METHANOL INSTITUTE

METHANOL: A FUEL WITH A FUTURE

Tim Chan, Manager, Government Relations and Business Development (AP & ME)

Methanol as a Marine Fuel Seminar

2018

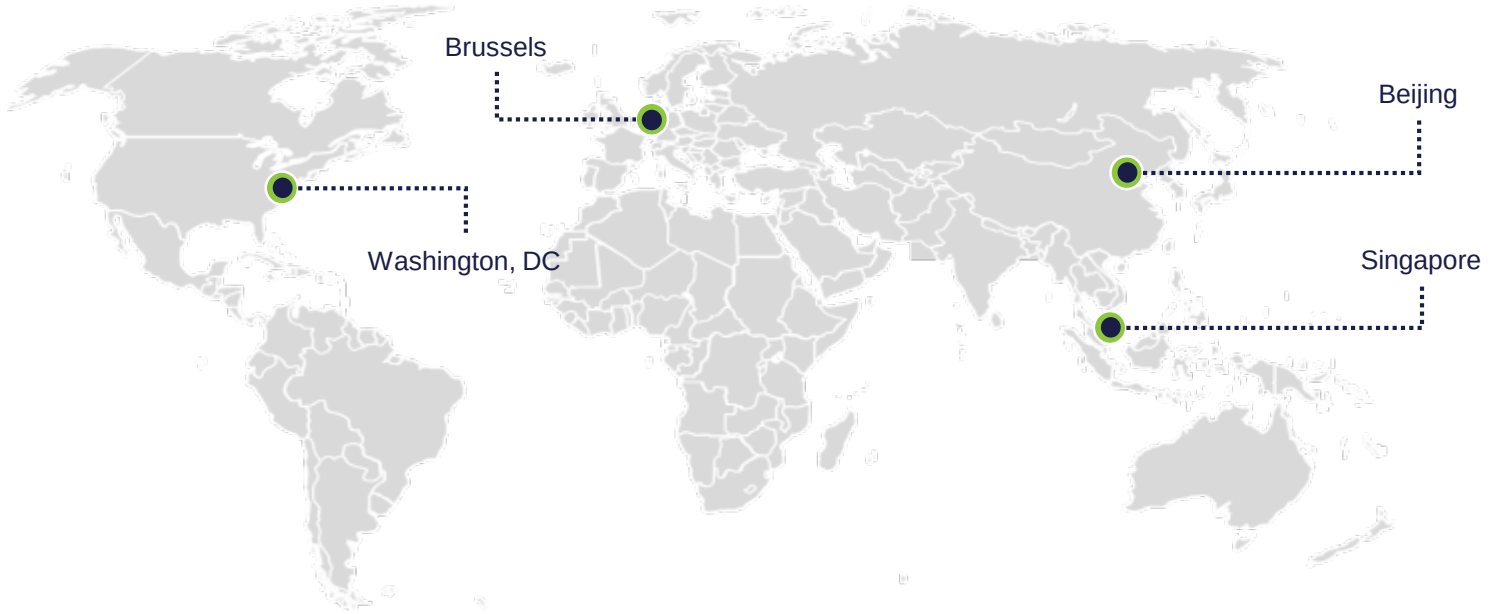
Dubai

Contents

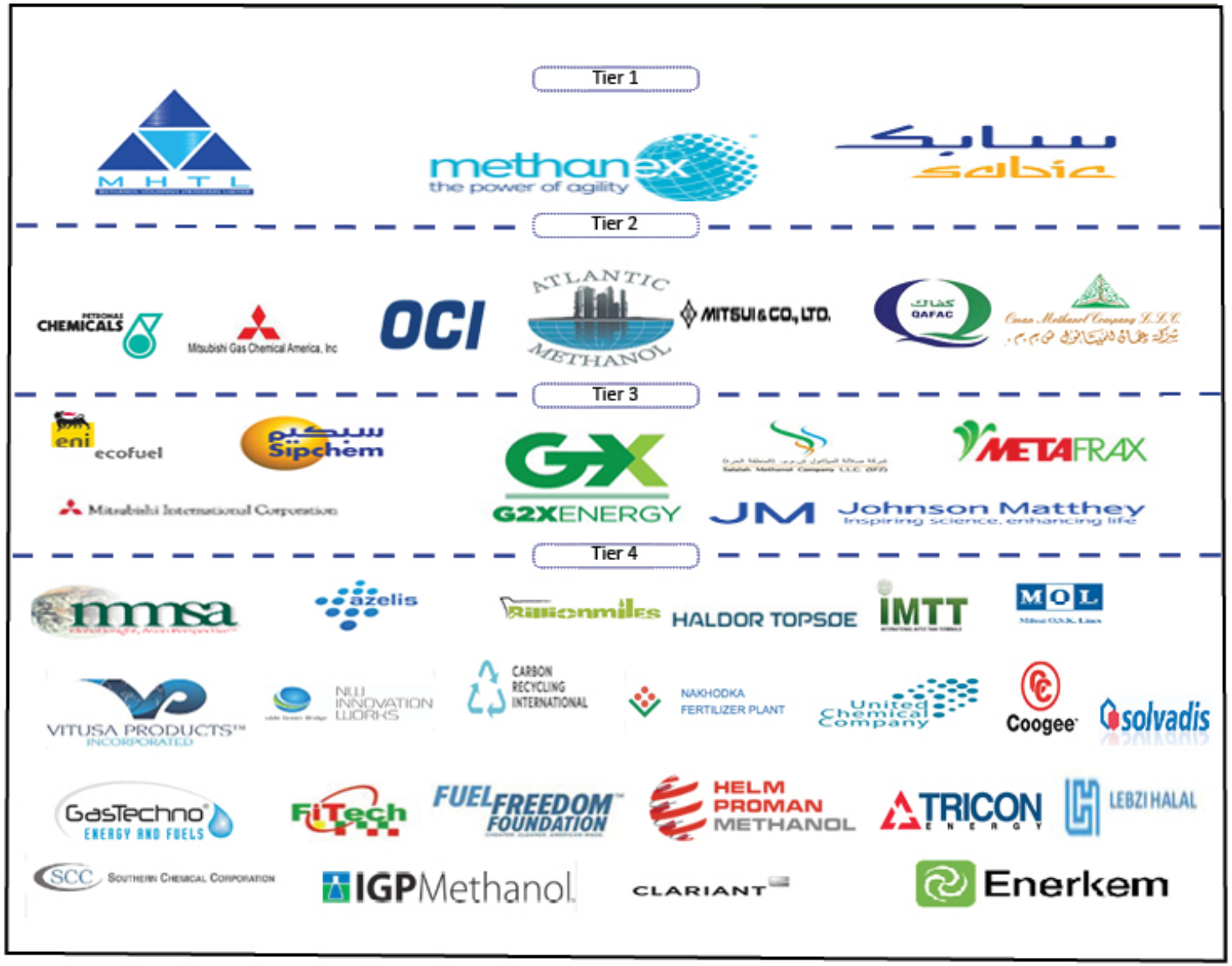
01 About MI

History

- The Methanol Institute (MI) was established in 1989
- 29 years later, MI recognized as the trade association for the global methanol industry
- Facilitating methanol's expansion from our Singapore headquarters and regional offices in Washington DC, Brussels, and Beijing



Members

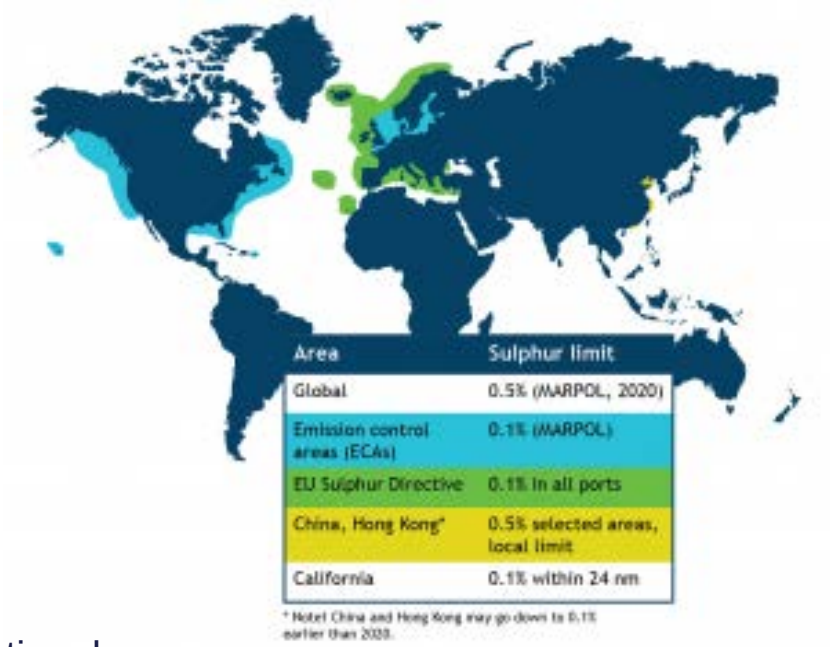

Tier 1
MHTL
methanex
the power of agility
سابك
sabic
Tier 2
CHEMICALS
Mitsubishi Gas Chemical America, Inc
OCI
ATLANTIC METHANOL
MITSUI & CO., LTD.
QAFAC
Oman Methanol Company L.L.C.
Tier 3
eni
ecofuel
سبچيم
Sipchem
GX
G2XENERGY
METAFRAX
Mitsubishi International Corporation
JM
Johnson Matthey
Inspiring science, enhancing life
Tier 4
mmsa
azelis
Ribconmiles
HALDOR TOPSOE
IMTT
MOL
VITUSA PRODUCTS
INCORPORATED
NILU INNOVATION WORKS
CARBON RECYCLING INTERNATIONAL
NAKHODKA FERTILIZER PLANT
United Chemical Company
Coogee
solvadis
GasTechno
ENERGY AND FUELS
FiTech
FUEL FREEDOM FOUNDATION
HELM PROMAN METHANOL
TRICON ENERGY
LEBZI HALAL
SCC
Southern Chemical Corporation
IGPMethanol
CLARIANT
Enerkem

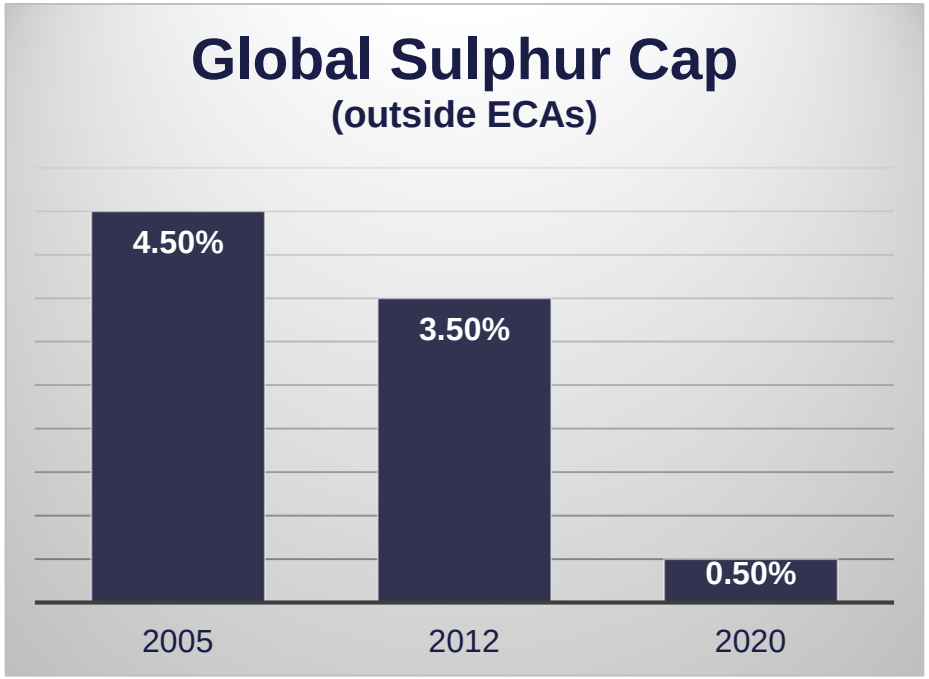
MI STRATEGIC PARTNERS

- *China Nitrogen Fertilizer Industry Association*
- *Asian Clean Fuels Association*
- *Chinese Association of Alcohol & Clean Ether Fuels & Automobiles (CAAEFA)*
- *Gulf Petrochemicals and Chemicals Association (GPCA)*
- *International DME Association (IDA)*
- *International Methanol Producers & Consumers Association (IMPCA)*
- *Peking University Center for New Global Energy Strategy Studies*
- *Lloyd's Register*
- *International Bunker Industry Association*
- *Dangerous Goods Advisory Council*
- *China Classification Society*

02 *International Regulatory Framework*

Sulphur Cap





International Convention for the Prevention of Pollution from Ships (MARPOL)

1973

2005

Annex VI Prevention of Air Pollution from Ships entered into force

ECAs first introduced with sulphur content limit of 1 %

2010

2015

Sulphur content lowered to 0.1% in ECAS

Global sulphur limit of 0.5%, effective January 2020

2016

>2020

?

Road to 2050

IMO Initial Strategy on the Reduction of GHG Emissions adopted at MEPC 72 (April 2018)

Level of ambition of Initial Strategy.

Carbon intensity of ships to decline through implementation of further phases of energy efficiency design index (EEDI) for new ships.

Reduce CO_2 emissions per transport work, as an average across international shipping by at least 40% by 2030, and 70% by 2050, compared to 2008.

Peak GHG emissions from international shipping ASAP, and reduce total annual GHG emissions by at least 50% by 2050 compared to 2008

Road to 2050

MEPC 72 (April 2018)

- Initial Strategy adopted

MEPC 73 (October 2018)

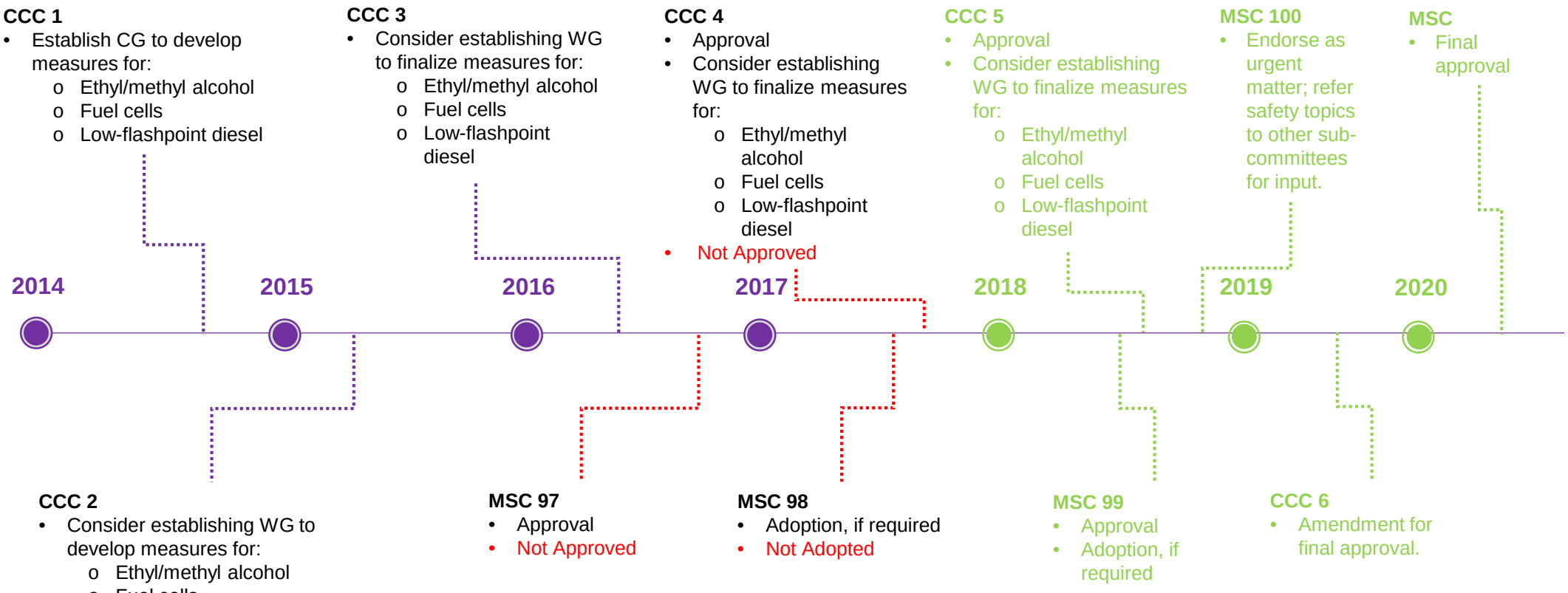
- Approved the programme of follow-up actions up to 2023
- 4th IMO GHG Study
- 5th Inter-sessional working group
  - To consider proposals on candidate short-term measures

MEPC 74 (May 2019)

- Consider candidate short-term measures; possible adoption and implementation?
- Procedure for assessing the impacts of candidate measures on States
- Candidate mid/long-term measures

International Developments

IMO CONFIRMATION OF ETHYL/METHYL ALCOHOLS

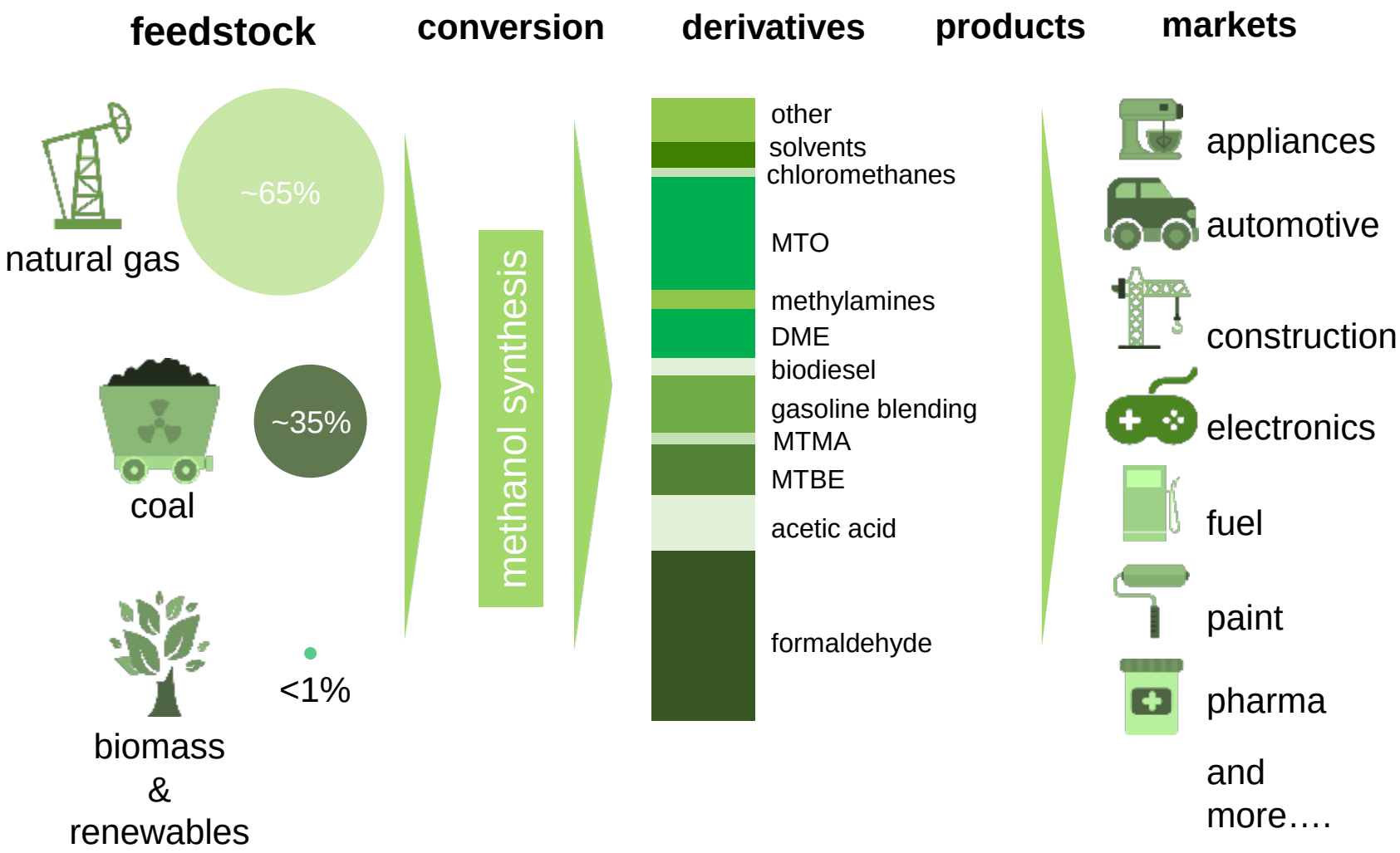


❖ After Approval, IGF Codes may be implemented at flag state level with the understanding that additional amendments may be added, requiring compliance, before IGF Codes come into Force

03

(Renewable) Methanol Production

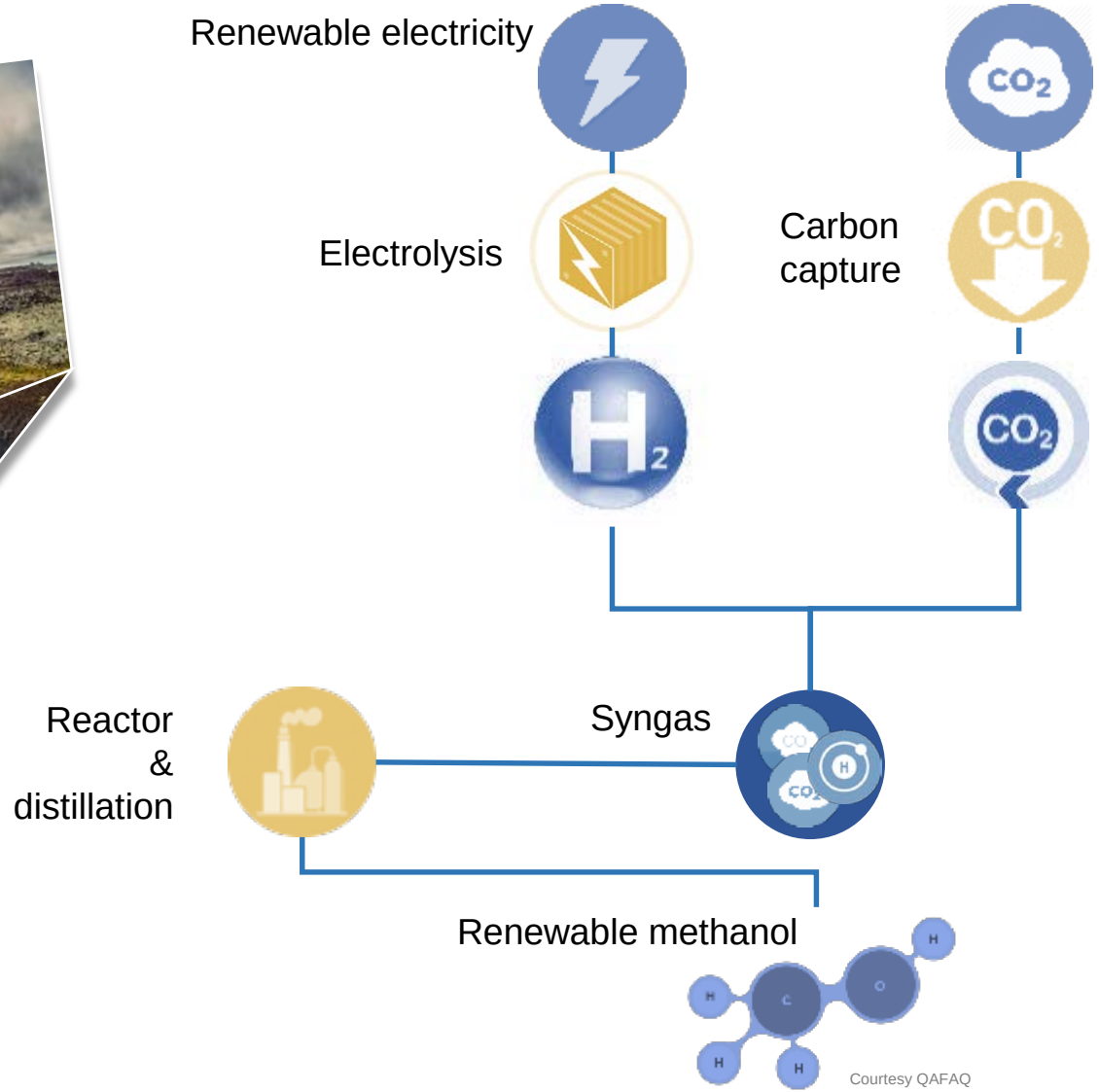
Broad Feedstock Range, Many Applications



Renewable Methanol

CRI, Iceland

CARBON RECYCLING INTERNATIONAL



Renewable Methanol from Gasification

Sustainable biomass
(residues, MSW, etc)

Gasification

Syngas

Reactor
&
distillation

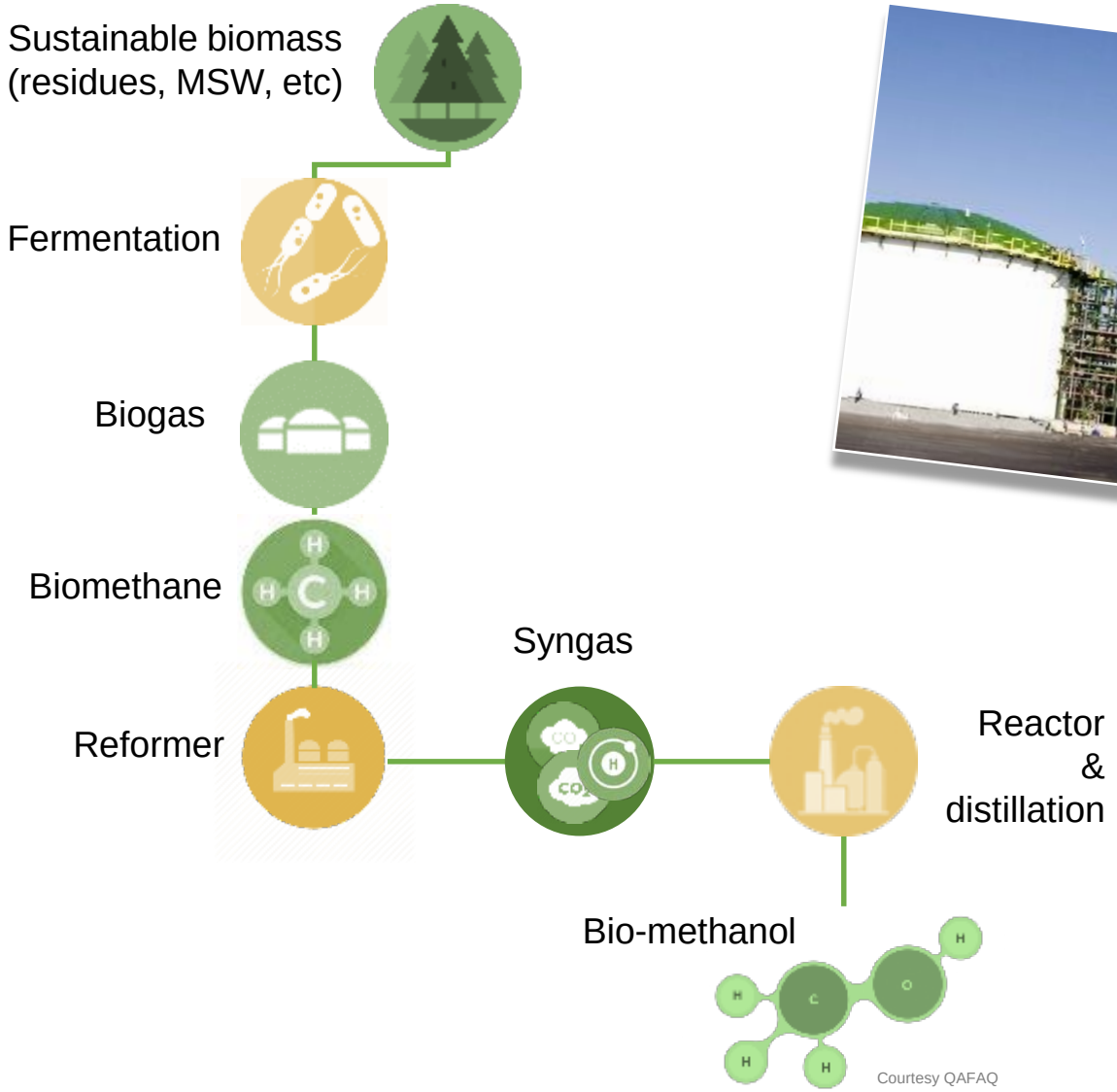
Bio-methanol

Enerkem, Canada

Enerkem

Courtesy QAFAQ

Renewable Methanol from Biorefining



BioMCN, The Netherlands

BioMCN

04 *Methanol's History as a Fuel*

Methanol is a Versatile Fuel Source

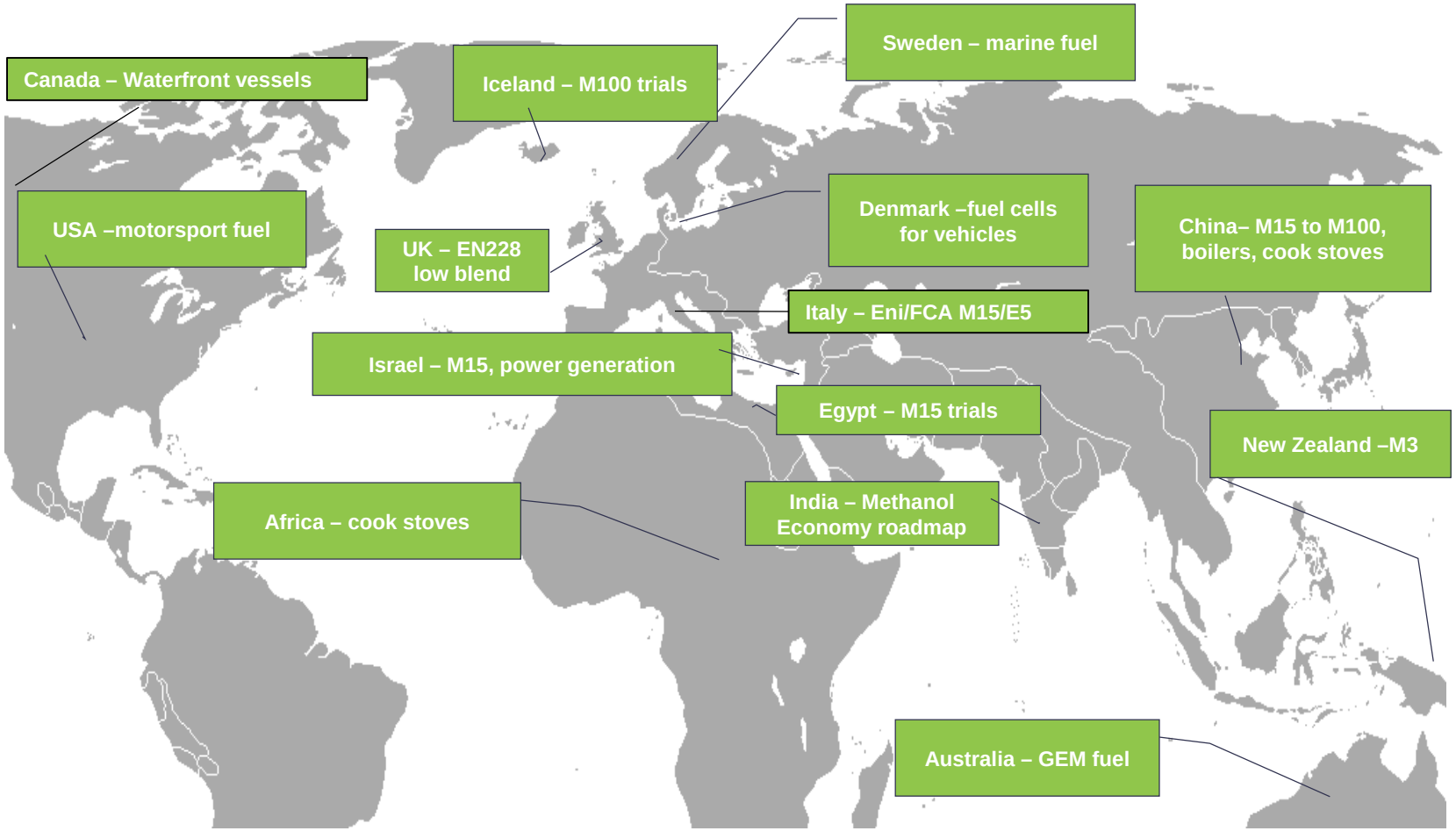
- Out of the ~75 million metric tons of methanol sold globally in 2017, energy and fuel uses represent 40% of total demand
- From 2009-2016, direct methanol fuel blending increased at an annual rate of nearly 23%

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

TECHNOLOGIES
- SI & CI engines
- Turbines
- Fuel cells

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

Global Methanol Fuel Examples



Global Transport Fuel Progress

Israel

- Cooperation with Italy Fiat to promote M15 Fiat 500 Car (Euro 6)
- Testing M70-85 in Flex fuel vehicles
- 2016 First M15 National Standard Released

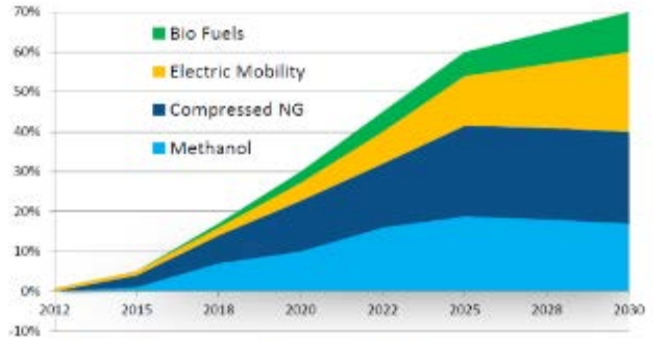
Italy

- ENI and FCA cooperation to promote A20 fuel (M15+E5)
- Fiat 500 cars for car sharing service in 2018
- Compliance with Euro 6 standard and 3% tailpipe emission reduction

Denmark

- Methanol Fuel Cell for EV range extension
- Europe's first methanol filling station in Aalborg, Denmark (Aug. 2015)

Israeli Government Decision:
***Reduce** the use of oil by 60% by 2025*



Expected Penetration Rate for Alternative Fuels in Israel

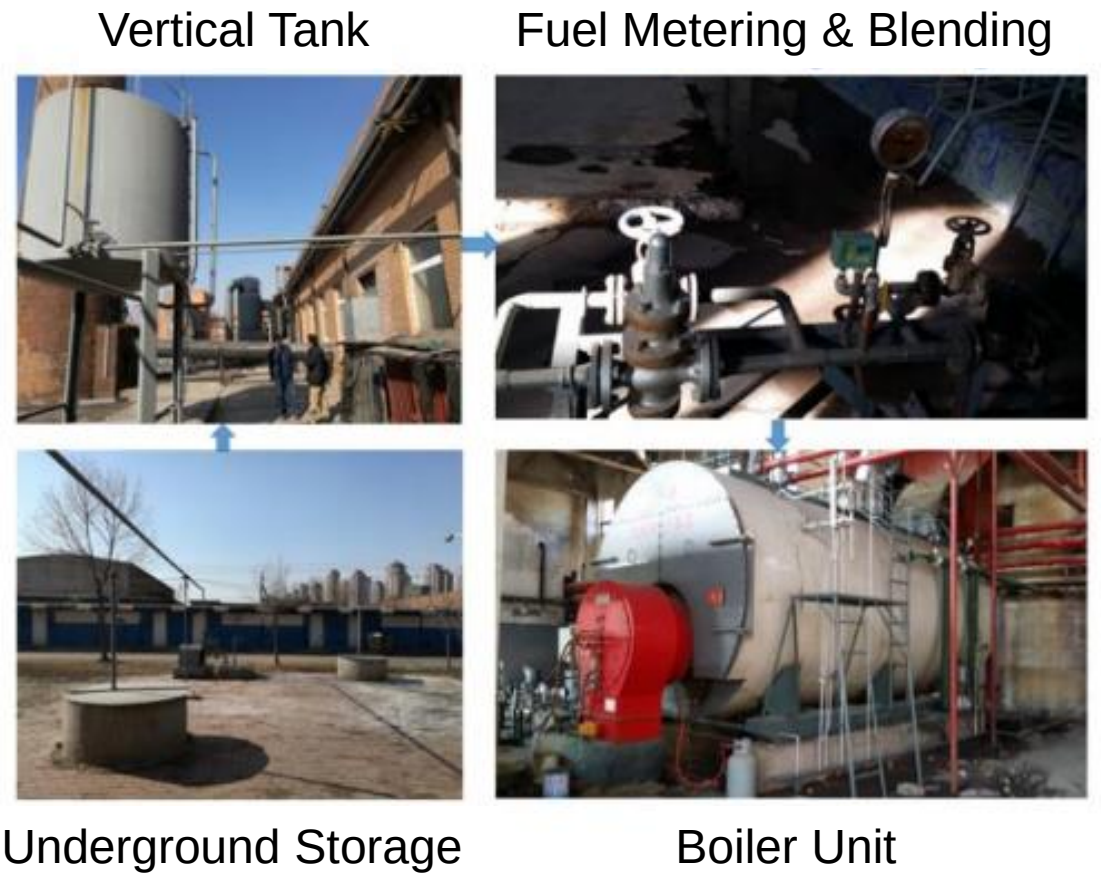
India: Roadmap to Methanol Economy

- September 2015, NITI Aayog formed the Methanol Economy Expert Group
- Methanol production from coal and biomass, and utilize methanol and DME as transportation fuels
- September 2016, MI jointly organized a Methanol Economy International Seminar held in Delhi
- Launching Projects:
  - M15 fuel blending
  - methanol/DME buses and trucks
  - railway engines
  - inland waterways
  - cook stoves
  - industrial boilers

Union & Road Transport Minister Nitin Gadkari

Methanol Boilers

- Widely used for heating and industrial steam, new-builds and replacing coal and HFO-fired units
- Capacity range from 1 - 20 t/h
- Standards with developed together with MI and Methanex support
- Blends starting as low as 60% (M60)
- ***Estimated more than 1,000 units currently, consuming over 2M mtpa of methanol***



Source: Methanol New Energy Applications in China: Boilers and Cook Stoves

Methanol Cook Stoves

- **Different types of methanol cook stoves:**
  - Single burner heating
  - Stir frying
  - Steaming
- Widely used in restaurants, central kitchens: **mainly cost driven**
- Simple storage and transportation, filling the deficit of NG pipeline capacity
- Fuel:
  - 100% methanol (M100)
  - 80% and higher blends (emulsified with water)

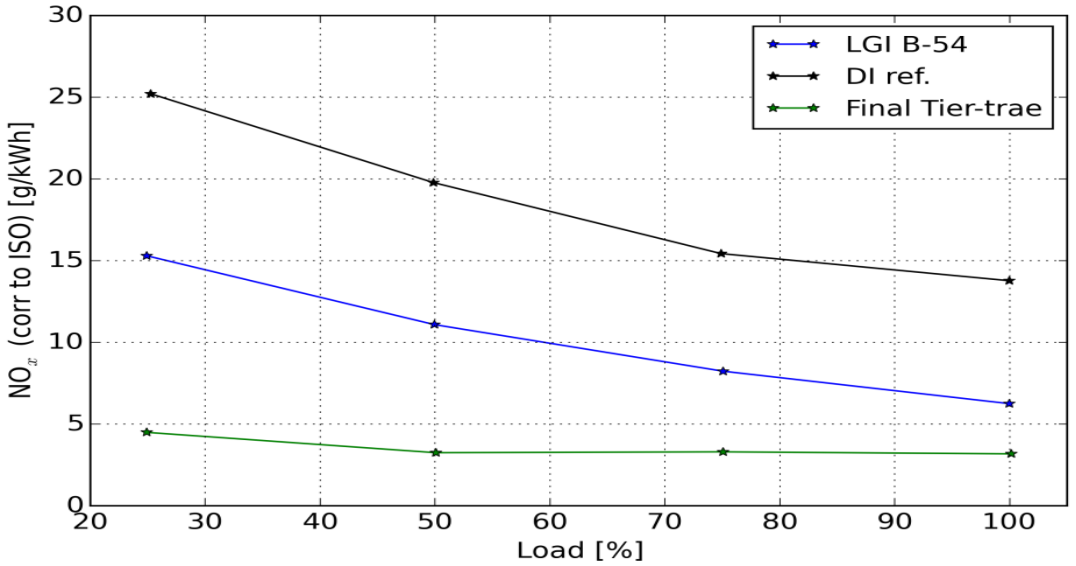
- ***Consuming over 3M mtpa of methanol***

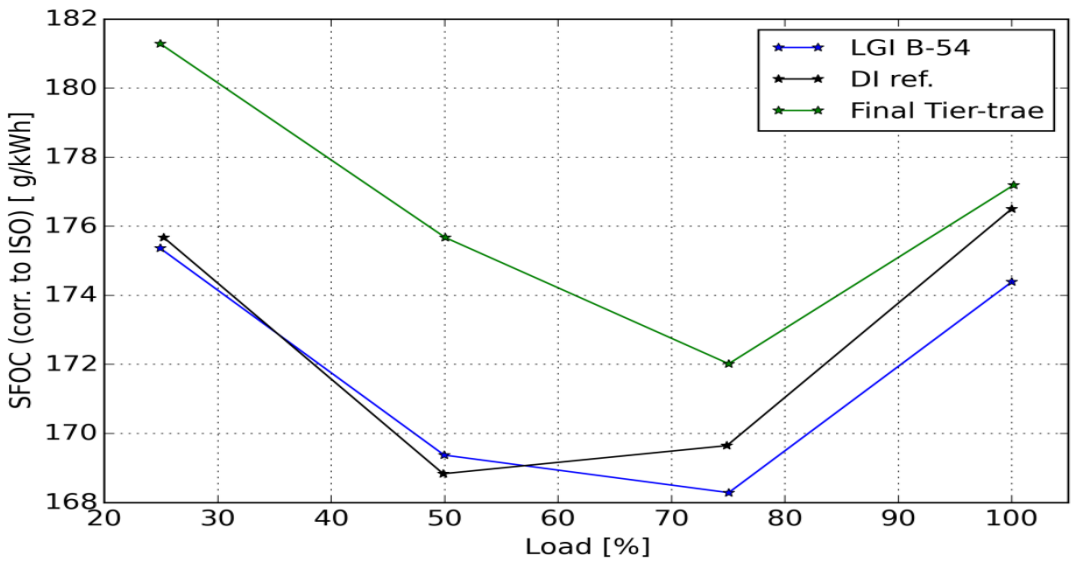
05 *Methanol as a Marine Fuel*

Emissions Scorecard

Methanol achieves low emissions & acts as the bridge fuel of the future with the possibility of being produced renewably (offering an attractive life cycle analysis).

METHANOL / WATER BLENDING (EMULSIFICATION)





Approx. 25-40% water added to the methanol and then we have a new tier III solution with very low penalty in fuel consumption.

Similar is being planned for fuel oil, so the tier III solution will be available for dual fuel.

R&D test completed - service test is under preparation.

Source: MAN

Methaship

- **Nationally-funded German research project**
- **Partners from shipbuilding, ship-safety, OEM manufacturers, methanol trading & production**
- **Study the use of methanol as a fuel for cruise ships and RoPax ferries**
- **Study concluded with the following findings:**
  - Properties of methanol surpass other alternative fuels in shipping;
  - A major benefit includes storage at ambient temperature and pressure without loss;
  - Methanol offers compelling environmental properties and has the most promising lifecycle analysis when produced from renewable sources; and
  - Widespread availability.

Partners

FLENSBURGER SHIPBUILDERS SINCE 1872

Lloyd's Register

MEYER WERFT PAPENBURG 1795

CATERPILLAR

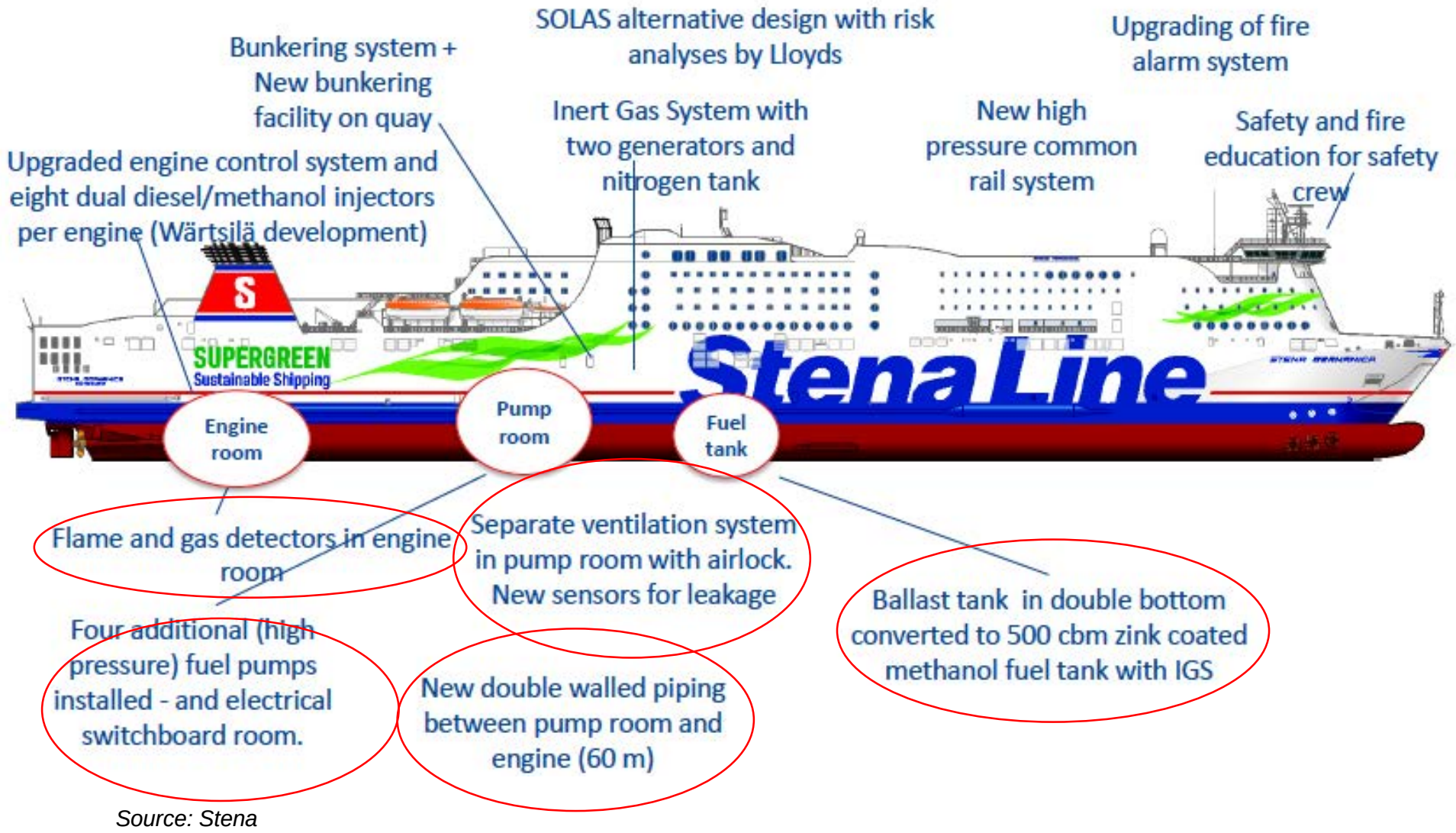
HELM

MAN

Marine Experience

- *March 2015: Stena Germanica – Wärtsilä methanol-fueled marine engine*
- *Apr 2016: Methanex's Waterfront Shipping – dual-fuel MAN methanol/diesel engines*
- *Lloyd's Register MethaShip project*
- *LeanShips dual-fuel demo*
- *Oct 2015: Billion Miles Singapore develops small-marine applications*
- *Jun 2016: ScandiNAOS Green Pilot Boat conversion*

THE GERMANICA MODIFICATIONS



Source: Stena

GERMANICA – BEFORE & AFTER (COMMON RAIL)

Source: Stena

BUNKERING THE GERMANICA

Sources: Haan Paa, Stena

- **Self-contained eye/body wash station**
- **Gas leak detection**
- **Flame detection**
- **Foam fire extinguishing system**
- **Coffer dam**
- **Secure, no-drip connections**

BUNKERING THE GERMANICA – COFFER DAMS

Sources: Haan Paa, Stena

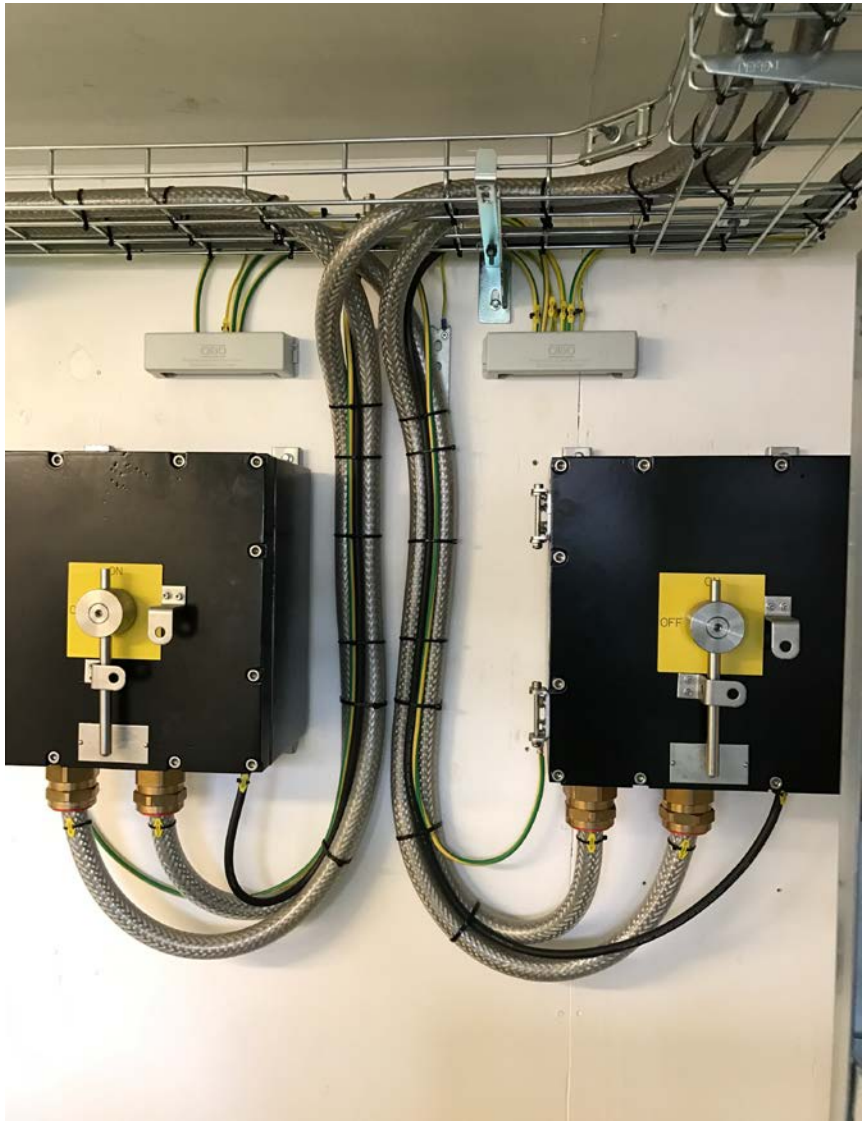
BUNKERING THE GERMANICA – FIRE FIGHTING

Sources: Haan Paa, Stena

BUNKERING THE GERMANICA – FIRE FIGHTING

Sources: Haan Paa, Stena

BUNKERING THE GERMANICA – NO SPILL / BREAKERS



Sources: Haan Paa, Stena

BUNKERING THE GERMANICA – PUMP ROOM

Sources: Haan Paa, Stena

BUNKERING THE GERMANICA – SHIP SIDE

Sources: Haan Paa, Stena

MAN's Experience with Dual-Fuel Engines

Service status:

- 4 vessels from HHI in service
- 3 vessel from MES in service
- Currently more than 38.000 service hours are obtained
- First start up of MeOH operation was carried out by the crew alone

Challenges:

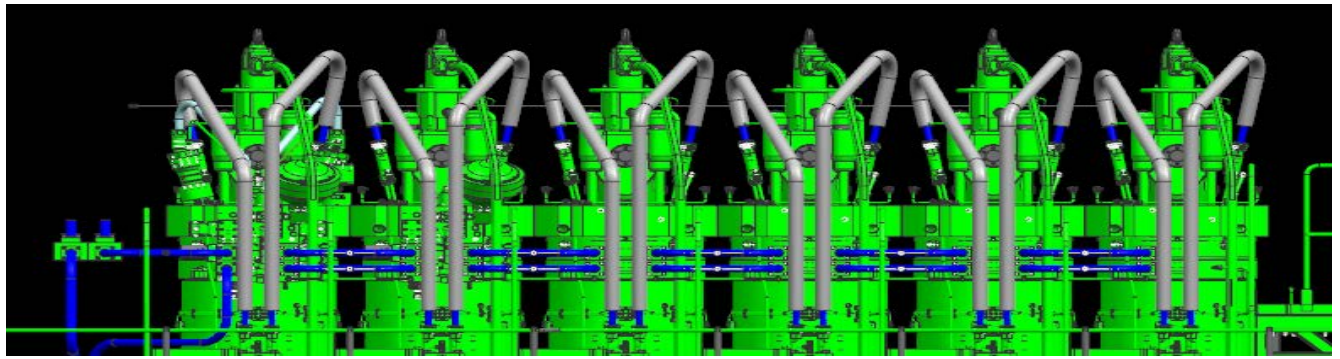
- **Broken springs in fuel diesel fuel valves**
- **Broekn cut-off shafts in Fuel Booster Injector Valves**
- **Micro cracks observed in FBIV atomizers**
- **Damage of sealing rings in FBIV suction valves**
- **Unstable hydrocarbon sensors**
- **Several software bugs**

MAN Energy Solutions

MAN's Experience with Dual-Fuel Engines

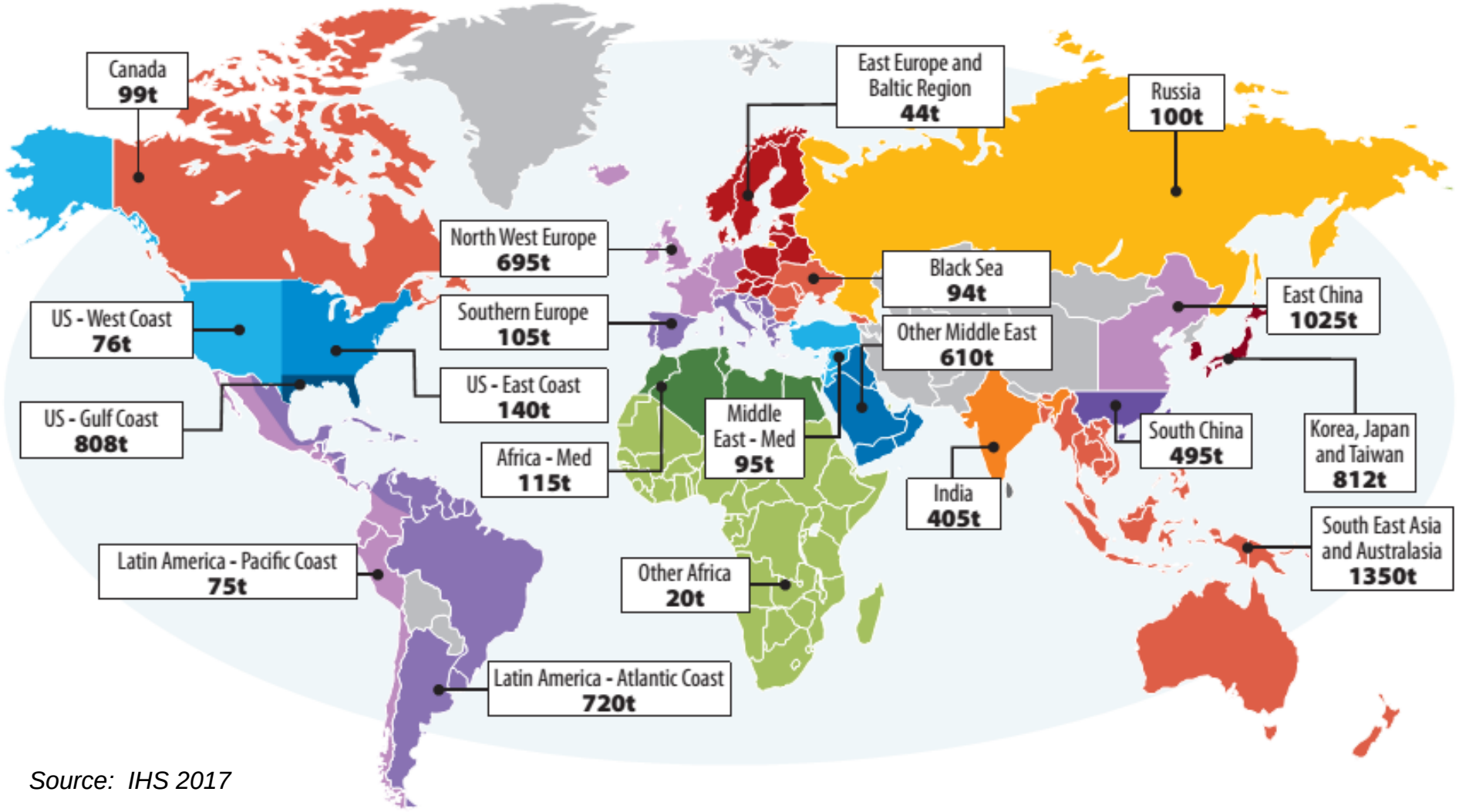
Benefits:

- Diesel cycle high fuel efficiency - 50%; much higher for other engine types
- High fuel flexibility
- No derating because of knocking danger
- Negligible fuel slip; no formaldehyde in the exhaust gas
- Robust Gas combustion - unchanged load responses; unaffected by ambient conditions



MAN Energy Solutions

Global Port Terminal Availability



Source: IHS 2017

Flammability and Toxicity

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.

Economic Impact - HFO vs Methanol:

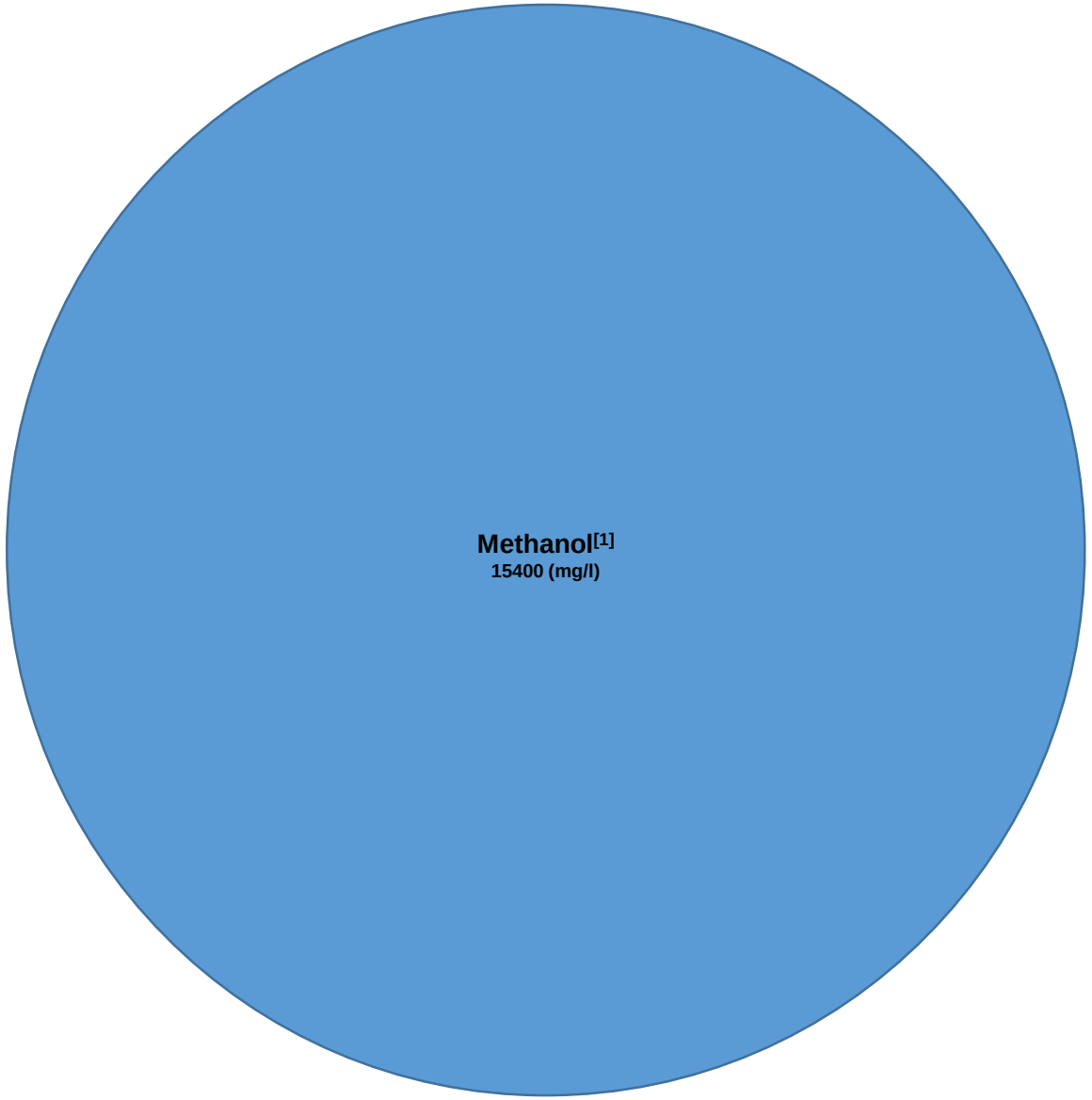
	Maritime accident	Maritime accident	Simulation
Ship	Erika	Tanio	-
Fuel	Heavy Fuel Oil	Heavy Fuel Oil	Methanol
Released amount	19 000 t	13 500 t	10 000 t
Affected coastline	400 km	200 km	0 km
Total damage:	$914M	-	-
Cleaning	$100M	$50M	$0
Fishing industry	$98,3M	-	-
Tourist industry	$400-500M	-	-
Claim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

Takeaways:

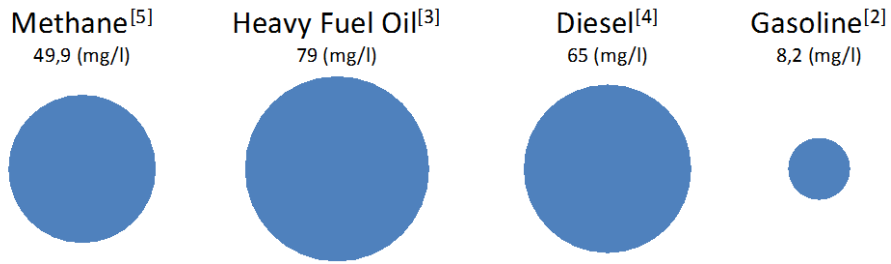
- Not more toxic than gasoline or diesel
- Methanol poisoning is treated simply and is not carcinogenic
- No GHG potential (methane)
- Miscible in water – a large concentration spill will rapidly decrease with only short term effects
- Far less hazardous to the environment

Sources: Economic, Social & Environmental Effects of the "Prestige" Oil Spill, Meyer-Werft

Safer for the Environment



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

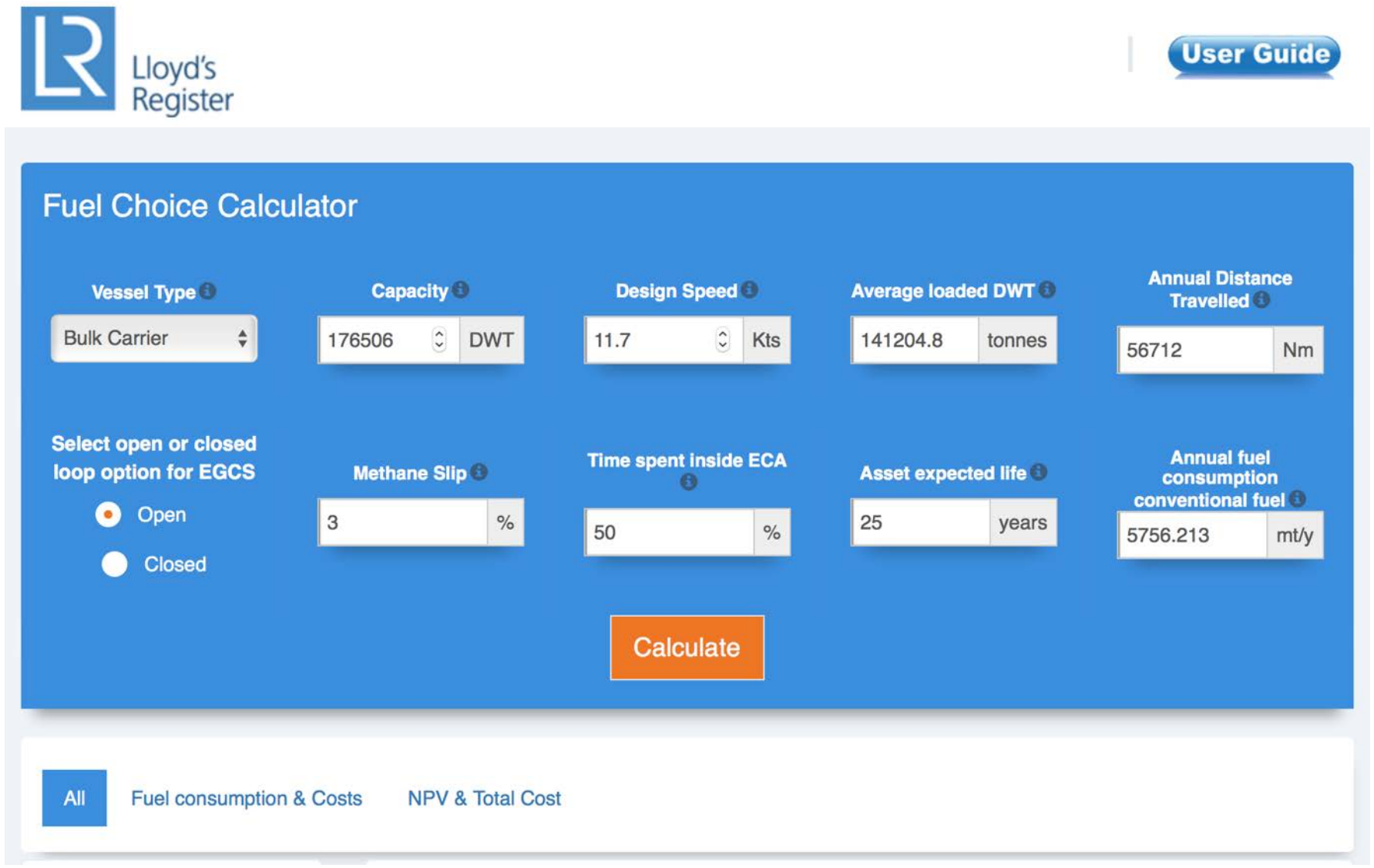


Methanol better than
- **Diesel** by factor **240**
- **Gasoline** by factor **1900**

[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

Fuel Comparison Model & Online Evaluator



SUMMARY

- *Cost effective and "future proof" fuel which can be produced from a variety of feedstocks – to include renewables*

- *Methanol is one of the top 5 seaborne chemical commodities and has been safely handled for over 50 years*

- *Capital costs for ship conversions are less than LNG and after treatment technologies*

- *New Build dual fuel tankers are only marginally more expensive than conventionally-fueled vessels*

- *Widely available and alleviates many infrastructure limitations on land and at sea*

06 Contacts

Contacts

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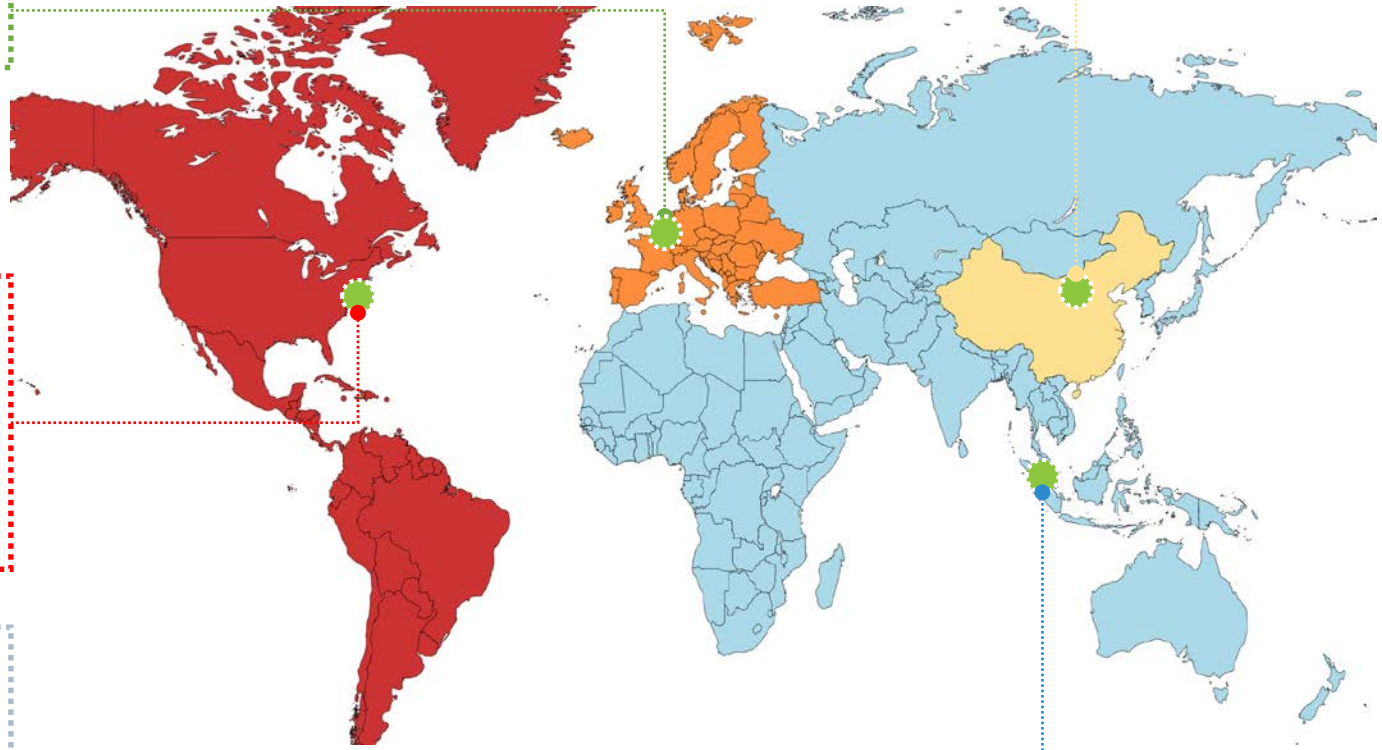

www.methanol.org www.methanolfuels.org

THANK YOU