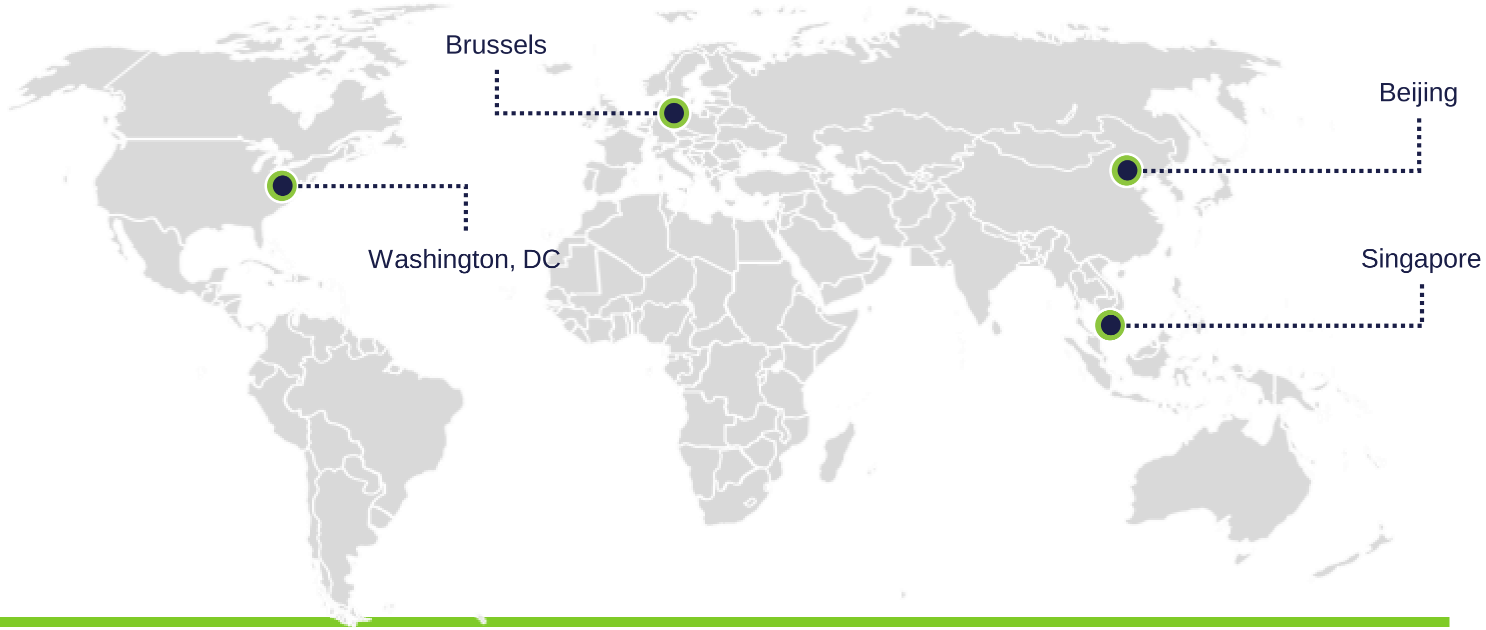
Methanol: An Emerging Alternative Marine Fuel

Gregory Dolan, CEO – Methanol Institute

July 2018

MI History

- The Methanol Institute (MI) was established in 1989 to lobby the US Congress.
- 29 years later, MI is recognized as the trade association for the methanol industry, representing world's leading methanol producers, distributors and technology companies.



MEMBERS

Tier 1

- MHTL
- methanex the power of agility
- سابك sabic

Tier 2

- Mitsubishi
- شركة قطر لإضافات البترولية المحدودة Qatar Fuel Additives Company Limited
- XENERGY
- MITSUBISHI GAS CHEMICAL AMERICA, INC.
- PETRONAS
- OCI
- Oman Methanol Company L.L.C.

Tier 3

- Eni Ecofuel
- سبكيم Sipchem Excellence everywhere
- Mitsubishi International Corporation
- G2XENERGY
- Salalah Methanol Company LLC (SPC)
- METAFRAX
- JM Johnson Matthey Inspiring science, enhancing life

Tier 4

- CARBON RECYCLING INTERNATIONAL
- FiTech
- منتجات Muntajat
- azelis
- HELM AG GERMANY
- MOL Mitsui O.S.K. Lines
- LEBZI HALAL
- SCC Southern Chemical Corporation
- TRICON ENERGY
- Double Green Bridge
- NU INNOVATION WORKS
- FUEL FREEDOM CHEAPER. CLEANER. AMERICAN-MADE.
- IMTT
- NAKHODKA FERTILIZER PLANT
- HALDOR TOPSØE
- IGPMethanol
- Billionmiles
- CLARIANT
- Enerkem
- CoogeeChemicals
- VITUSA PRODUCTS INCORPORATED
- solvadis we do chemistry

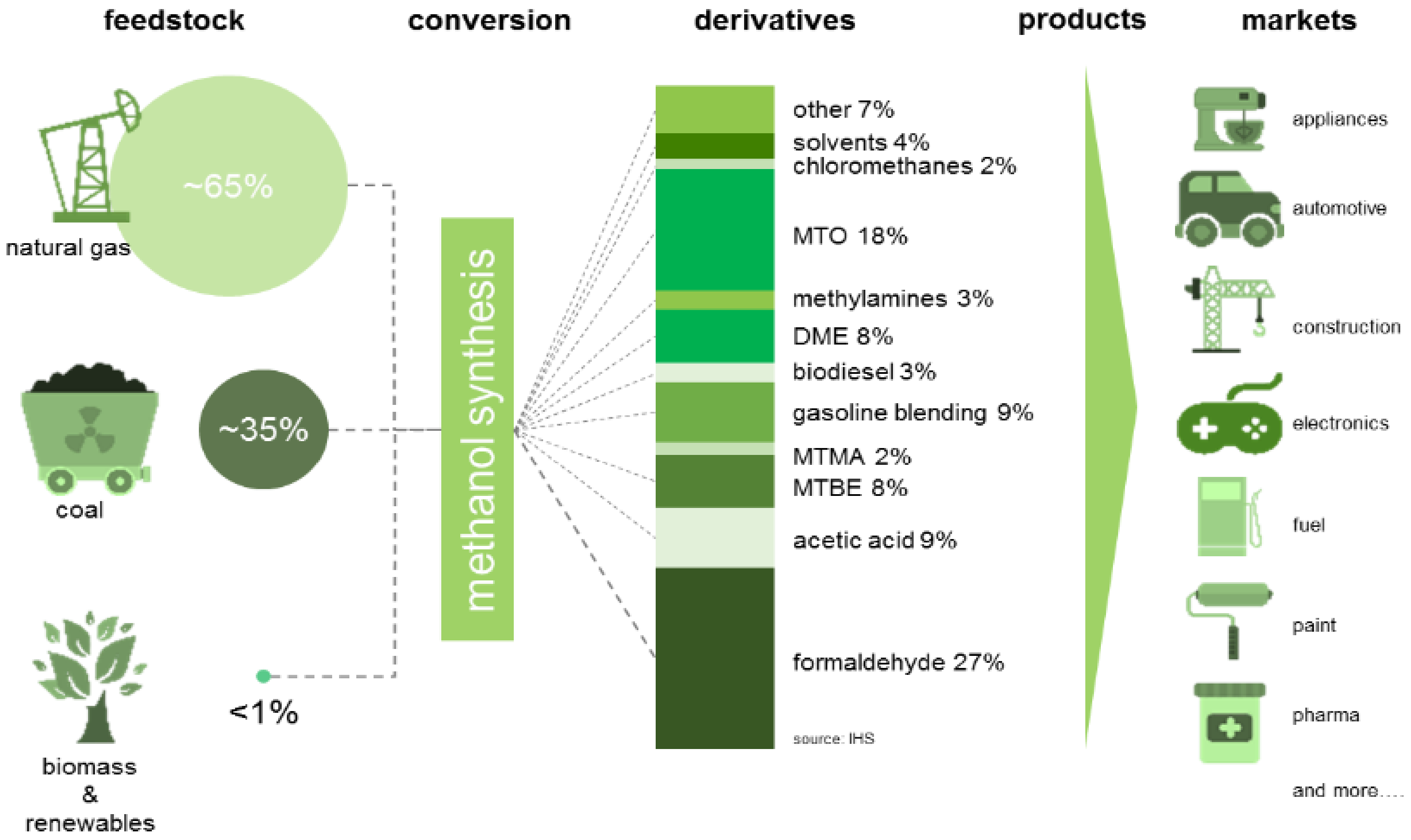
Strategic Partnerships

- European Sustainable Shipping Forum (ESSF)
- International Bunker Industry Association
- Lloyd's Register
- Dangerous Goods Advisory Council
- American Chemistry Council
- Asian Clean Fuels Association
- China Ministry of Industry & Information Technology
- China Nitrogen Fertilizer Industry Association
- Chinese Association of Alcohol & Clean Ether Fuels & Automobiles
- European Chemical Industry Council (CEFIC)
- Formacare
- Gasification & Syngas Technologies Council
- German Regenerative Methanol Network
- Gulf Petrochemicals and Chemicals Association
- International DME Association
- International Methanol Producers & Consumers Association
- National Biodiesel Board
- National Institution for Transforming India (NITI Aayog)
- Oslo University Hospital
- Peking University Centre for Global New Energy Strategic Studies
- Solar Fuels Institute

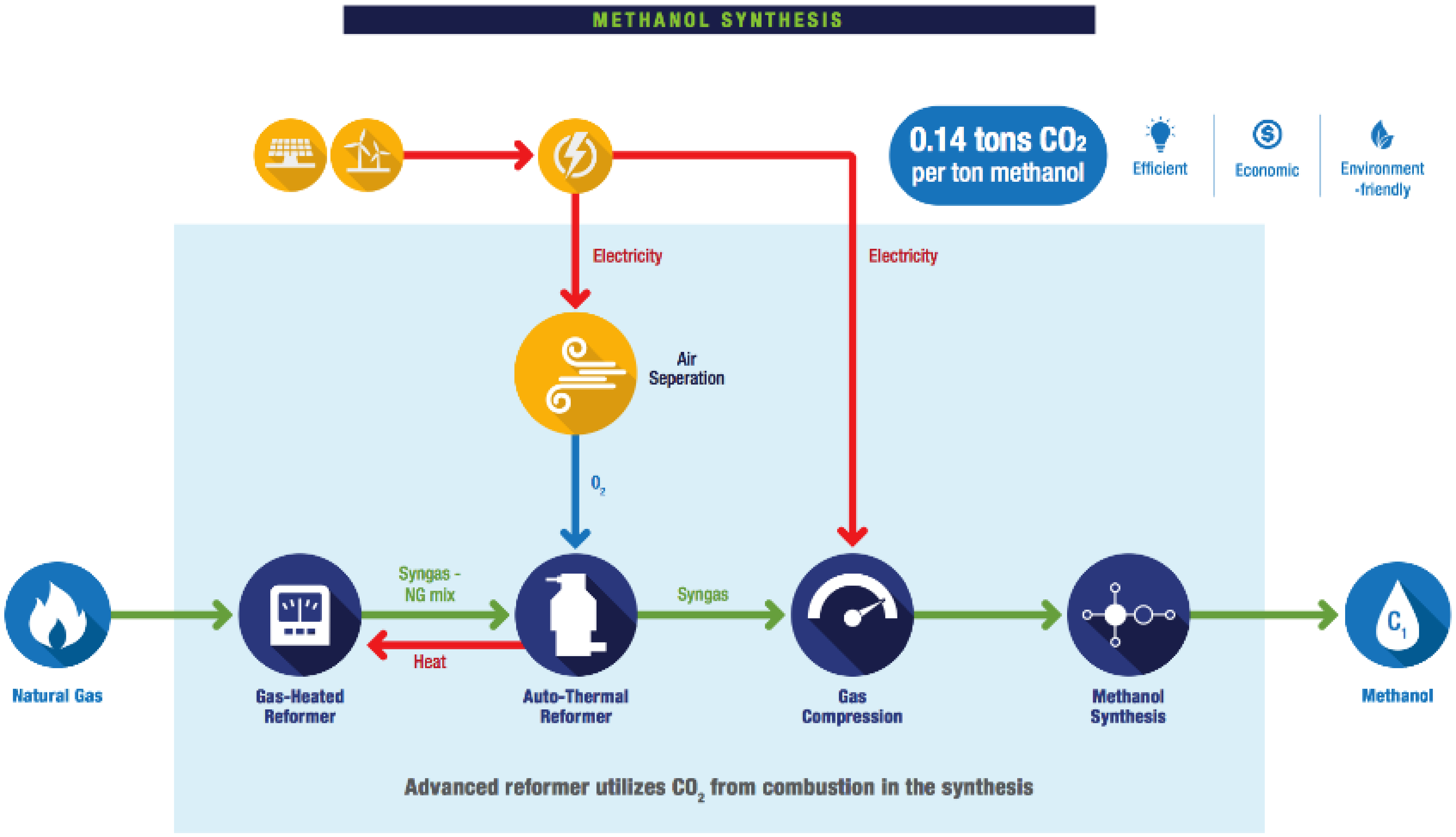
Marine Fuel Drivers

- ✓ **Scale**: Marine sector consumes 370 million metric tonnes of bunker fuel per year.
- ✓ **Sustainability**: There needs to be a viable pathway to low- & no-carbon marine fuels.
- ✓ **Price**: Need to be price competitive with current bunker fuels and other alternatives such as LNG.
- ✓ **Supply:** Fuel needs to be available globally.
- ✓ **Safety:** Ship operators need to be assured of safe handling on-board vessel and for bunkering.

Broad feedstock range, many applications

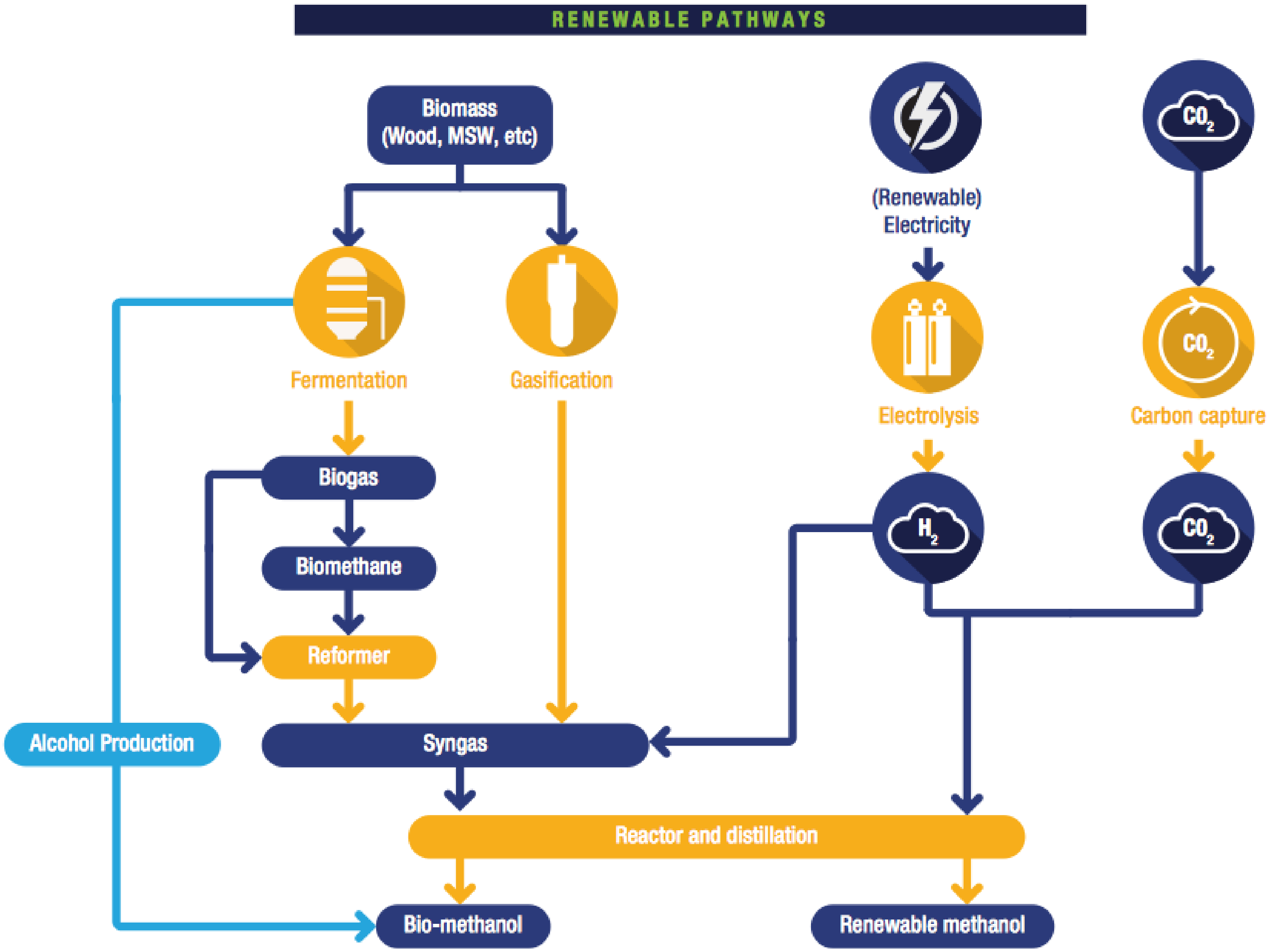


Reduced Carbon Initiatives

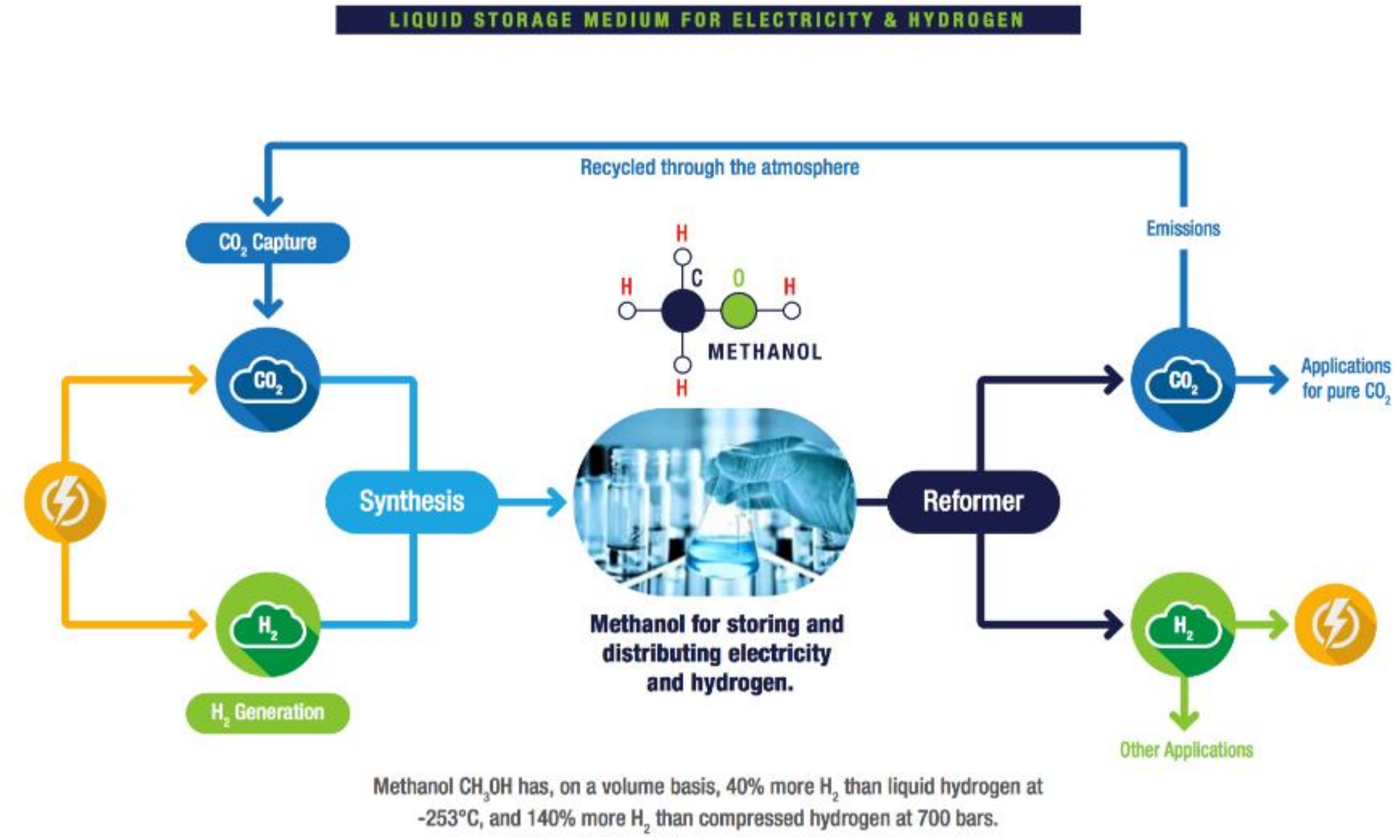


*Comparable CO_2 emissions for 1G-Coal and 2G-Gas are 3.33 and 0.56 tons respectively

Renewable Pathways



An Efficient Energy Carrier



Renewable methanol projects different stages of development

Methanol category	Commercial	Feasibility and R&D	Stopped or On-hold
Bio-methanol	• BioMCN (NL) • Enerkem (CAN) • New Fuel (DEN) • Oberon (USA)	• Biogo (GER) • Enerkem (NL) • LowLands Methanol (NL) • Södra (SE)	• BioMCN (glycerine) (NL) • Chemrec (SE) • Range Fuels (USA) • Schwarze Pumpe (GER) • Värmlands Metanol (SE) • Woodspirit (NL)
Renewable methanol	• CRI (IC) • Innogy (GER)	• Blue Fuel Energy (CAN) • CRI (CN) • Infraserv (GER) • Liquid Wind (SE) • Port of Antwerp (BE) • STEAG (GER) • Swiss Liquid Future (CH) • ZASt (GER)	
Hybrid methanol		• Haldor Topsoe (DEN) • OPTIMeoH (GER)	
Low carbon methanol	• GPIC (BAH) • Methanex (CAN) • QAFAC (QAT) • SABIC (KSA)	• Carbon2Chem (GER) • FRESME (SE) • NCF (CN)	

Methanol is a versatile fuel source

- Out of the ~75 million metric tons of methanol sold globally in 2017, energy and fuel uses represent 40% of total demand
- From 2009-2017, direct methanol fuel blending has increased at an annual rate of nearly 23%

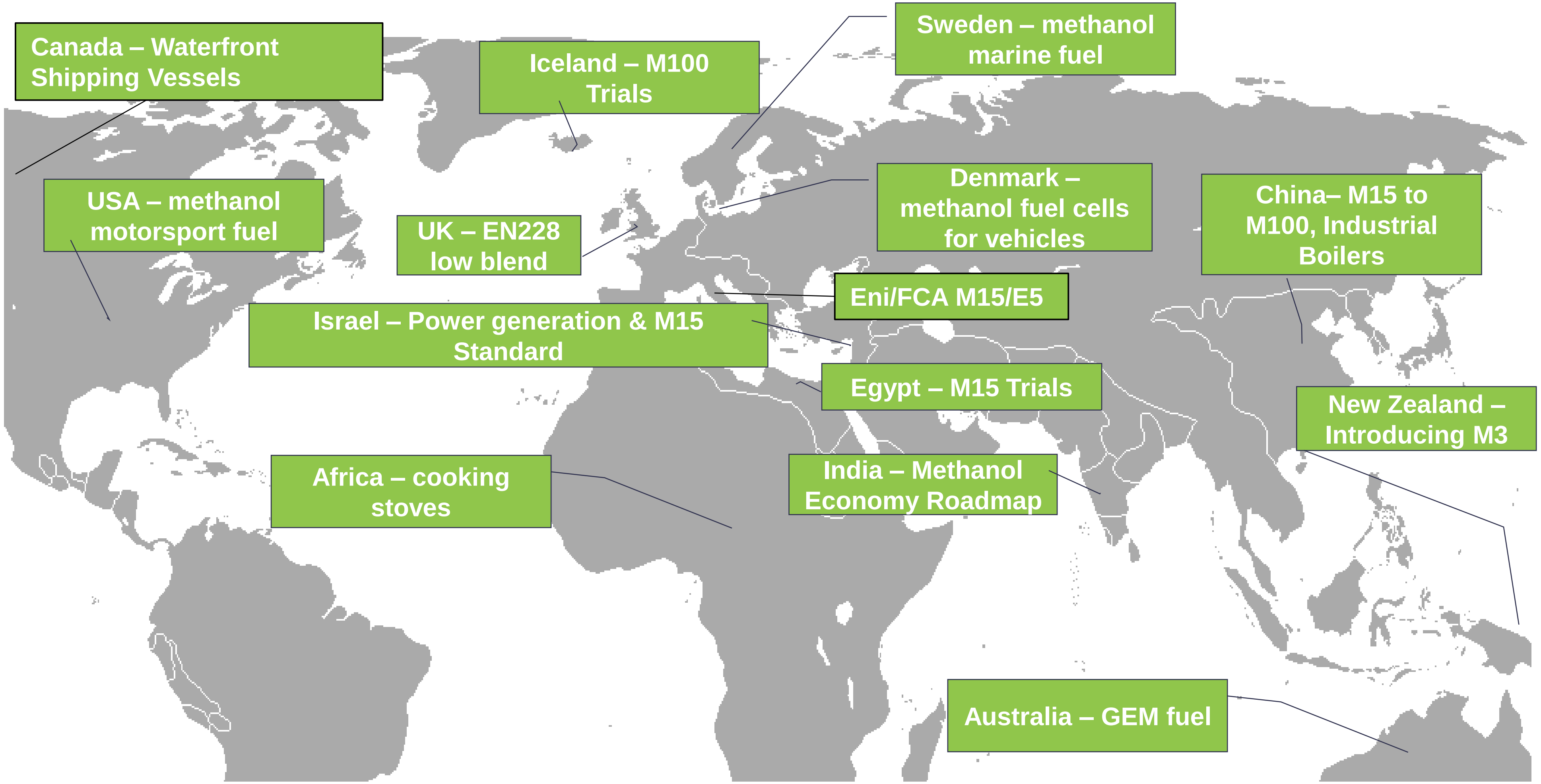
FUELS
- Neat fuel
- Low blends
- High blends
- GEM
- MTBE
- Biodiesel
- DME & OME
- MTG

TECHNOLOGIES
- SI & CI engines
- Turbines
- Fuel cells
- Industrial boilers
- Cook Stoves




SEGMENTS
- Road & non-road transportation
- Power & heat generation
- Marine

Methanol Fuel Examples Around the World



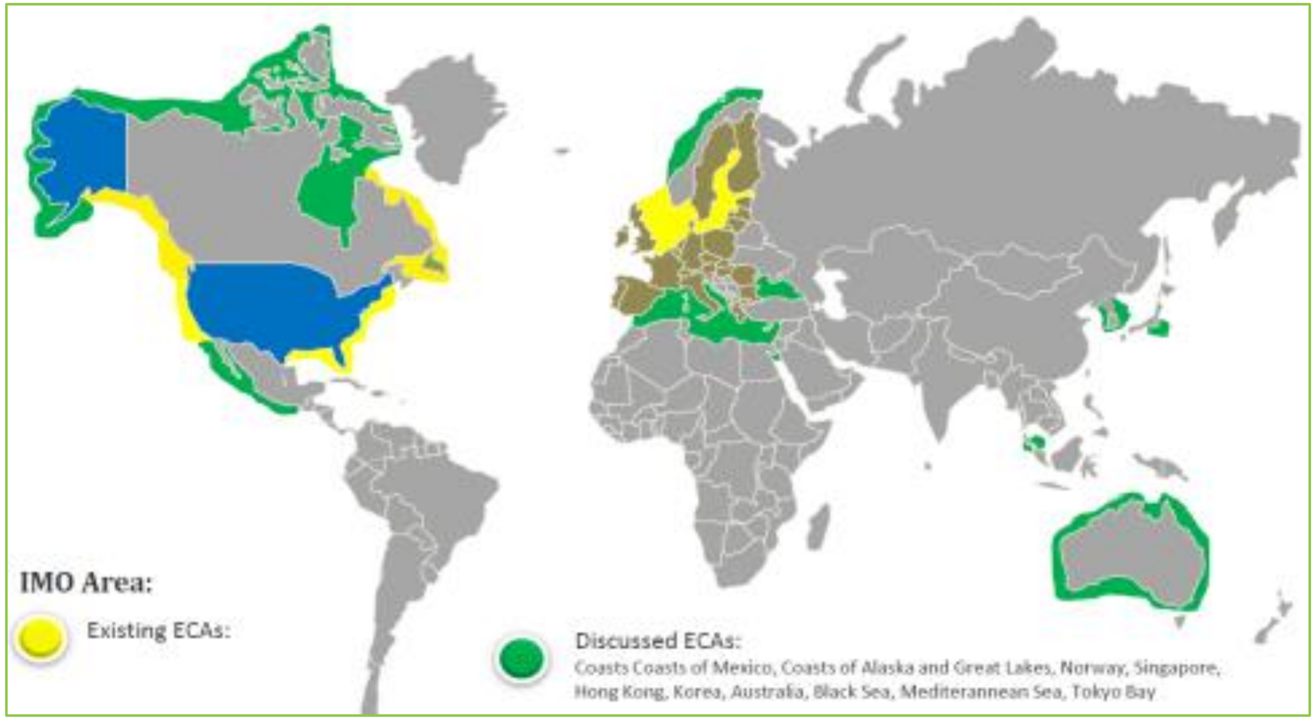
The Clear Alternative Marine Fuel

Diesel Bunker Fuel

Methanol Marine Fuel

Emissions regulations driving market

- The International Maritime Organization has adopted regulations for SOx and NOx that are transforming the shipping industry
- While 2020 global SOx reductions may be met with low sulfur fuels, the combination of SOx and NOx reductions driving shipboard solutions
- Recent IMO action on greenhouse gas emission reductions further narrow future options for shipping – at least 50% GHG reduction by 2050



Options available to ship owners

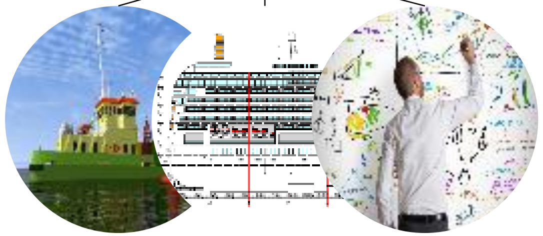
HFO +scrubbers

MGO or HFO/MGO Hybrid

LNG

Methanol

Examples of vessels running on methanol

DUAL FUEL			FUEL CELL		PROJECT and R&D
					
7x	1x	1x	1x	1x	
chemical tankers	ROPAX ferry	Pilot boat	Tourist boat	Ferry	Cruise ships, fishing boat, barge, dredge, a.o.
MOL, WL, Marinvest	Stena Line	Swedish Maritime Admin	Innogy	Viking Line	SUMMETH/MARTEC, Lean Ships, Methaship, Billion Miles, FiTech, India, PCG Product Vessel, NTU Test Bed Port of Rotterdam Barge
2 stroke MAN	4 stroke Wärtsila	high speed Scania, Weichai, a.o.	Serenergy fuel cells propulsion	Serenergy fuel cells hotel load	SI hybrid, dual fuel, etc.
new build	retrofit	retrofit	retrofit	retrofit	new build & retrofit

Industry welcomes four new ocean-going vessels capable of running on methanol

- *"We are very happy to be working with Waterfront Shipping again on this innovative technology. With seven engines already in operation and proven in the field, this new order confirms the ME-LGI concept as a mature technology. Since this dual-fuel engine entered the market in 2016, its price has dropped considerably, which makes it an even more attractive propulsion option. Allied with its environmental credentials and convenience of use when employing methanol as a fuel, we are confident the ME-LGI will continue its promising progress," states René Sejer Laursen, Promotion Manager, MAN Diesel & Turbo.*

WATERFRONT Shipping Company Limited A Responsible Care® Company

methanex the power of agility

MAN Diesel & Turbo

飯野海運株式会社 IINO KAIUN KAISHA, LTD.

MITSUI & CO.

NYK LINE

MARINVEST

INDUSTRY WELCOMES FOUR NEW OCEAN-GOING VESSELS CAPABLE OF RUNNING ON METHANOL

[February 14, 2018] -- Waterfront Shipping Company Ltd. (WFS), Marinvest/Skagerack Invest (Marinvest), IINO Kaiun Kaisha, Ltd. (IINO), Mitsui & Co., Ltd. (Mitsui), and the NYK Group (NYK) are proud to announce their investment to build four new ocean-going vessels powered by clean-burning methanol fuel. These four 49,000 dead weight tonne vessels will be delivered in 2019 and built with MAN B&W ME-LGI 2-stroke dual-fuel engines that can run on methanol, fuel oil, marine diesel oil or gas oil.

The vessels will join the existing seven methanol-fueled vessels chartered by WFS. In 2016, WFS, Marinvest, Mitsui O.S.K. Lines, Ltd., and Westfal-Larsen Management announced the delivery of these seven fuel-efficient ocean-going vessels to the sea. These innovative vessels are built with the first-of-its kind MAN B&W ME-LGI 2-stroke dual fuel engines and have achieved accolades from the marine industry for their use of clean-burning methanol as an alternative fuel.

"We are very happy to be working with Waterfront Shipping again on this innovative technology. With seven engines already in operation and proven in the field, this new order confirms the ME-LGI concept as a mature technology. Since this dual-fuel engine entered the market in 2016, its price has dropped considerably, which makes it an even more attractive propulsion option. Allied with its environmental credentials and convenience of use when employing methanol as a fuel, we are confident the ME-LGI will continue its promising progress," states René Sejer Laursen, Promotion Manager, MAN Diesel & Turbo.

"It's been great working with MAN and our shipping partners who are as committed as we are in advancing sustainable clean marine technology. Our seven methanol-fueled vessels have been operating safely and reliably since 2016, and we expect these new vessels to benefit from ongoing technological advances that will continue to optimize performance and efficiency," says Paul Hexter, President, Waterfront Shipping. "We are proud to see 40 per cent of our fleet powered by methanol-fuel technology in the coming year."

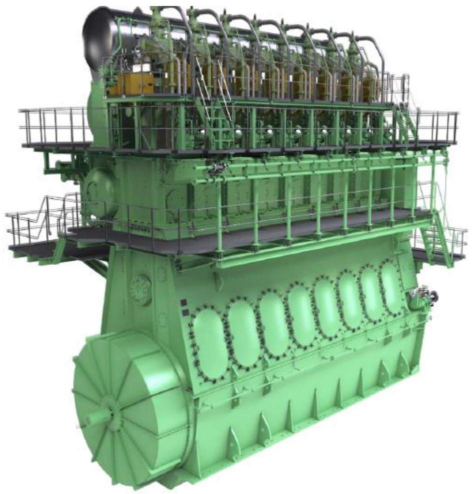
As a safe, biodegradable and clean-burning fuel, methanol is a promising alternative marine fuel that can meet new and existing environmental regulations from the International Maritime Organization (IMO) that require vessels to decrease emissions of sulphur oxide and nitrogen oxides. By using methanol rather than conventional marine fuel, the vessels produce significantly fewer emissions than conventional vessels.

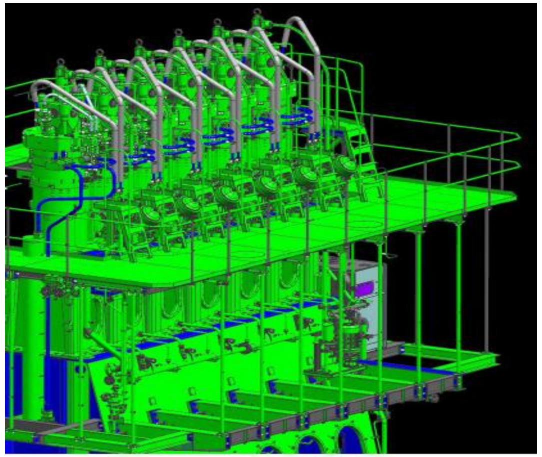
The four new vessels will be built in Korea at Hyundai Mipo Dockyard, where several of the first generation of methanol-fueled vessels were built. WFS will charter the four vessels to replace older vessels and support growing demand for methanol around the world. Two of the vessels will be owned in a joint venture between WFS and Marinvest, one will be owned by NYK and the fourth will be owned in a joint venture between IINO and Mitsui.

"We have been very pleased by the performance of the vessels delivered in 2016 and excited to be investing in another two. Our overall focus in the development of the dual-fuel system concept has been safety and engine reliability. We have found the technology for handling methanol is well developed and offers a safe dual-fuel solution for low-flashpoint liquid fuels", states Patrik Mossberg, Chairman, Marinvest.

https://www.methanex.com/news/industry-welcomes-four-new-ocean-going-vessels-capable-running-methanol

MAN Duel-Fuel Engine Configuration





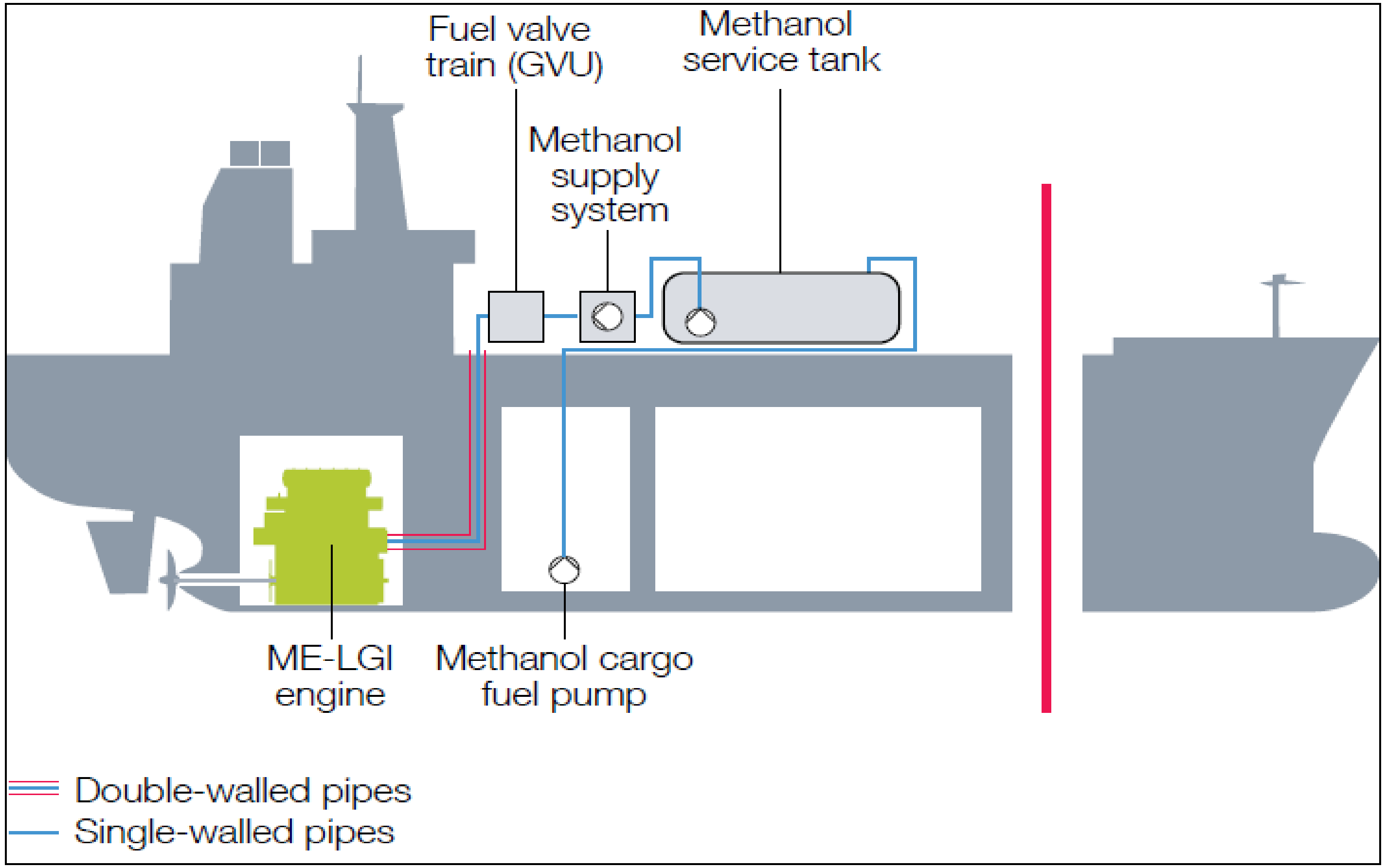


Fig. 4: ME-LGI system overview

SUMMETH

- **Sustainable Marine Methanol (Sweden)**
  - MI 2015 support of USD$68,000
  - The research concluded that there are no obstacles to the efficient use of Methanol in a converted diesel engine and that smaller vessel conversion projects are feasible and cost-effective, with levels of safety that easily meet existing requirements
  - Road ferry with an engine capacity of about 350 kW
  - Potential for Biomethanol to be progressively blended into the mix as more becomes available
  - http://summeth.marinemethanol.com/?page=reports

M/S Jupiter Vessel Particulars	
Main Dimensions	
Length Overall (LOA)	86 m
Breadth	14 m
Depth	3.45 m
Ramp Length	11 m
GT	737 tonnes
Design speed	11.6 knots
Cargo	
Passengers	397
Passenger cars	60
Loading capacity	340 tonnes
Main Engine	4 x Volvo Penta D12D-C, 331 kW, total installed power is 1324 kW
Fuel Tank	2 x 28 m^3 (diesel) (total capacity 56 m^3)

GREENPILOT

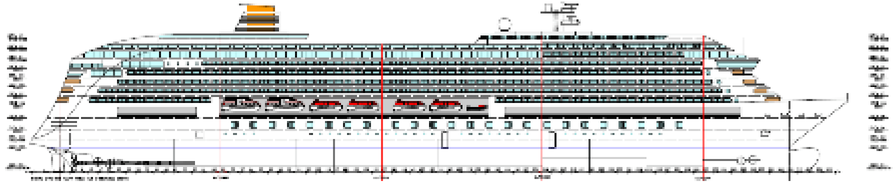
- **GreenPilot (Sweden)**
  - MI 2015 support of USD$112,000
  - Funding from Methanol Institute and Swedish Maritime Administration
  - WeiChai 6-cyl, 365kW, M100 converted NG engine provided by FiT, in high-speed, rescue/pilot vessel
  - Sea trials started on WeiChai engine in March, which concluded year end, 2017
  - WeiChai-powered vessel and converted Scania engine on stand, both exhibited at Nor-shipping on May 30th, 2017
  - Closing workshop was 3 May 2018 Gothenburg

Converted WeChai engine is planned to be used in a Singapore pilot project together with Nanyang Technological University, Q4 2018

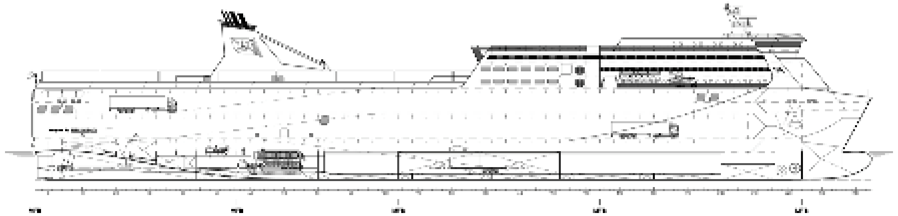
METHASHIP: Cruise & RoPax

- **MethaShip (Germany)**
  - 2 designs – cruise and ropax, with Lloyds, Meyer Werft, HELM, Flensburger Schiffbau-Gesellschaft
  - MethaShip is a national research project funded by the BMWi (Federal Ministry for Economic Affairs and Energy)
  - 45-month project, closed on 28 May 2018
  - Recently completed successful truck-to-ship bunkering
  - Presented at IMO's most recent CCC4
  - https://www.vsm.de/de/presseinformation/7818

Main data	
Length	238.0 m
Width	32.2 m
Tonnage	62 800 GT
Passengers	2050 + 570 Crew
Engines	4 x 9 MW medium speed engines
Main fuel	Methanol



Main data	
Length	199.8 m
Width	28.6 m
Draught	6,5 m
Passengers	600 + 50 Crew
Engines	Dual Fuel 2 x 9 MW medium speed
Main fuel	Methanol

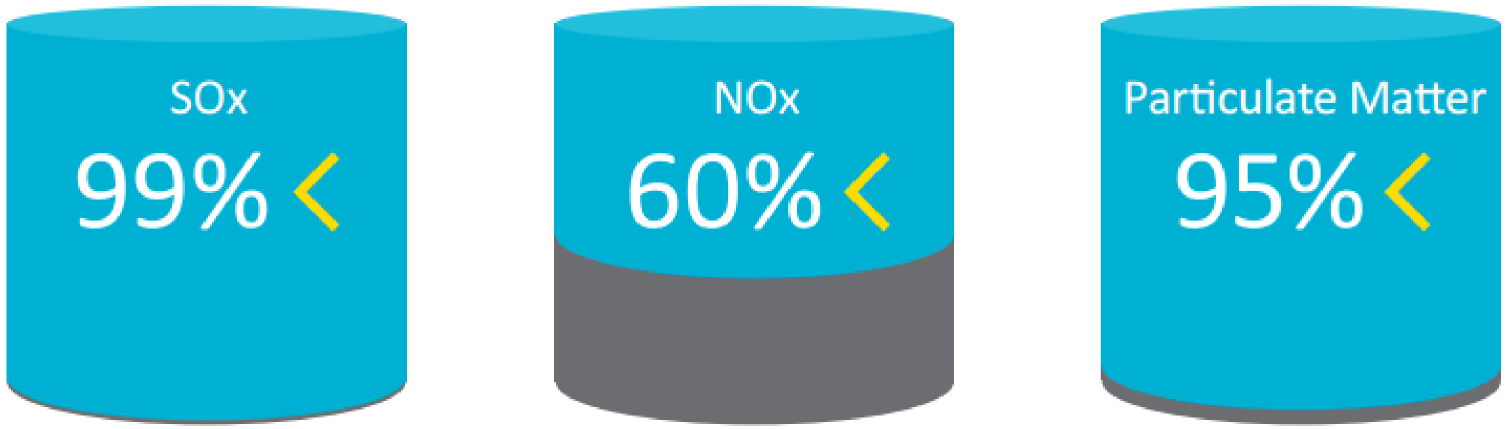


Other Pilot Projects

- **Methanex**
  - Tianjin University and ZiChai (engine OEM) as partners
  - Converted 1,100kW marine engine with DMCC technology for commercial fishing vessel applications (Tianjin University)
- **Billion Miles (Singapore)**
  - 4-cyl M100 prototype, skid-mounted, auxiliary power formally launched in 2018
  - Main propulsion unit coming later in 2018
- **FiTech**
  - Fujian (140kW), fishing vessel (still discussing)
  - MoA multi-vessel, LNG to methanol conversion (still discussing)
- **PCG Product Supply Vessel Interest** (still discussing)
  - Dual-fuel
  - Small product carrier (5,000 mt)
- **NTU's test bed facility** (about to launch)
  - 1st Phase
    - Test bed emissions and fuel consumption analysis
    - Converted WeChai engine with FiT, ScandiNAOS, LR, IBIA, CCS, Keppel
    - No vessel yet, but targeting single-engine, shore-to-ship crew transport vessel
- **Plus:** EU inland waterways; India fishing boats; Celeste EU methanol fuel cell vessel

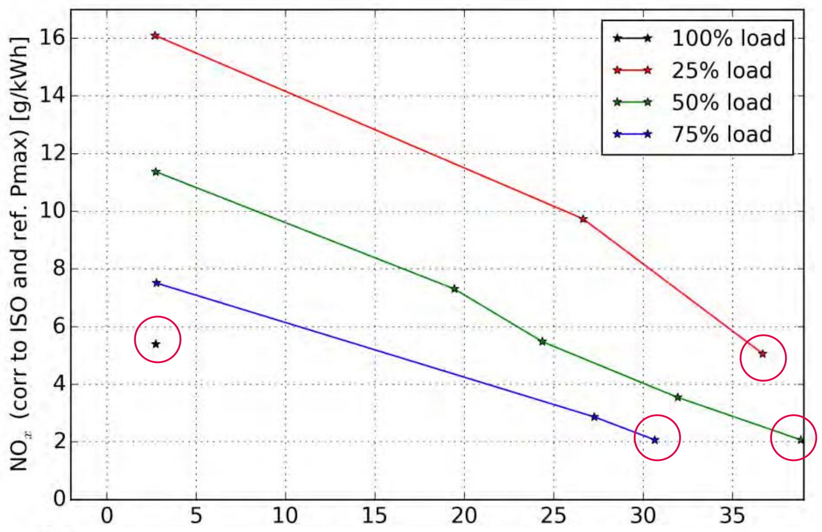
Emissions Reductions

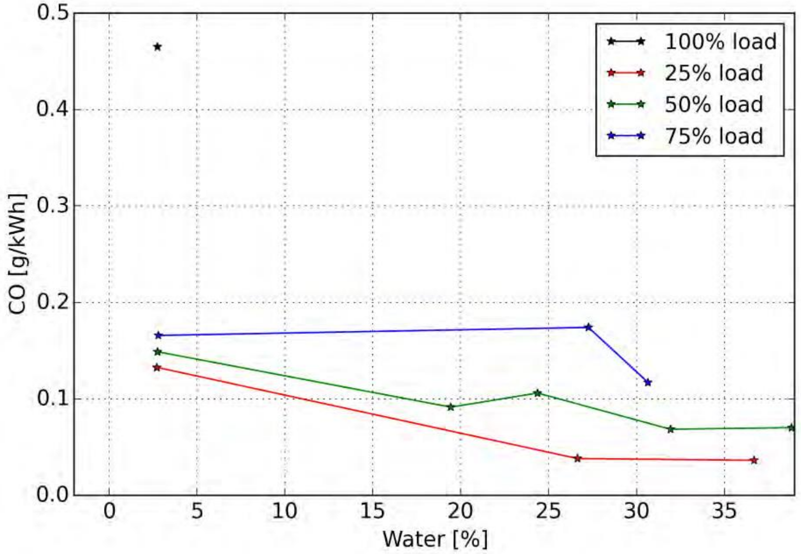
Methanol is among the lowest emission fuels for marine engines

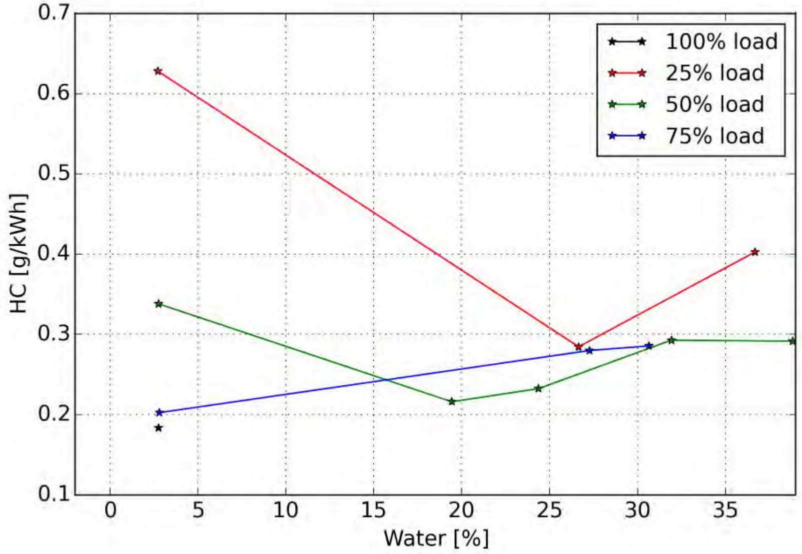


Source: Stena Lines -- Emission reductions when compared to alternative fuels currently available (fuel oil)

Methanol / Water Blending (Emulsification)



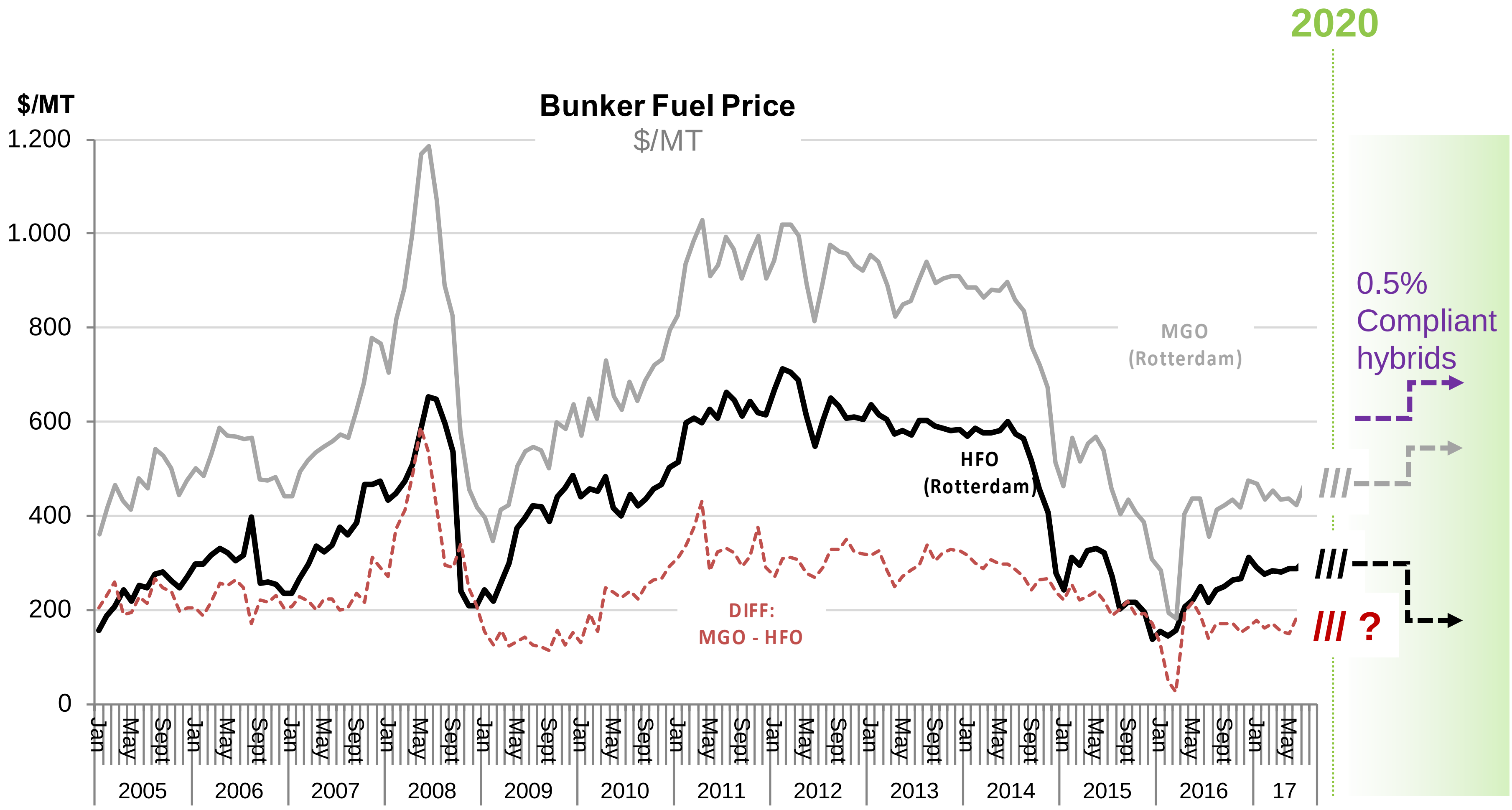




Source: MAN

- NOx decreases almost linearly with water content
- NOx emissions are close to 2 g/kWh at 50 and 75% load
- NOx emissions at 25% load is at the “not to exceed limit” for Tier-III, but can be lowered further
- 100% load with high water content not possible due to system limitations

Future Fuel Pricing



Source: Bunkerindex

Cost Competitiveness

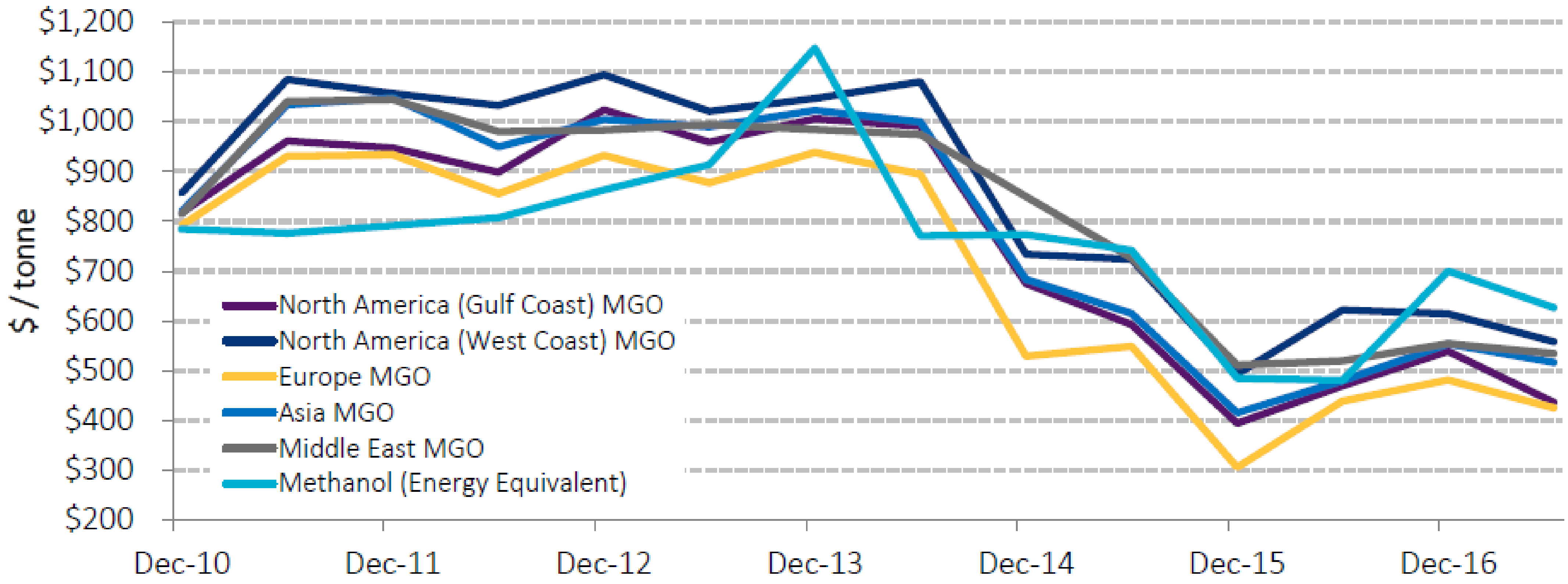


Chart source: Platts and IHS Chemical

- MGO NA GC: Avg New Orleans, Houston; MGO NA WC: Avg LA, San Francisco, Seattle, Vancouver; MGO Europe: Avg Rotterdam, Antwerp, Hamburg; MGO Asia: Avg Shanghai, Korea; MGO Middle East: Avg Fujairah, Kuwait, Khor Faakan
- Methanol: Avg USGC, China and Europe spot prices; adjusted to energy equivalent of MGO (2.16 factor)

methanex
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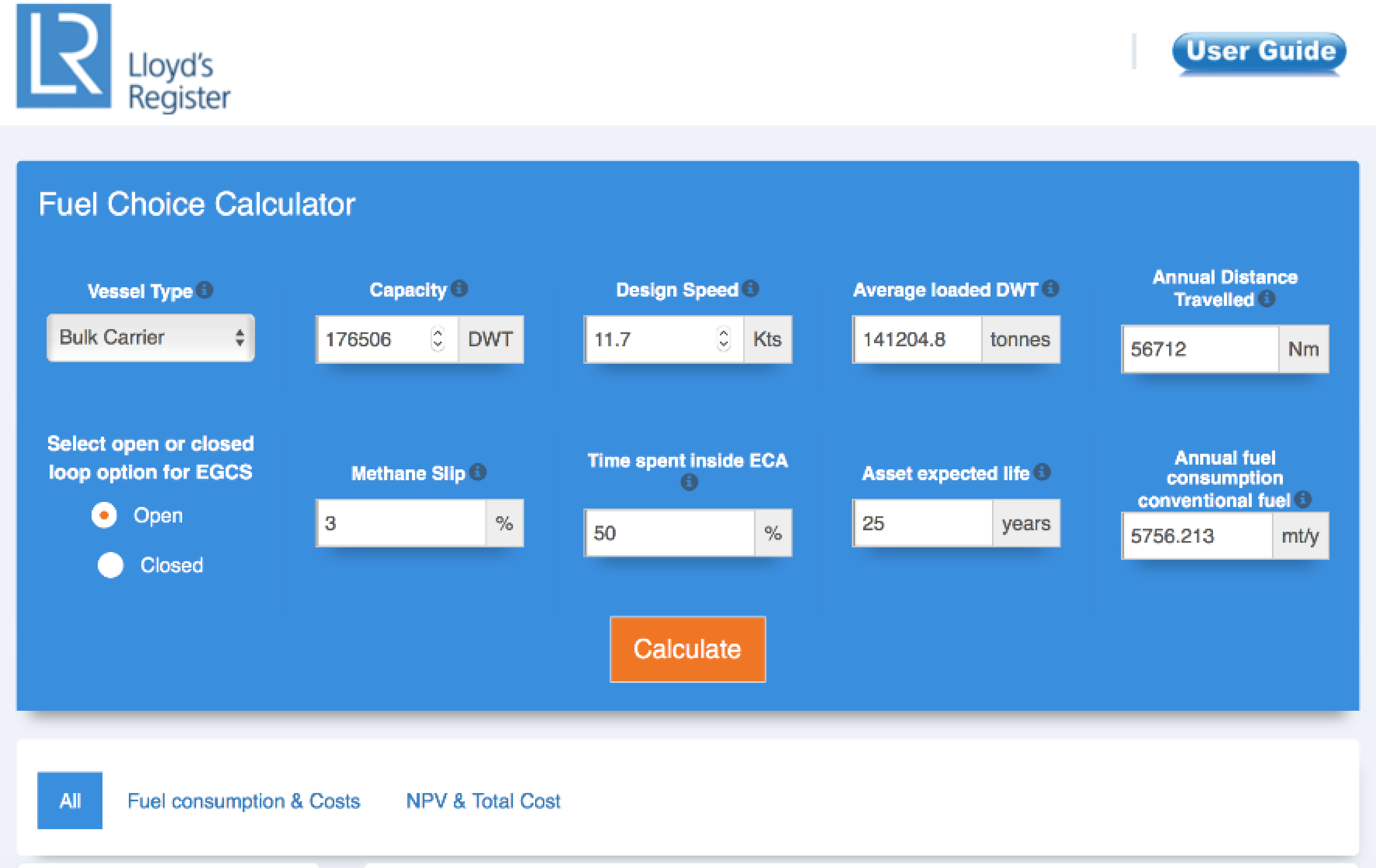
Fuel Comparison Model & Online Calculator



Fuel Comparison Model & Online Calculator

Total Fuel CAPEX

Total CAPEX LNG	49.766	M USD
Total CAPEX HFO scrubbers	44.167	M USD
Total CAPEX Compliant fuel	42.3	M USD
Total CAPEX Methanol	44.913	M USD

Price Differentials (USD/MT)

	Low	Medium	High
LNG	2(	260.0	31
HFO 3.5	1‹	185.0	22
Methanol	1!	199.0	23

Calorific Value

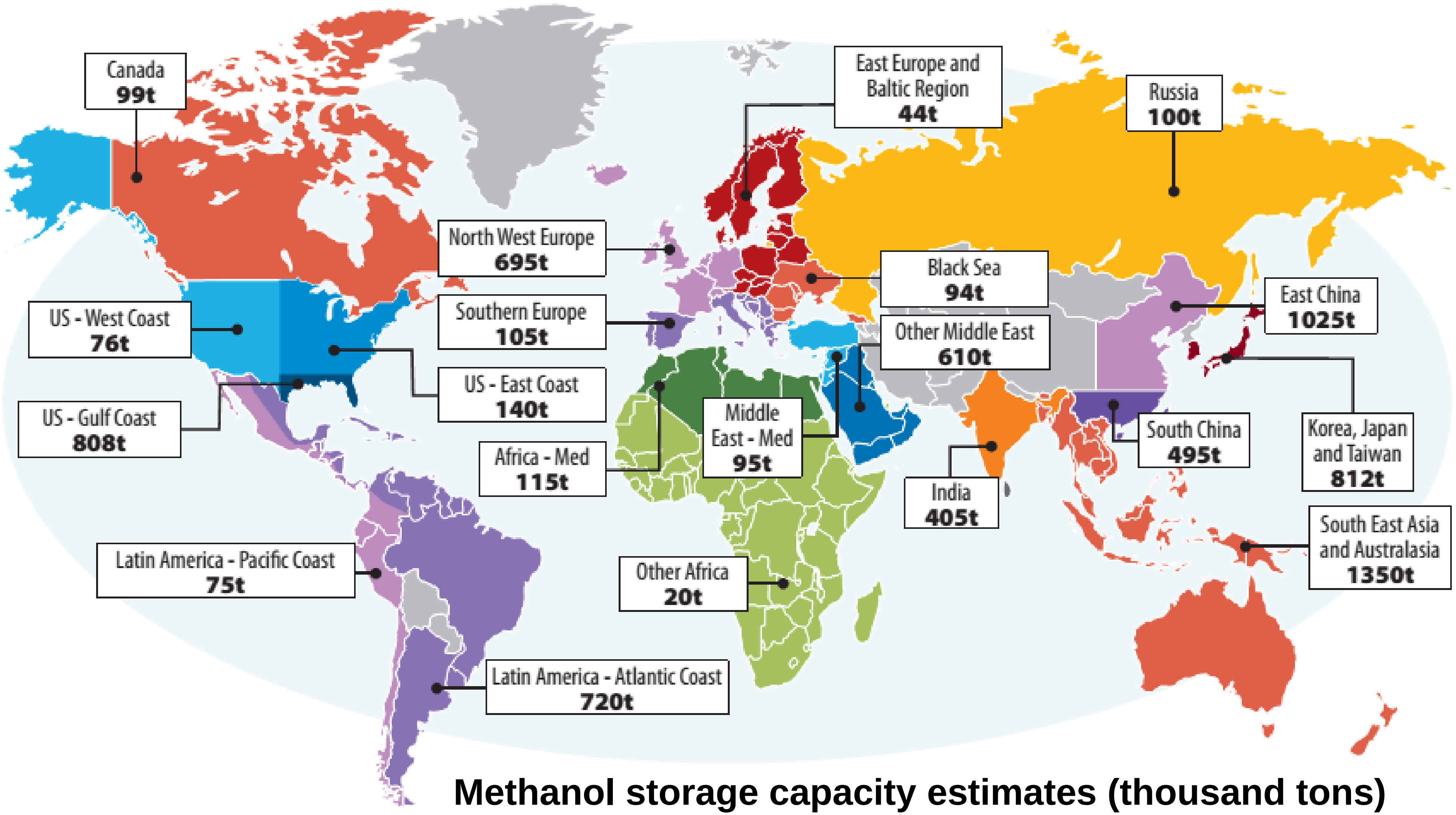
Calorific Value LNG	49	kJ/kg
Calorific Value HFO 3.5	41	kJ/kg
Calorific Value Compliant fuel	43	kJ/kg
Calorific Value Methanol	20	kJ/kg

Fuel Costs

Check Fuel Prices

LNG price	315	USD/mt
HFO 3.5 price	390	USD/mt
HFO 0.50 price	550	USD/mt
MGO 0.10 price	600	USD/mt
Methanol price	376	USD/mt

Available in many ports around the world



Methanol storage capacity estimates (thousand tons)

Methanol is widely available and easy to handle

- Liquid at atmospheric pressure
- Available in many ports around the world and along rivers
- Low infrastucture cost
- Flexible, modular system
- Environmentaly friendly as it’s **biodegradable**

IMO IGF Code for Ethyl/Methyl Alcohols

CCC 1
- Establish CG to develop measures for:
  - Ethyl/methyl alcohol
  - Fuel cells
  - Low-flashpoint diesel

CCC 2
- Consider establishing WG to develop measures for:
  - Ethyl/methyl alcohol
  - Fuel cells
  - Low-flashpoint diesel
- Consider re-establishing CG
- Consider the need for other sub-committees to examine drafts or parts of them and, if so, make the necessary request to the relevant sub-committee(s)

CCC 3
- Consider establishing WG to finalize measures for:
  - Ethyl/methyl alcohol
  - Fuel cells
  - Low-flashpoint diesel

MSC 97
- Approval
- Not Approved

CCC 4
- Approval
- Consider establishing WG to finalize measures for:
  - Ethyl/methyl alcohol
  - Fuel cells
  - Low-flashpoint diesel
- Not Approved

MSC 98
- Adoption, if required
- Not Adopted

CCC 5
- Approval
- Consider establishing WG to finalize measures for:
  - Ethyl/methyl alcohol
  - Fuel cells
  - Low-flashpoint diesel

MSC 99
- Approval
- Adoption, if required

MSC 100
- Approval
- Adoption, if required

2014 2015 2016 2017 2018 2019

- ❖ Not clear when IGF Codes will be Approved (ie; which future CCC X)
- ❖ Not clear after IGF Codes will be Approved, at which MSC they could be Adopted In Principle
- ❖ IMO has reserved 2024 by which IGF Codes must come into Force
- ❖ After Approval, IGF Codes may be implemented at flag state level with the understanding that additional amendments may be added, requiring compliance, before IGF Codes come into Force

Comparing apples to apples

	METHANOL	DIESEL	GASOLINE
Hazard pictograms (CPL)			
Signal word: (CPL)	Danger	Danger	Danger
Hazard statements (CPL)	H225 Highly flammable liquid and vapour. H301 Toxic if swallowed. H311 Toxic in contact with skin. H331 Toxic if inhaled. H370 Causes damage to organs.	H226: Flammable liquid and vapour. H304: May be fatal if swallowed and enters airways. H315: Causes skin irritation. H332: Harmful if inhaled. H351: Suspected of causing cancer. H373: May cause damage to organs through prolonged or repeated exposure. H411: Toxic to aquatic life with long lasting effects	H224: Extremely flammable liquid and vapour. H304: May be fatal if swallowed and enters airways H315: Causes skin irritation H340: May cause genetic defects H350: May cause cancer H361: Suspected of damaging fertility or the unborn child H336: May cause drowsiness or dizziness H411: Toxic to aquatic life with long lasting effects
Precautionary statements (CLP)	P210 - Keep away from heat. - No smoking P280 - Wear protective gloves, protective clothing, eye protection, face protection P304+P340 - IF INHALED: remove victim to fresh air and keep at rest in a position comfortable for breathing P303+P361+P353 - IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower P301+P310 - IF SWALLOWED: Immediately call a POISON CENTRE or doctor P403+P235 - Store in a well-ventilated place. Keep cool	P201: Obtain special instructions before use P210: Keep away from heat/sparks/open flames/hot surfaces – No smoking P240: Ground/bond container and receiving equipment P241: Use explosion-proof electrical/ventilation/ lighting equipment P242: Use only non-sparking tools P243: Take precautionary measures against static discharge P260: Do not breathe dust/fume/gas/vapours/spray P264: Wash hands thoroughly after handling P270: Do not eat, drink or smoke when using this product P273: Avoid release to the environment P280: Wear protective gloves/clothing/eye protection P301+P310: IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician P302+P352: IF ON SKIN: Wash with plenty of soap and water P303+P361+P353: IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower P304+P340: IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing P308+P313: IF exposed or concerned: Get medical advice/attention P312: Call a POISON CENTER or doctor/physician if you feel unwell P331: Do NOT induce vomiting P332+P313: If skin irritation occurs: Get medical advice/attention P370+P378: In case of fire: Use water spray or foam for extinction P391: Collect spillage P403+P233: Store in a well-ventilated place. Keep container tightly closed P403+P235: Store in a well-ventilated place. Keep cool P405: Store locked up P501: Dispose of contents/container in accordance with local/regional/national/international regulation	P201: Obtain special instructions before use P202: Do not handle until all safety precautions have been read and understood P210: Keep away from heat/sparks/open flames/hot surfaces – No smoking P233: Keep container tightly closed P240: Ground/bond container and receiving equipment P241: Use explosion proof electrical/ventilation/ lighting equipment P242: Use only non sparking tools P243: Take precautionary measures against static discharge P261: Do not breath fume/gas/mist/vapours/spray P264: Wash hands thoroughly after handling P271: Use only outdoors or in a well-ventilated area P273: Avoid release to the environment P280: Wear protective gloves/clothing/eye protection P301+P310: IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician P302+P352: IF ON SKIN: Wash with plenty of soap and water P303+P361+P353: IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower P304+P340: IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing P308+P313: IF exposed or concerned: Get medical advice/attention P312: Call a POISON CENTER or doctor/physician if you feel unwell P331: Do NOT induce vomiting P332+P313: If skin irritation occurs: Get medical advice/attention P370+P378: In case of fire: Use water spray or foam for extinction P391: Collect spillage P403+P235: Store in a well-ventilated place. Keep cool P405: Store locked up P501: Dispose of contents/container in accordance with local/regional/national/international regulation

Less dangerous than gasoline

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF MOBILE SOURCES

EPA [illegible]

Methanol Fuels and Fire Safety

Vehicle Fire Risk

In 1986, there were 500,000 vehicle fires and 1,400 vehicle fire fatalities in the United States. Gasoline was the first material to ignite in 180,000 of these fires and many of the other fires ultimately involved gasoline.

Gasoline-ignited fires in 1986 involving cars, buses, or trucks resulted in 760 deaths, 4,100 serious injuries, and $215 million in property damage.

Projections indicate that casualties would drop dramatically if methanol were substituted for gasoline as the country's primary automotive fuel. Looking just at vehicle fires in which gasoline is the first material to ignite, a switch to methanol could save an estimated 720 lives, prevent nearly 3,900 serious injuries, and eliminate property losses of millions of dollars a year.

Methanol's fire safety advantage over gasoline stems from several physical and chemical properties (see figures on page 3):

- **LOWER VOLATILITY** (Figure 1)
  Methanol does not evaporate or form vapor as readily as gasoline does. Under the same conditions, exposed gasoline will emit two to four times more vapor than will exposed methanol.
- **HIGHER FLAMMABILITY REQUIREMENT** (Figure 2)
  Methanol vapor must be four times more concentrated in air than gasoline vapor for ignition to occur.
- **LOWER VAPOR DENSITY**
  Gasoline vapor is two to five times denser than air, so it tends to travel along the ground to ignition sources. Methanol vapor is only slightly denser than air and disperses more rapidly to non-combustible concentrations.
- **LOWER HEAT RELEASE RATE**
  Methanol burns 25 percent as fast as gasoline and methanol fires release heat at only one-eighth the rate of gasoline fires.

These properties together make methanol inherently more difficult to ignite than gasoline and less likely to cause deadly or damaging fires if it does ignite. Methanol is the fuel of choice for Indianapolis-type race cars, in part because of its superior fire safety characteristics.

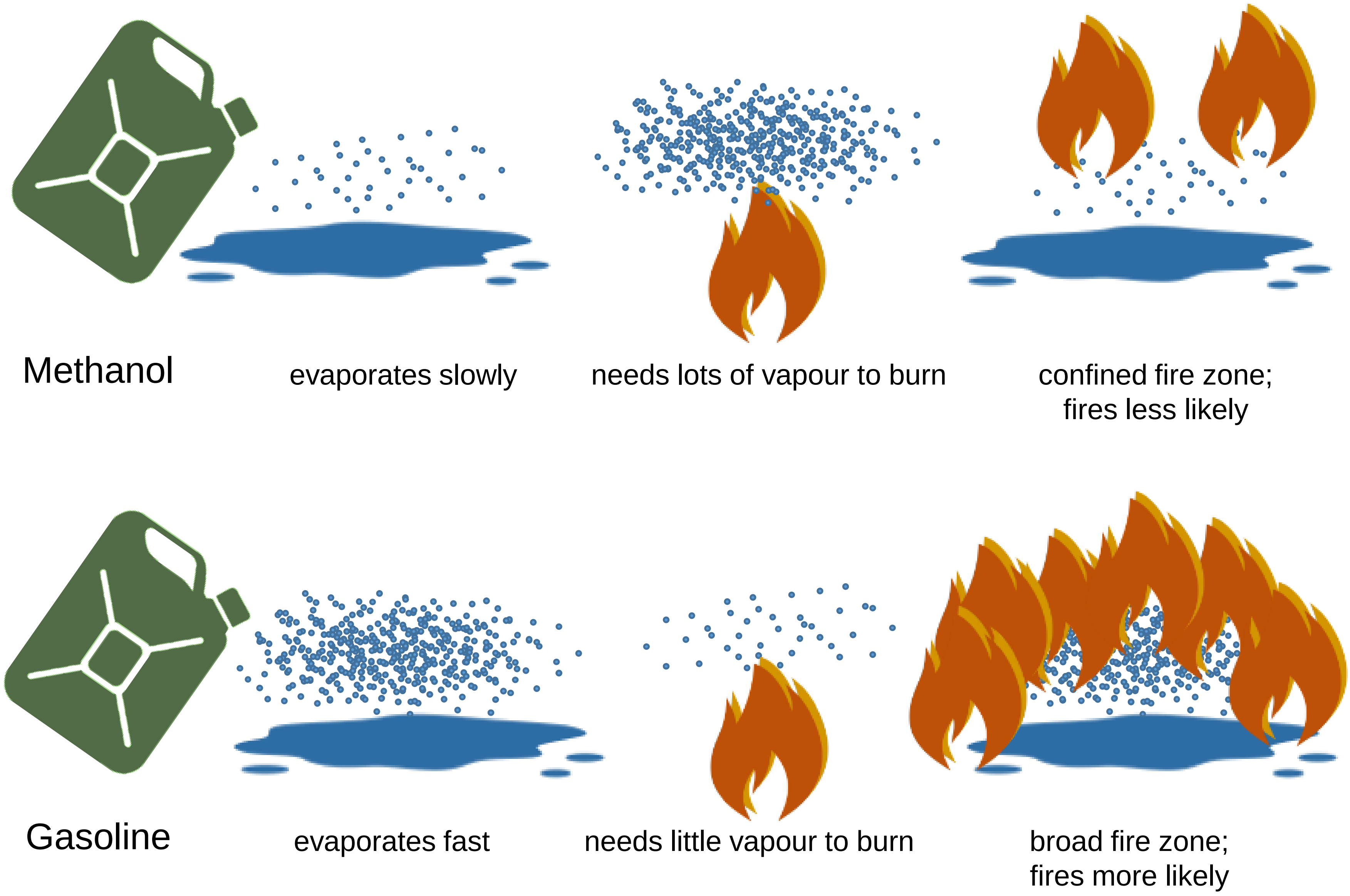
TABLE 6-1
HAZARD SUMMARY[a]

	M100	Gasoline
Flammability		
Ease of Occurrence		
Open & Restricted Areas	4	9
Enclosed Spaces	8 (2-4)[b]	2
Relative Hazard if Fire		
Fire Severity	3	10
Ease of Extinguishing	7	10
Flame Visibility	8	1
Toxicity		
Inhalation-Low Conc.		
Toxicity	3	10
Ease of Occurrence	10	10
Inhalation - High Conc.		
Toxicity	10	10
Ease of Occurrence	3	4
Skin Contact.		
Toxicity	9	8
Ease of Occurrence	3	3
Ingestion		
Toxicity	10	10
Ease of Occurrence	8(2)[c]	3

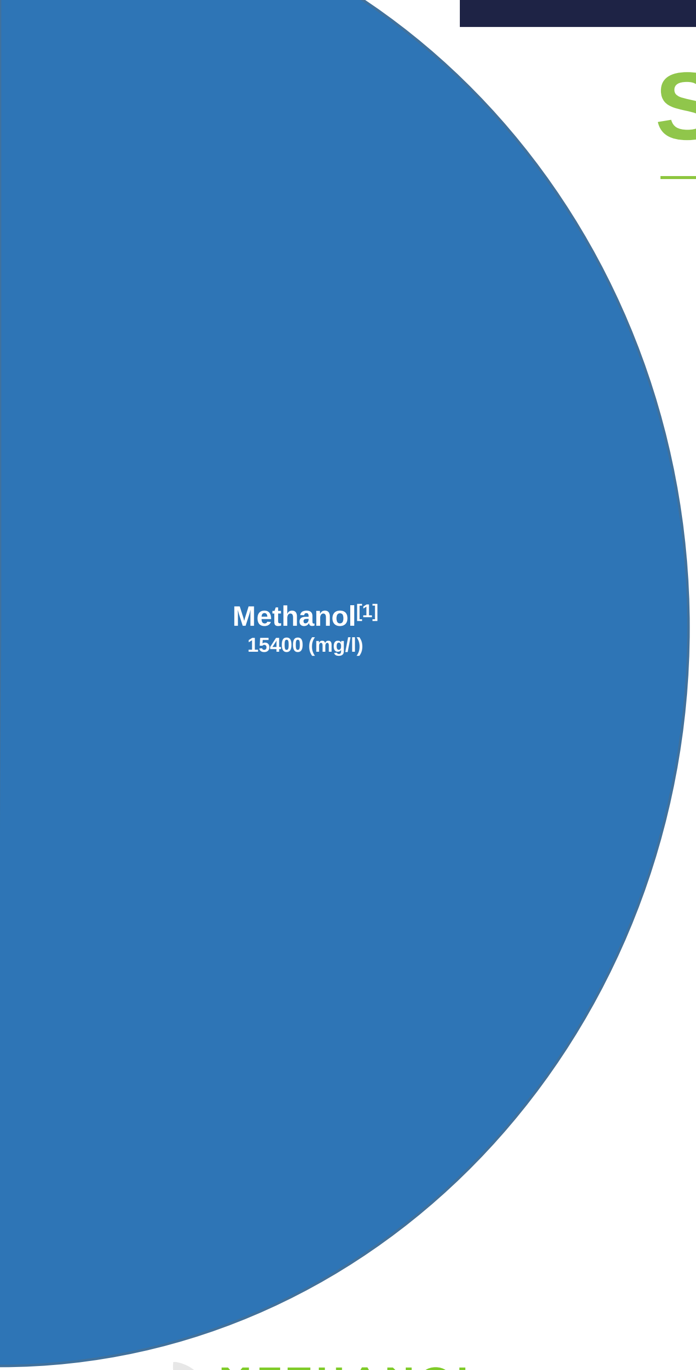
Table adapted from Machiele, 1998; [a] 1-No concern. 2 to 3 = Low Level concern. 4 to 6 = moderate concern. 7 to 8 = high-level concern. 9 to 10 = extreme hazard. [b] Numbers in parenthesis reflect hazard reductions resulting from design changes. [C] Number in parenthesis incorporates the lowered likelihood of ingestion due to the presence of additives.

Source: Malcolm Pirnie, Inc. , Technical Memorandum

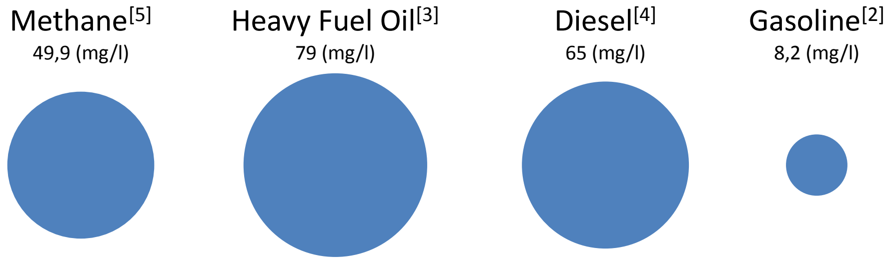
Methanol has lower fire risk



Safer For The Environment



(LC50, LC=Lethal Concentration):
Concentration in water, at which half the population died within a specified test duration.



Methanol better than
- **Diesel** by factor **240**
- **Gasoline** by factor **1900**

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

Additional Source: Meyer-Werft

Methanol safer for marine environment

	Maritime accident	Maritime accident	Simulation
Ship	Erika	Tanio	-
Fuel	Heavy Fuel Oil	Heavy Fuel Oil	Methanol
Released amount	19 000 t	13 500 t	10 000 t
Affected coastline	400 km	200 km	0 km
Total damage:	$914M	-	-
Cleaning	$100M	$50M	$0
Fishing industry	$98,3M	-	-
Tourist industry	$400-500M	-	-
Claim for damages	$120M	$17M	-
Killed birds	≈ 60,000	≈ 40, 000	-> 0

Source: MethaShip

MI Focus: Methanol as a Marine Fuel

- Participate in formation of international regulations and safe handling guidelines for methanol as alternative fuel
- Work with engine OEMs on new build and conversion offerings across multiple scales
- Encourage and support pilot demonstrations of methanol marine fuels in multiple markets, to validate environmental, technical and economic merits
- Direct marketing campaign

Methanol...

- is plentiful, available globally
- can be made 100% renewable
- runs well in existing engine technology and has potential for further optimization
- complies with increasingly stringent emission reduction regulations
- requires only minor modifications to current bunkering infrastructure
- is biodegradable!
- safe handling can rely on long history and experience in shipping and industry
- shows slight regional price variation
- ***NEEDED: Vessels, guidelines, standards***

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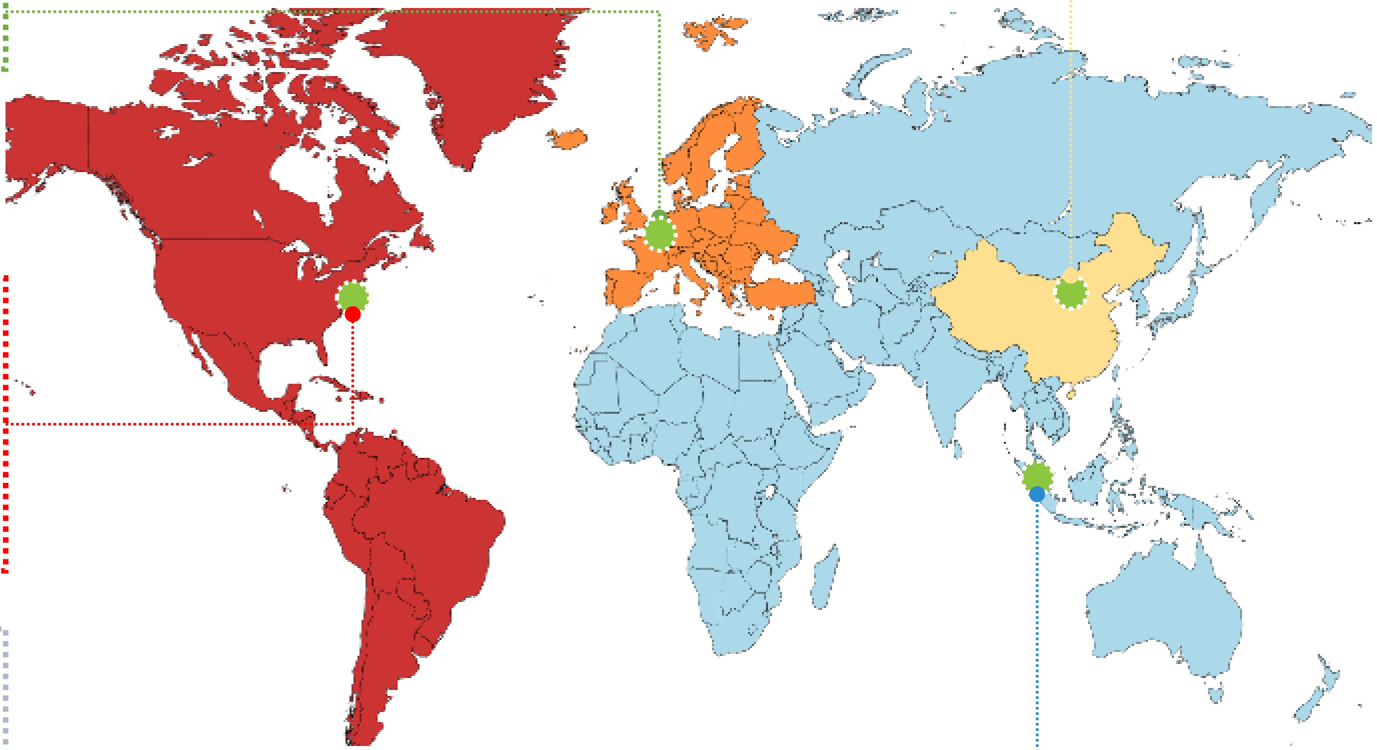

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