is among the lowest emission fuels for marine engines

Source: Stena Lines -- Emission reductions when compared to alternative fuels currently available (fuel oil)

IMO GHG Interim Strategy

- In operation, conventional methanol offers lower CO2 emissions compared to conventional marine fuel
- If produced from one of numerous renewable pathways, such as biomass or renewable electricity combined with recycled carbon dioxide, methanol has the potential to significantly reduce CO2 emissions on a well-to-wake basis

Maersk and Renewable Methanol

May 26, 2020

Fact sheet:

Delivering the sustainable fuels of the future

Copenhagen Airports, A.P. Moller - Maersk, DSV Panalpina, DFDS, SAS and Ørsted have formed a new partnership that has a vision of developing what could become one of the world's largest electrolyser and e-fuel facilities in the Greater Copenhagen Area. To drive down the cost of renewable hydrogen and sustainable fuels to competitive levels, regulatory support and a regulatory framework that enable the demand and production of sustainable fuels will be required as well as commitment, investment, and innovation by industry. If successfully executed, Denmark can become a hub for a new green industry based on Power-to-X technologies with substantial potential for job creation.

Denmark has taken the lead in the fight against climate change by committing to reduce carbon emissions by 70% by 2030 compared to 1990. A critical component in achieving this ambitious target is to replace fossil fuels in heavy transport with sustainable alternatives, such as renewable hydrogen and sustainable fuels produced from renewable energy.

Copenhagen Airports, A.P. Moller - Maersk, DSV Panalpina, DFDS, SAS and Ørsted have joined forces in a new partnership with the vision to develop new innovative solutions to secure a greener future for the partners and society. The vision of the partnership is to develop a new ground-breaking hydrogen and e-fuel production facility as soon as 2023 which, when fully scaled-up by 2030, could deliver more than 250,000 tonnes of sustainable fuel for busses, trucks, maritime vessels and airplanes every year. Production would potentially be based on a total electrolyser capacity of 1.3 gigawatts.

COWI and BCG act as knowledge partners for the project, and the project is supported by the Municipality of Copenhagen in line with Copenhagen's ambitious policies for decarbonisation. However, the partnership hopes that the project can, over time, act as a catalyst for similar projects in other parts of Denmark and internationally.

Denmark's abundant offshore wind resources and diverse supply chain within sustainable solutions have the potential to make Denmark a hub for the development of Power-to-X solutions for which there will be a considerable demand in the future. This can solidify Denmark's position as a green energy leader and create jobs both short and long-term. Denmark is also a leading nation within transport and logistics and thus has a unique starting point to develop new sustainable transport solutions, while also helping to decarbonise core parts of the economy and secure long-term competitiveness.

With swift action from both society and industry, Denmark has the opportunity to develop a leading position within Power-to-X and create a new industrial stronghold which can generate substantial amounts of jobs and create new business opportunities for Danish companies.

As global climate ambitions increase, the position as a hub for sustainable fuels is likely to attract other industries which have a strong demand for hydrogen-based fuels and solutions. Denmark has already

https://www.maersk.com/news/articles/2020/05/26/leading-danish-companies-join-forces-on-an-ambitious-sustainable-fuel-project

- Maersk, DSV Panalpina, DFDS, SAS and Ørsted formed partnership to develop an industrial-scale sustainable fuels production facility in Copenhagen
- When fully-scaled up by 2030, the project will deliver 250,000 tonnes of sustainable fuel, including renewable methanol for Maersk fleet
- *"In Denmark, we have an opportunity now to accelerate the green transformation and take lead in powering the future with sustainable energy and I am pleased that we can contribute with concrete actions. We need many such projects both in Denmark and around the globe to achieve our ambition in Maersk of becoming carbon neutral by 2050."* Søren Skou, CEO, A.P. Moller - Maersk

IMO Methanol Safety Guidelines

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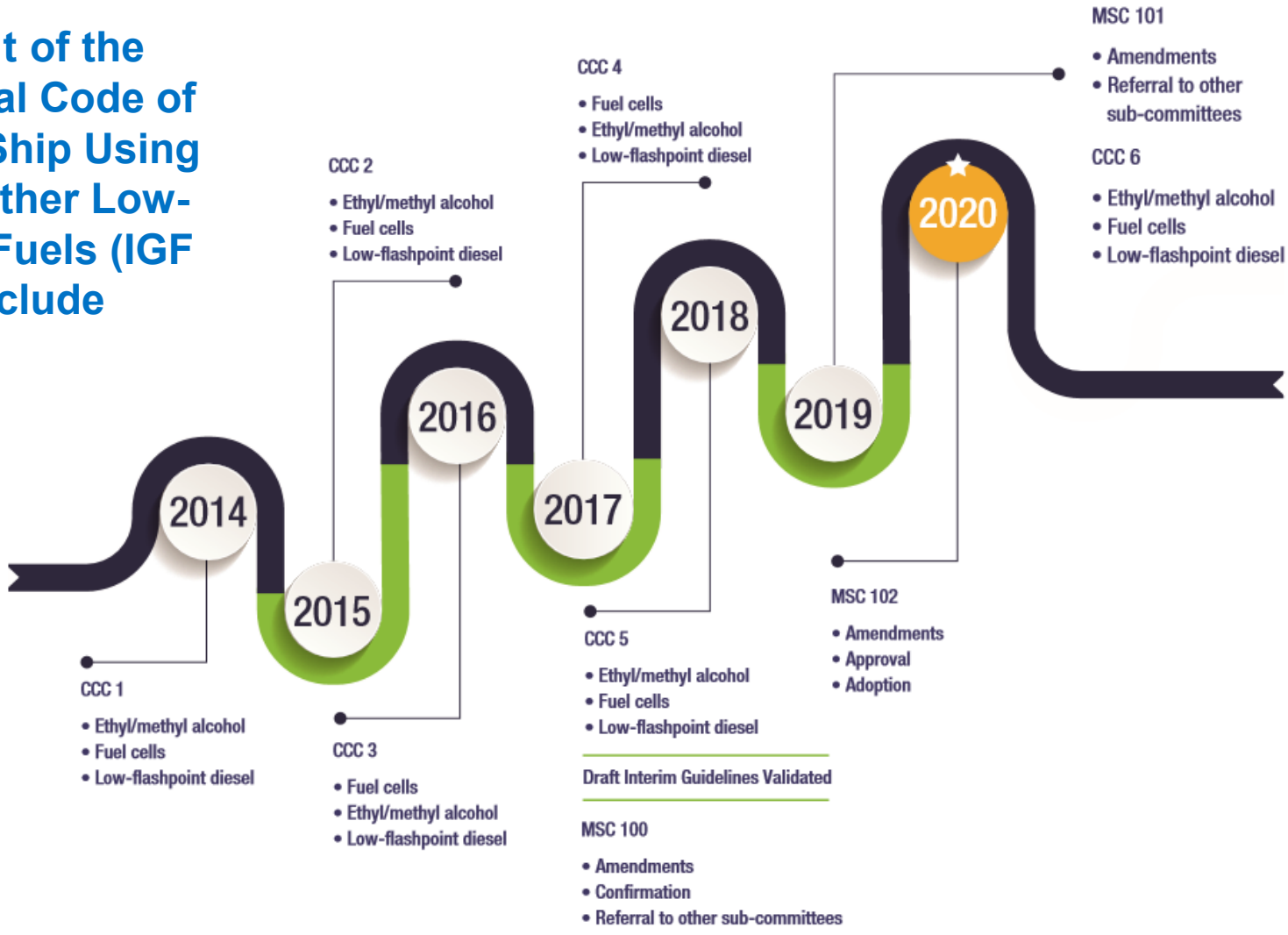
Amendment of the International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels (IGF Code) to include Methanol



Methanol Vessels on the Water

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	DUAL FUEL			FUEL CELL		PROJECT R&D
						
Quantity	>12	1	1 + 1	2	1	+4
Vessel Type	Chemical Tankers	Ropax Ferry	Pilot Boat	Tourist Boat	Ferry	Cruise Ships, Fishing Boats, Barges, Dredges, Others
Owner	MOL, WL, Marinvest, Mitsui, NYK, Waterfront Shipping, Mitsui O.S.K. Lines, Ltd., Westfal-Larsen Management, Marinvest/Skagerack Invest. IINO Kaiun Kaisha, Ltd., Mitsui & Co Ltd., and the NYK Group	Stena Line	MI/SMA ScandiNaos	Innogy HTWG Konstanz	Viking Line	SUMMETH/MARTEC, Lean Ships, Methaship, Billion Miles[1], FiTech[2], IWAI[3], PCG Product Vessel[4], NTU[2], GMM, Fastwater, Port of Rotterdam Barge, Jupiter, Paxell, Methanex Fishing[5]
Engine Type	2 Stroke Man	4 Stroke Wärtsila	High Speed Scania, Weichai	Serenergy Fuel Cell Stacks		Si Hybrid, Dual Fuel, etc.
Design	New Build	Retrofit				New Build & Retrofit

All projects are based in the EU unless noted otherwise China/SG[1], EU/China/SG[2], India[3], Malaysia[4], China[5]

More on the Way

Sweden/Switzerland: Proman Stena Bulk – joint venture of shipowner Stena Bulk and Proman Shipping a subsidiary of methanol producer Proman – to build two 50,000 dwt tankers with methanol dual fuel engines

Netherlands: Damen Shipyards has developed new concept Offshore Support Vessel (OSV) to operate on methanol

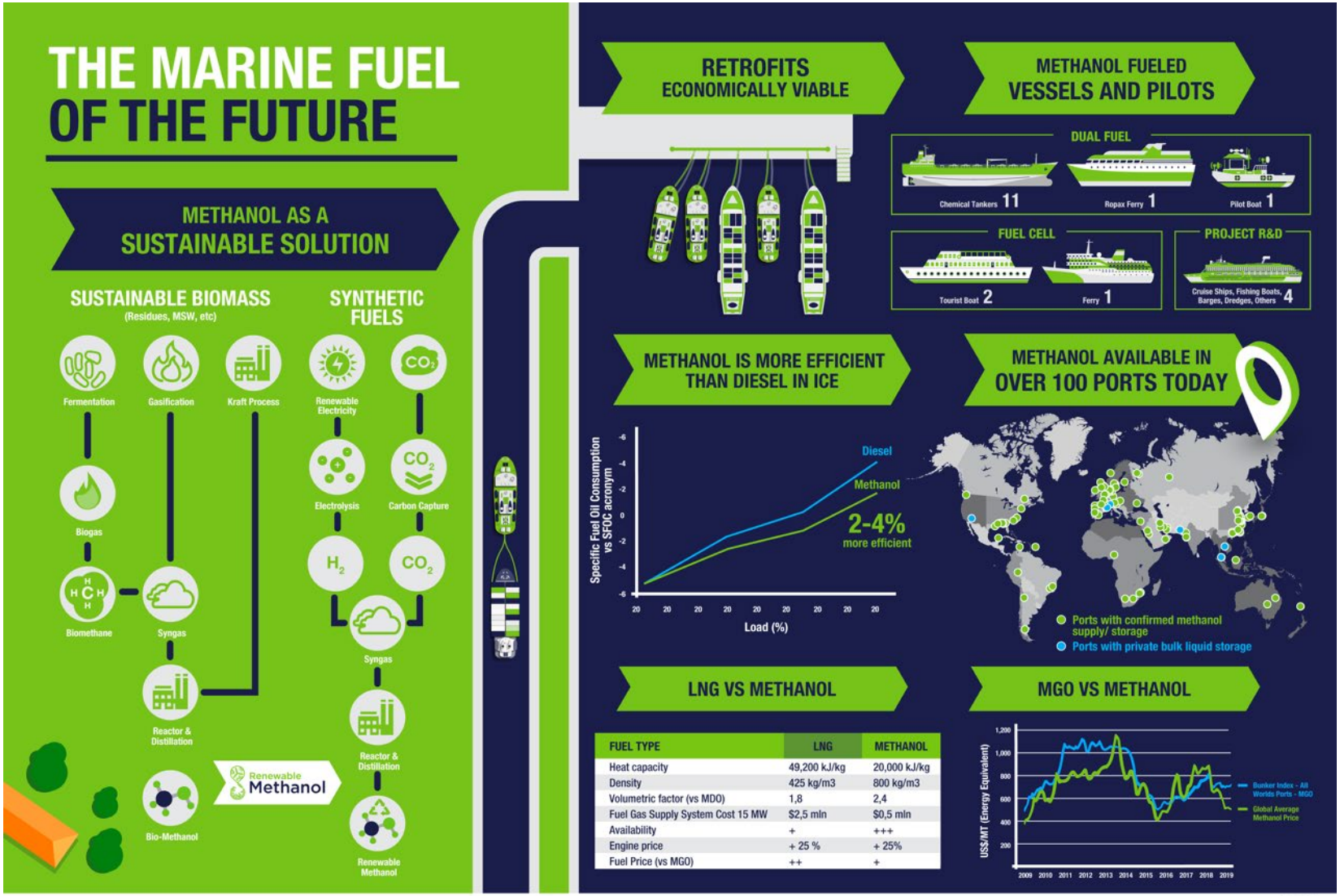
Germany: Shipowner Liberty One has ordered new multipurpose (MPP) ship powered by methanol

Germany: Shipowner SAL Heavy Lift to install FUELSAVE hydrogen/methanol injection system in 6 vessels

Germany: Abeking & Rasmussen shipyard designing “green cruise” concept vessel using methanol fuel cells for hotel load and methanol propulsion engines

Germany: AIDAnova will employ methanol fuel cells for propulsion as early as 2021 under Pa-X-ell2 project

Joint Marketing – MAN ES



FUEL TYPE	LNG	METHANOL
Heat capacity	49,200 kJ/kg	20,000 kJ/kg
Density	425 kg/m3	800 kg/m3
Volumetric factor (vs MDO)	1,8	2,4
Fuel Gas Supply System Cost 15 MW	$2,5 mln	$0,5 mln
Availability	+	+++
Engine price	+ 25 %	+ 25%
Fuel Price (vs MGO)	++	+

Joint Marketing – MAN ES

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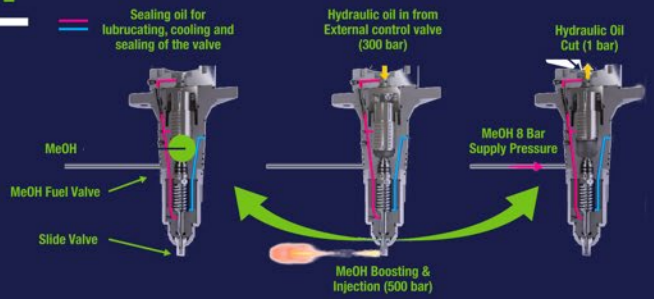
ADVANCED DUAL FUEL TECHNOLOGY

MAN ME-LGI METHANOL

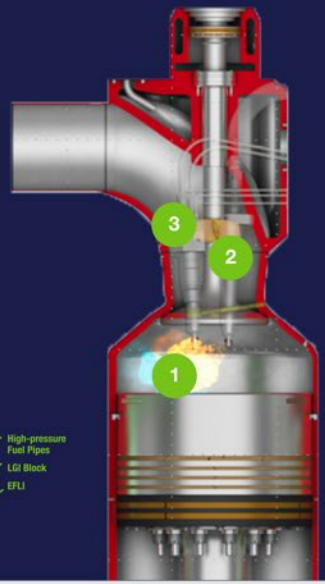
ME-B Engine + LGI-M Technology = ME-B LGI-M

THE FUEL BOOSTER INJECTION VALVE

Principle of the FBIV – Fuel Booster Injection Valve



1. Combustion Illustration
   Yellow = Pilot Oil
   Blue = Methanol
2. Conventional Slide Fuel Valve
3. Methanol Injection Valve (FBIV-M)



4 FUEL VALVES PER CYLINDER

TWO STANDALONE FUEL SUPPLY SYSTEMS

ME-LGI METHANOL DEVELOPMENT MILESTONES

www.man-es.com

2015

- **LGI Demonstration Event** at RCC 4T50ME-X
- **Test at MES** 7S50ME-B9-3-LGIM
- **Test at HHI** 7G50ME-B9 3LGIM

2016

- **1st Sea Trials On Methanol** MNS Taranaki Sun & HMD Lindanger

2017

- **Development of Test III** compliance by water in methanol

2019

- **NOx Certification** 6G50ME- C9.5 LGIM-W at HHI June 2019

2020

- **Order Book** of 14 LGIM engines in total, 11 in service >65,000 running hours accumulated on Methanol

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Methanol Institute www.methanol.org

What do the Operators say?

STENA LINE

"We are very enthusiastic about Methanol's possibilities and it has the potential to be the maritime fuel of the future"

Carl-Johan Hagman
CEO
Stena Line

MARINVEST / SKAGERACK INVEST

"We have found the technology for handling Methanol is well developed and offers a safe dual-fuel solution for low-flashpoint liquid fuels"

Patrik Mossberg
Chairman
Marinvest/Skagerack Invest

MITSUI O.S.K. LINES, LTD.

"Investing in technology that encourages the use of a fuel like Methanol that significantly reduces emissions is a step forward for both our company and the shipping industry"

Akio Mitsuta
Senior Managing Executive Officer
Mitsui O.S.K. Ltd

WESTFAL-LARSEN MANAGEMENT

"We have found Methanol to be one of the best alternative fuels due to its wide availability, the use of existing infrastructure, and the simplicity of the engine design and ship technology"

Rolf Westfal-Larsen Jr.
CEO
Westfal-Larsen Management

Current Projects

Major Dutch maritime firms join forces to study methanol as fuel

Lee Hong Liang | Feb 22, 2019

A consortium of major Dutch maritime companies has joined forces to look into the feasibility of using methanol as a sustainable alternative bunker fuel under the Green Maritime Methanol project.

The consortium includes shipowners Boskalis, The Royal Netherlands Navy, Van Oord, Wagenborg Shipping; shipbuilders Damen Shipyards, Feadship, Royal IHC; engine manufacturers Pon Power, Wartsila and their trade association VIV; equipment su Noord; and service providers including C-Job Naval Architect

Work to study the infrastructure and supply chain for metha participation of the Netherlands' two largest ports, Rotterda methanol suppliers BioMCN and Helm Proman and trade o

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Zero carbon vessels will require investment, technology – and community – readiness alignment

Splash · April 21, 2020 · 7 · 3 minutes read

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Antwerp launches initiative to achieve fossil-free shipping

By Port Technology International Team • 24 June 2020, 15:47 BST • Automation and Optimization

The Port of Antwerp has launched the FASTWATER consortium, an initiative designed to demonstrate how methanol can be used to achieve fossil-free commercial shipping.

In a statement, the port said the consortium wanted to examine the potential for using methanol on retrofit and newbuild vessels as a "pathway" towards greener operations.

With funding from the European Commission, FASTWATER will focus on high impact outcomes, designing solutions for existing ships and designs for newbuilds, demonstrating methanol as a future-proof marine fuel to create a fast track to carbon neutral shipping.

How does Antwerp compare to other major ports in Europe?

Latest News

Hapag-Lloyd officer destroyed in Beirut

Dubai launches AI

244 Views · 1 Shares

Article Preview

Methanol Institute Joins 1st Comprehensive Study of Methanol in China

The study will create comprehensive guidance and policy suggestions for the use of methanol as a marine fuel.

BY THE MARITIME EXECUTIVE 11-30--0001 12:00:00

Washington, DC and Shanghai, PRC, 14 July, 2020. The Methanol Institute (MI) has joined a study led by the China Waterborne Transportation Research Institute (CWTRI), the think tank of the Chinese Ministry of Transport, which will consider the technical and operational requirements for the use of methanol as a marine fuel.

The study is supported by Methanex, the world's largest methanol producer and distributor and Shanghai Huayi Energy Chemical Co., Ltd., one of the largest methanol producers and distributors in China.

Based on the characteristics of China's energy and shipping industries, the study will create comprehensive guidance and policy suggestions for the use of methanol as a marine fuel, reflecting the experience already gained in large and small methanol-fuelled marine engines, and will develop a roadmap for the adoption of methanol as a marine fuel in China.

Green Maritime Methanol

- MI has joined an industry consortium organized by TNO to study the use of (green) methanol in short sea shipping, a spin-off from the Horizon 2020 LeanShips project.
- TNO is an internationally renowned research institute with a great reputation for objective analysis.
- The study will set the stage for a pilot with actual ships on the water with project partners (Horizon 2020 or other).
- Focus is on renewable methanol but the technology, safety guidelines and policy can be used for conventional methanol too.

https://www.einnews.com/pr_news/477078882/major-dutch-maritime-companies-join-green-maritime-methanol-project
https://www.leanships-project.eu/home/
https://www.tno.nl/en/focus-areas/buildings-infrastructure-maritime/roadmaps/maritime-offshore/clean-ships/

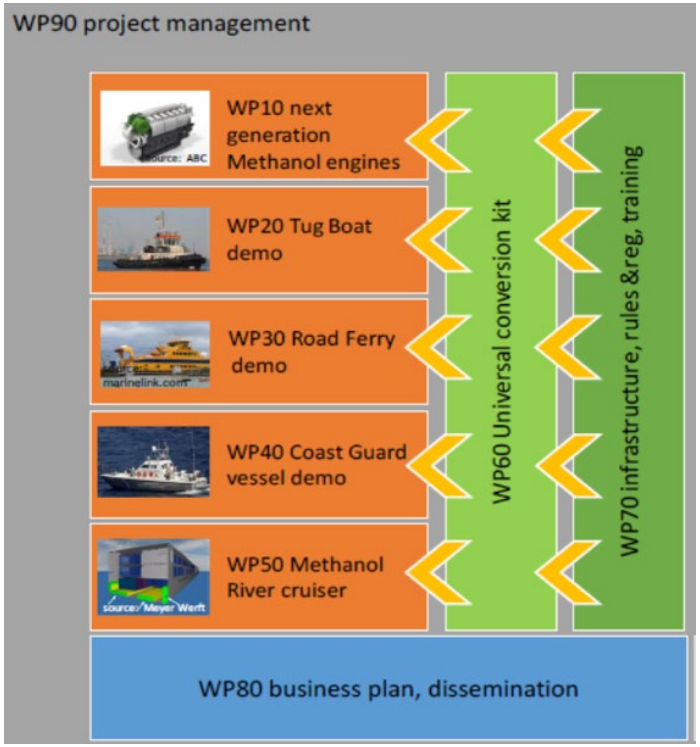
FASTWATER

- Consortium of Europe's maritime research and technology leaders formed in 2020
- Demonstrate the feasibility of retrofit and newbuild vessels to operate on methanol as a pathway to fossil-free shipping
- Funded by European Commission, FASTWATER will focus on high impact outcomes, designing solutions for existing ships and designs for new buildings

www.fastwater.eu

FASTWATER

- Aims to commercialize medium and high-speed methanol-fueled engines for shipping, and will demonstrate feasibility on a harbour tug, pilot boat and coast guard vessel
- Conversion concepts and validation for a river cruise ship including a universal, scalable retrofit kit for converting diesel fueled ships (200 kW - 4 MW)
- Training programs for crew and port staff | R&R
- Demonstrate the complete value chain for bunkering methanol and elaborate a business plan for methanol as marine fuel
- Identify CO2 and conventional pollutant reductions facilitated by the next generation methanol propulsion systems



China WTRI study

China Waterborne Transport Research Institute

- Study to produce a roadmap for adoption of methanol as a marine fuel in China
- Partners: WTRI, Methanex, Shanghai Huayi, SINOPEC, Methanol Institute
- Key elements will include: Policy Analysis; Recommendations; Best Practices

Assumptions

- China bunker demand 30m mtpa
- 630,000 vessels operating in China coastal regions
  - Fishing
  - Inland waterways (140,000)
- Potential methanol demand of several million metric tonnes per year

Targeted outcome is to achieve China MSA endorsement of the study and policy recommendations, which will allow China Classification Society to class methanol-fueled vessels, allowing MI to begin to promote methanol and buildout the market

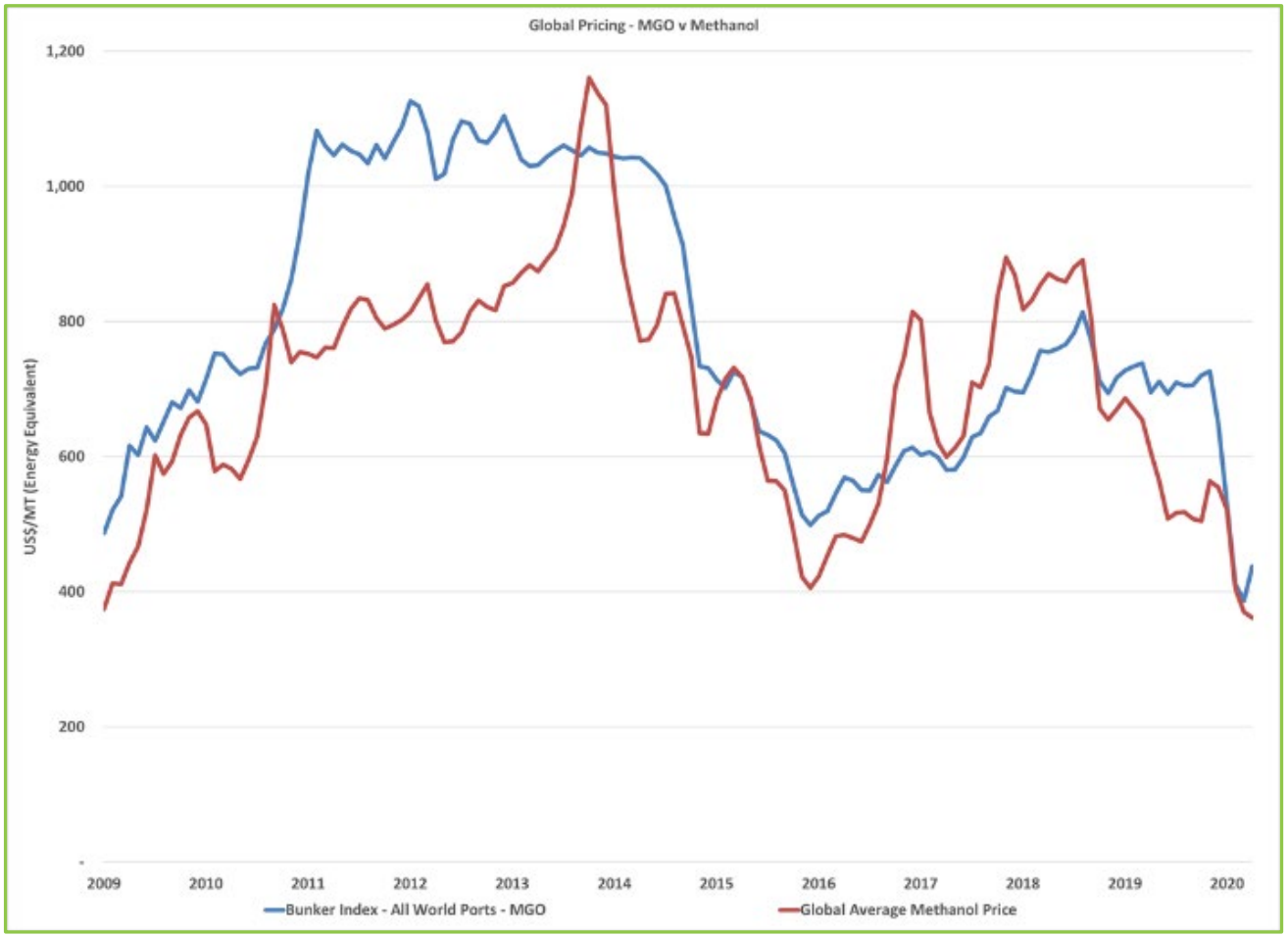
LR Techno-Economic Study | Methanol Bunkering | ISO

- **Techno-Economic Study:** In April 2020, with support from Methanol Institute, Lloyd's Register published an assessment of the current and future fuels available to help define solutions for the maritime industry as it seeks to reduce GHGs

- **Bunkering Technical Reference:** MI and Lloyd's Register have developed a methanol bunkering technical reference, work which was requested by shipping organizations studying methanol

- **ISO:** Following a request from IMO, the International Standards Organization (ISO) began work on a methanol marine fuel standard in mid-2019

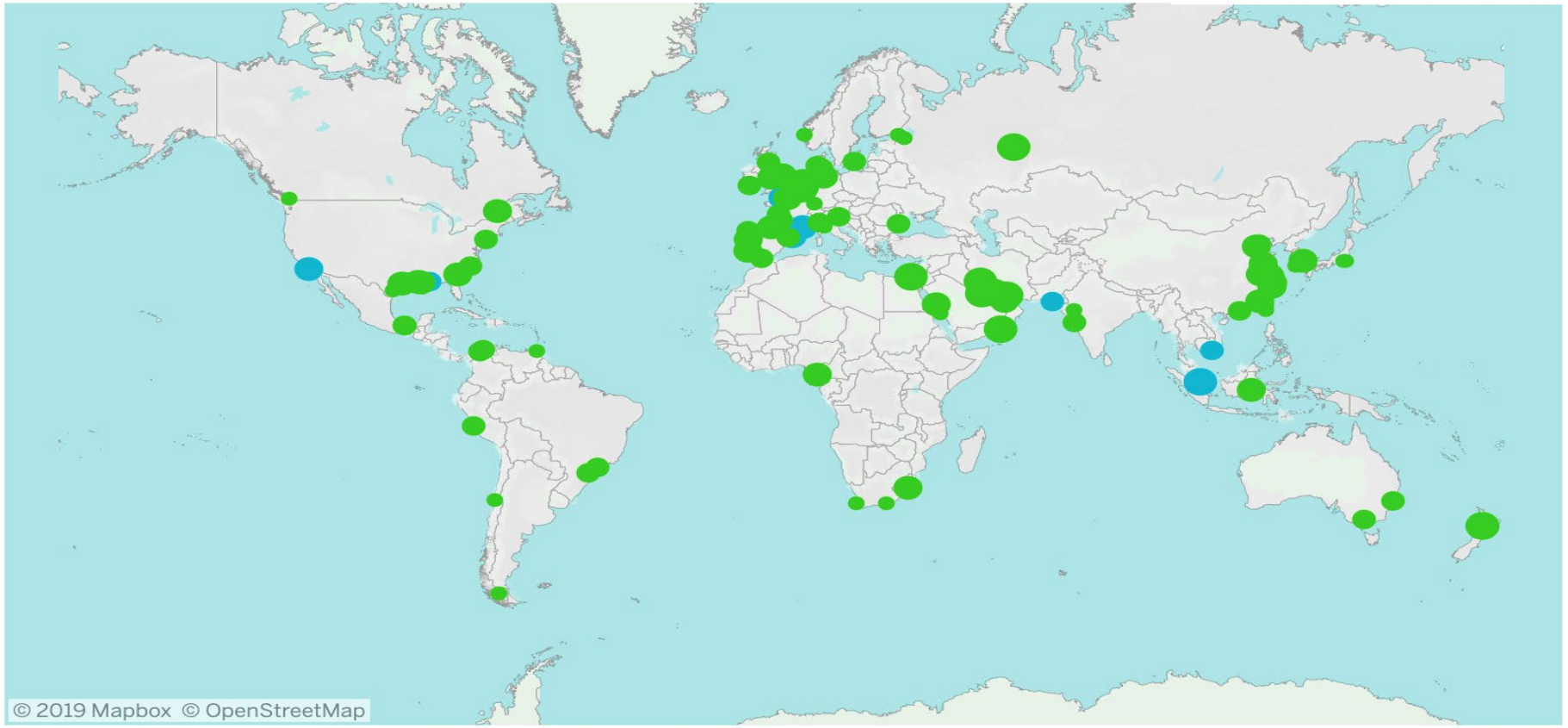
Compliance Cost Comparison



"Methanol is an economically competitive marine fuel over the cycle"

Paul Hexter, CEO Waterfront Shipping

Availability in Over 100 Ports



Ports with confirmed methanol supply/storage

Ports with private bulk liquid storage

No information on volume of methanol	Ports with methanol capacity of < 100,000 MT	Ports with methanol capacity of 100,000 MT to 1,000,000 MT	Ports with methanol capacity of > 1,000,000 MT
●	●	●	●

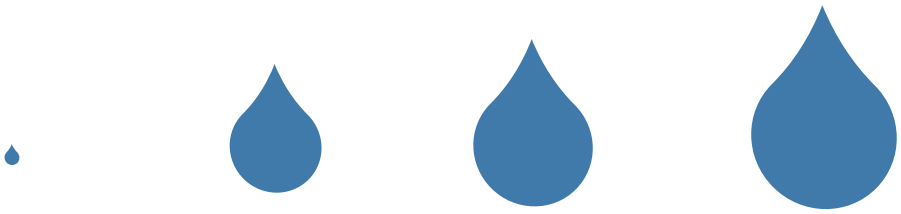
https://public.tableau.com/profile/quantzig#!/vizhome/MethanolAvailabilityDataTopGlobalMaritimePorts/MethanolFuelAvailabilityatPorts

Simple, Clean Bunkering

- Methanol is liquid at atmospheric pressure/temperature
- Available in many ports and inland terminals around the world
- Bunkering has low infrastucture cost (no cryogenics)
- Flexible, modular system
- Biodegradable product means low risk for environment/location

Pollution in Perspective

LC 50: Lethal Dose: Fish



Gasoline [1] 8,2 mg/l

Methane [2] 49,9 mg/l

Diesel [3] 65 mg/l

Heavy Fuel Oil [4] 79 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

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***

Methanol as A Marine Fuel

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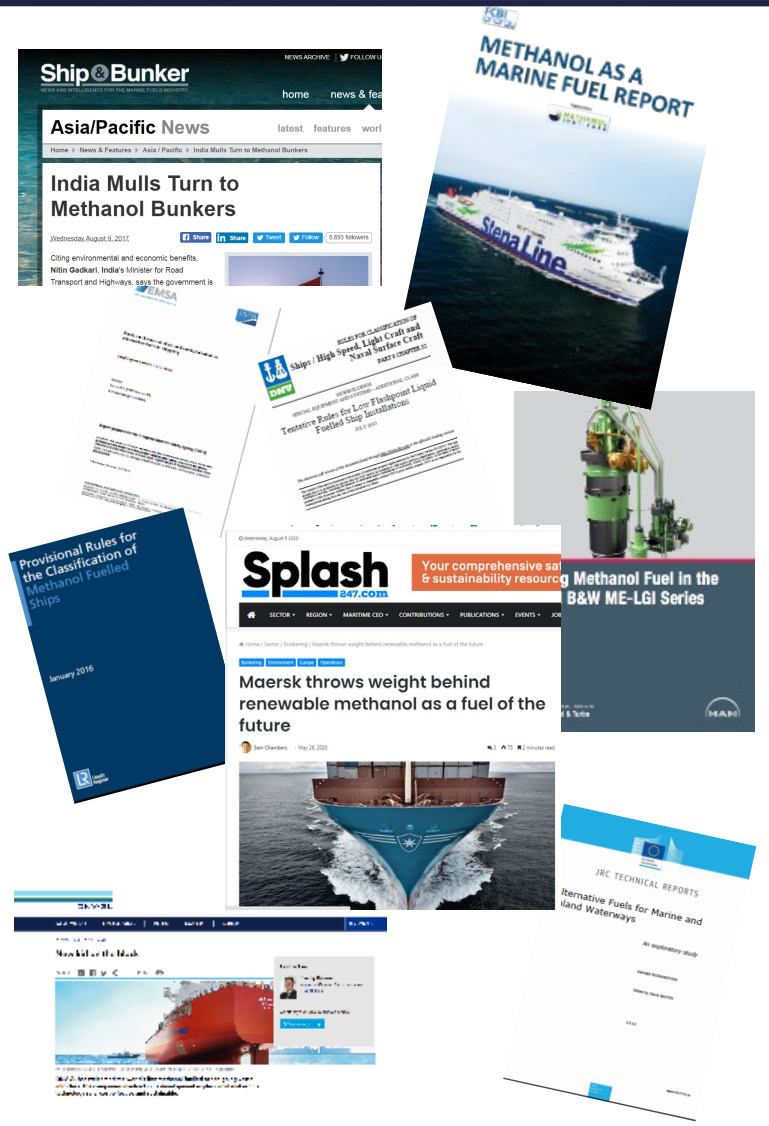
- A simple, safe liquid fuel, miscible in water
- Plentiful, available globally, price competitive to MGO
- Works with existing engine technologies as a drop-in or a dual fuel
- Complies with IMO2020 provides a pathway to IMO 2030 and 2050
- Requires only minor modifications to current bunkering infrastructure



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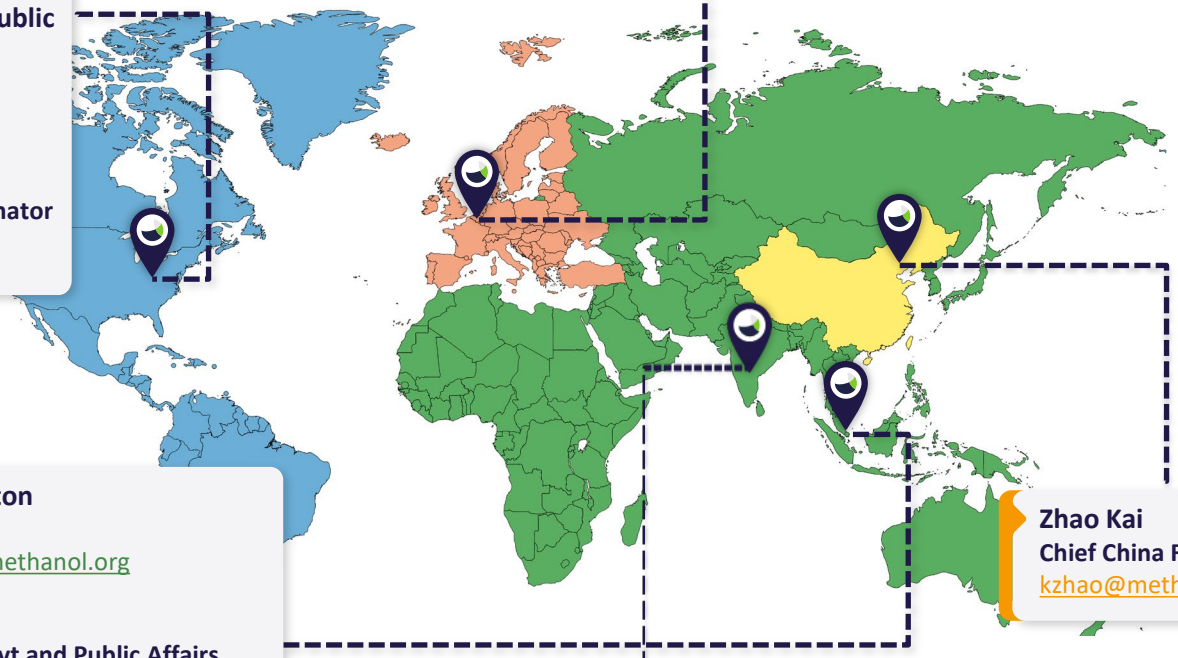

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