METHANOL INSTITUTE

FUELING THE MARITIME SECTOR: IMO 2020 AND BEYOND

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COO

FICCI FEDERATION HOUSE

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- MHTL
- methanex – the power of agility
- سابك sabic
- OCI

Tier 2

- Qatar Fuel Additives Company Limited
- MITSUBISHI GAS CHEMICAL AMERICA, INC.
- ATLANTIC METHANOL
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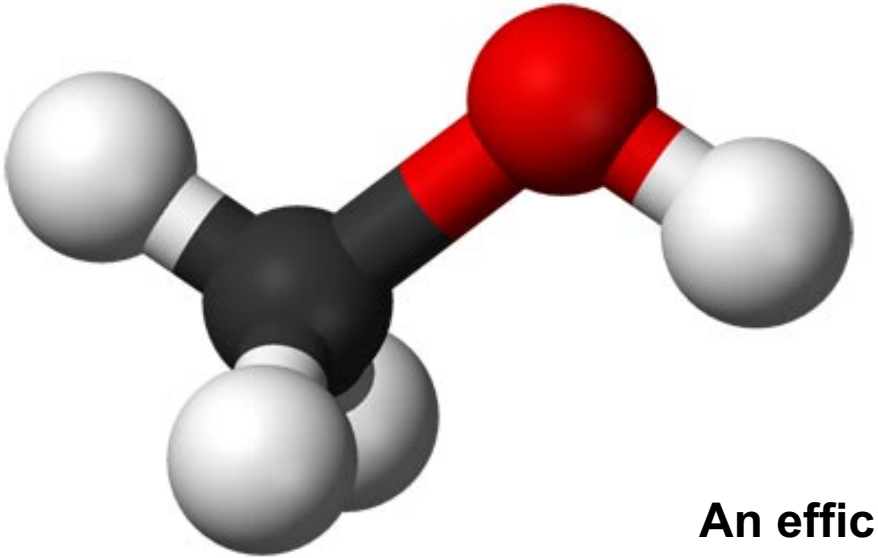
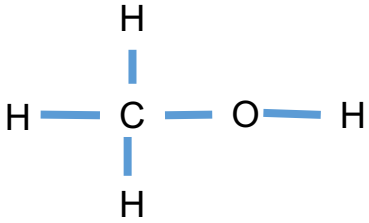
- OLAHMOTORS
- quantiam technologies inc.
- VITUSA PRODUCTS™ INCORPORATED

02 WHAT IS METHANOL?

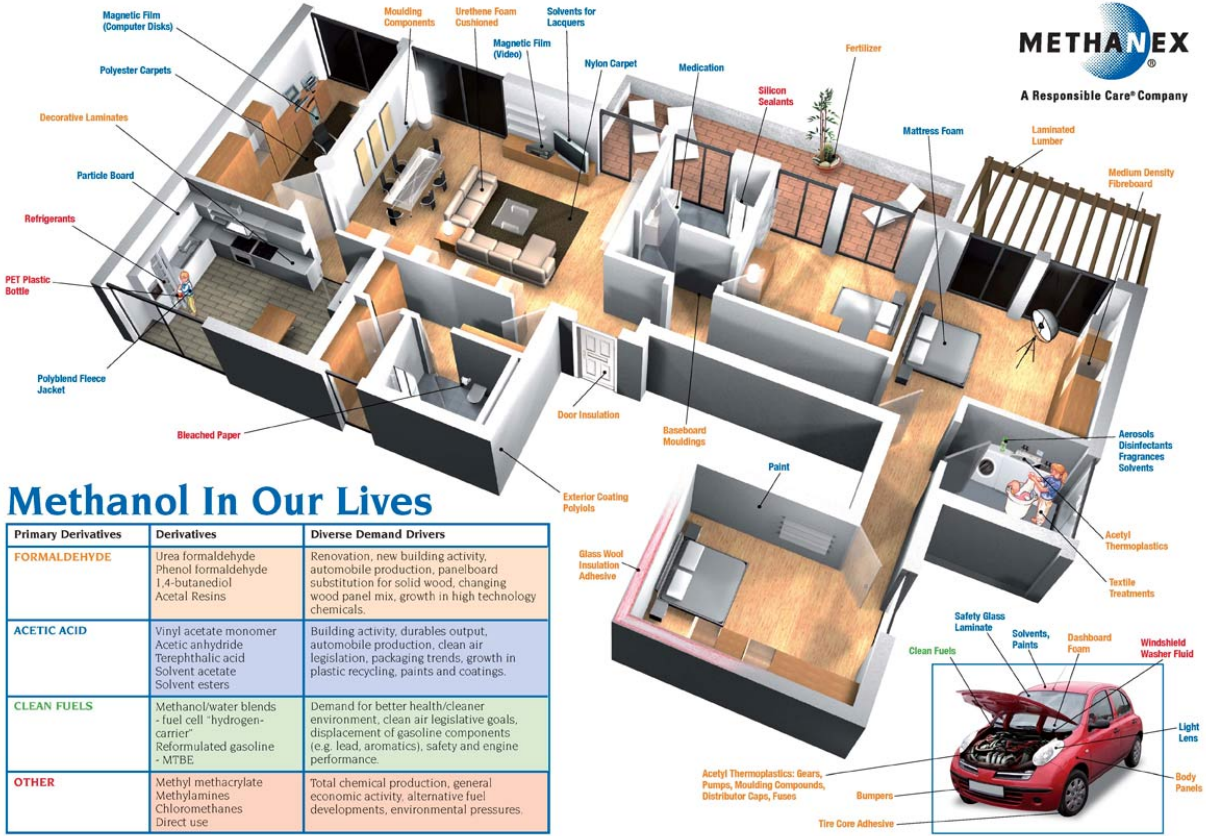
SIMPLEST MEMBER OF ALCOHOLS GROUP





An efficient, universal, future-proof, energy carrier that can be sustainably produced in large quantities

ESSENTIAL CHEMICAL BUILDING BLOCK



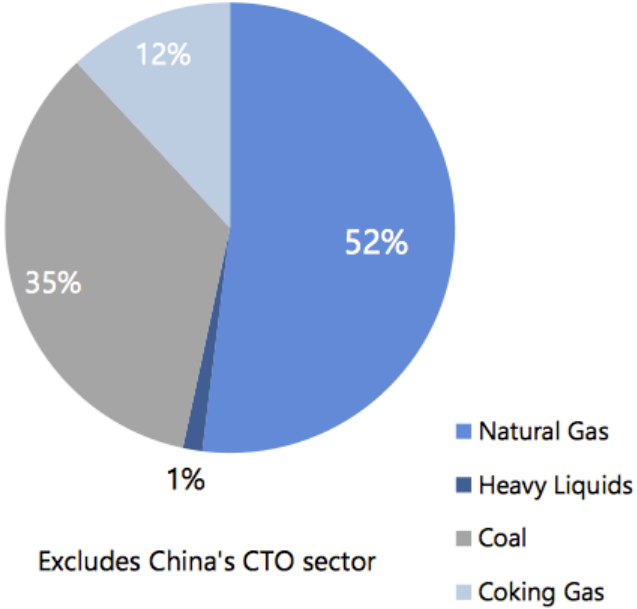
Methanol In Our Lives

Primary Derivatives	Derivatives	Diverse Demand Drivers
FORMALDEHYDE	Urea formaldehyde Phenol formaldehyde 1,4-butanediol Acetal Resins	Renovation, new building activity, automobile production, panelboard substitution for solid wood, changing wood panel mix, growth in high technology chemicals.
ACETIC ACID	Vinyl acetate monomer Acetic anhydride Terephthalic acid Solvent acetate Solvent esters	Building activity, durables output, automobile production, clean air legislation, packaging trends, growth in plastic recycling, paints and coatings.
CLEAN FUELS	Methanol/water blends - fuel cell "hydrogen-carrier" Reformulated gasoline - MTBE	Demand for better health/cleaner environment, clean air legislative goals, displacement of gasoline components (e.g. lead, aromatics), safety and engine performance.
OTHER	Methyl methacrylate Methylamines Chloromethanes Direct use	Total chemical production, general economic activity, alternative fuel developments, environmental pressures.

METHANOL PRODUCTION

World Total

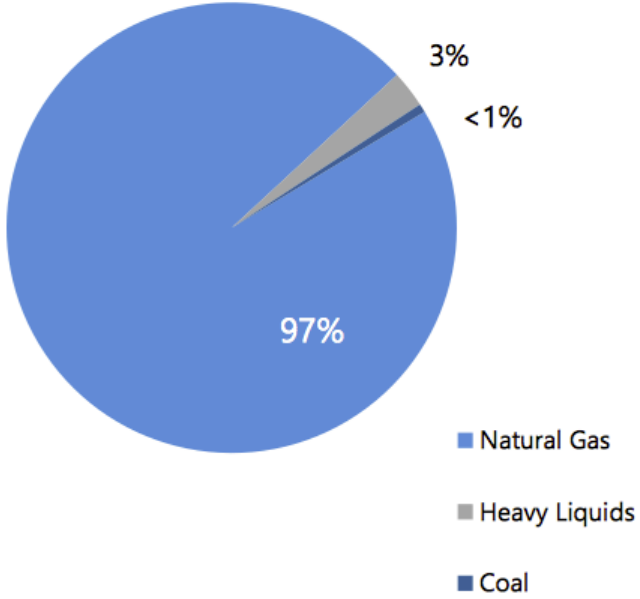
2018 ~ 122mn t nameplate capacity



Excludes China's CTO sector

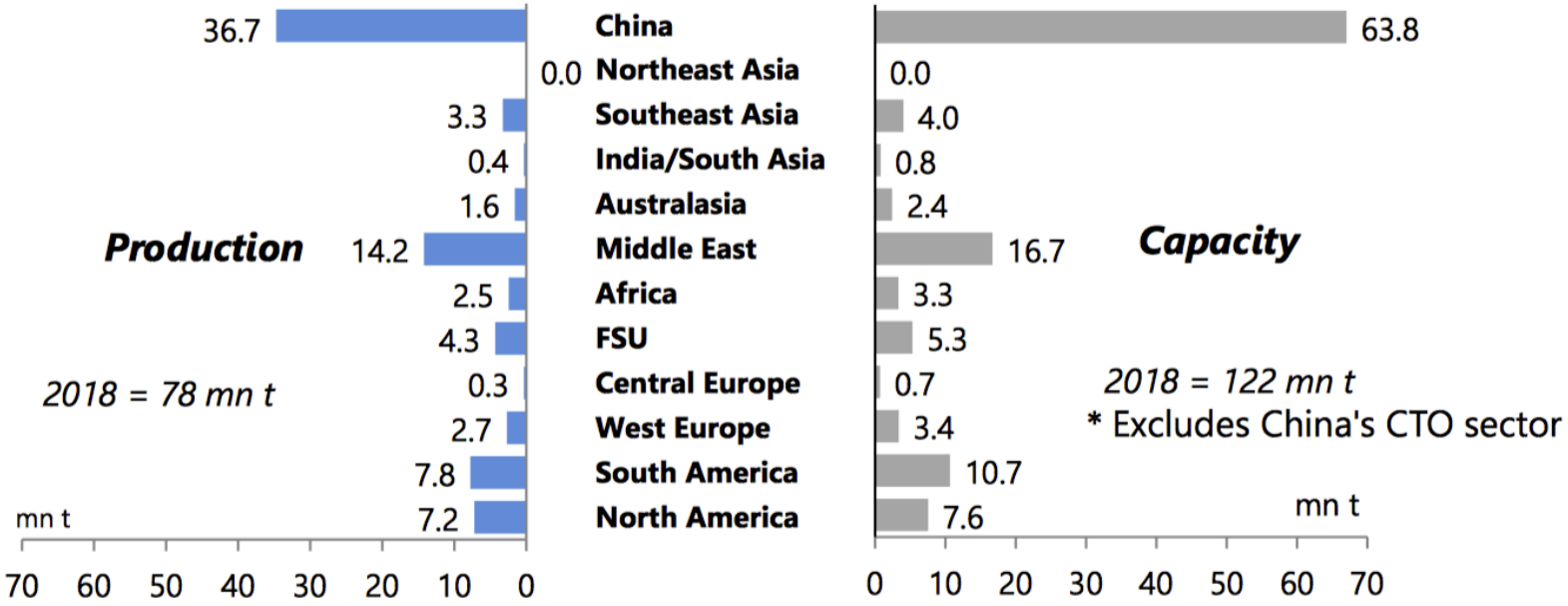
Rest of World – ex China

2018 ~ 55mn t nameplate capacity



Source: Argus

GLOBAL METHANOL PRODUCTION VS CAPACITY

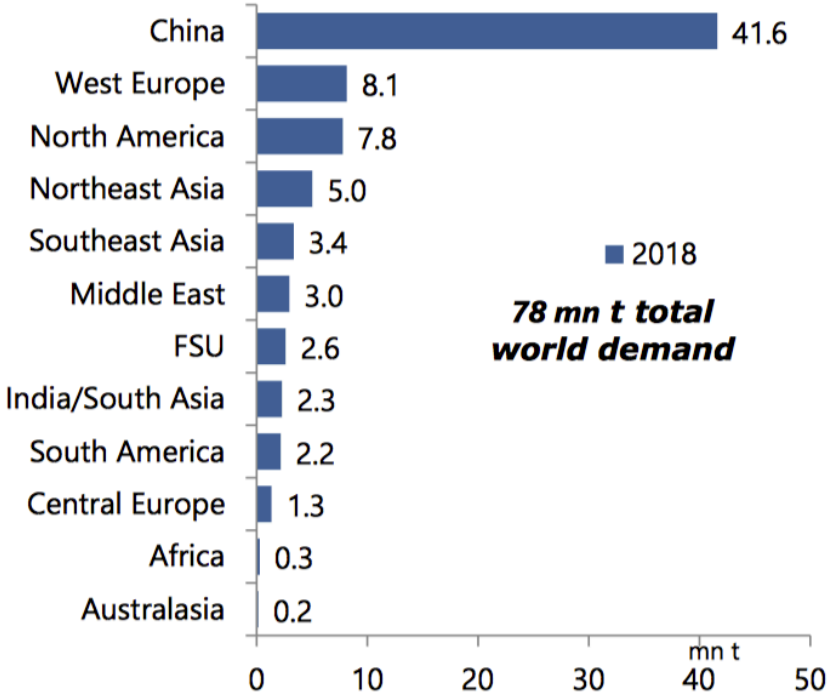


- Rest of world methanol production (excluding China) operates to best of abilities. Excess production from the rest of the world is exported to China
- China “generally” represents the high-cost methanol production bloc in the world and operates to meet China demand, less imports received from the rest of the world

Source: Argus

GLOBAL METHANOL DEMAND BY COUNTRY/REGION

- **China dominates global methanol industry demand – 54% in 2018**
- **W Europe and N America compete for the 2nd and 3rd spots – top three accounting for 75% of total**
- **Concentrated consumer base, ~30% of demand from top 25 consumers**
  - Main consumers are large, global chemical companies and China MTO producers: BASF, Momentive, Celanese, BP, Dow/Dow Corning, Lucite, Evonik, LyondellBasell, SABIC, Sinopec, Ningbo Fund, Jiangsu Sailboat, etc
- **Industry growth expected at 4.5% per year. The equivalent of 2 world scale methanol units**

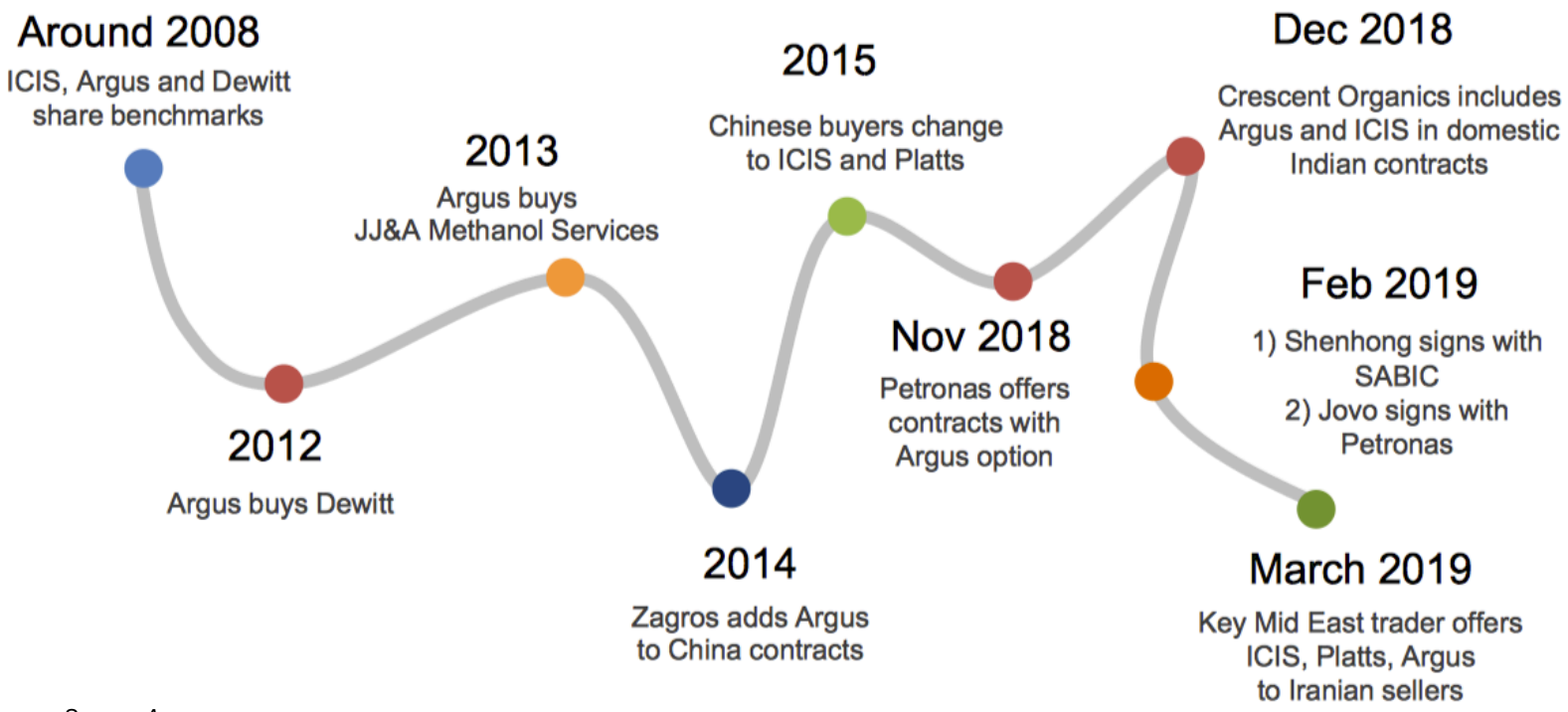


**Excludes China's CTO sector*

Source: Argus

METHANOL'S TRANSPARENT PRICE INDEXATION PROVIDES HIGH VISIBILITY

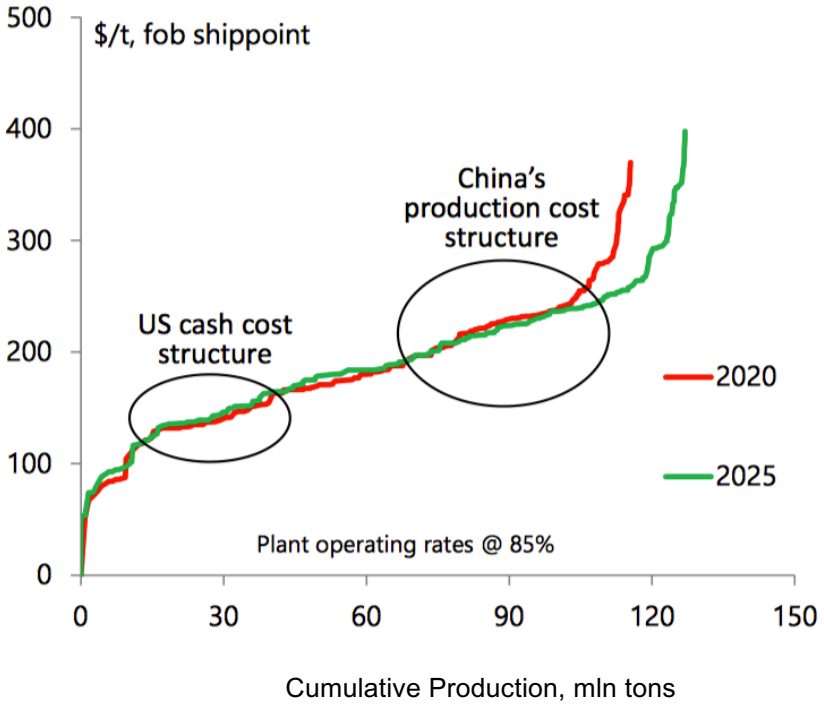
Global pricing reference points are readily obtainable



Source: Argus

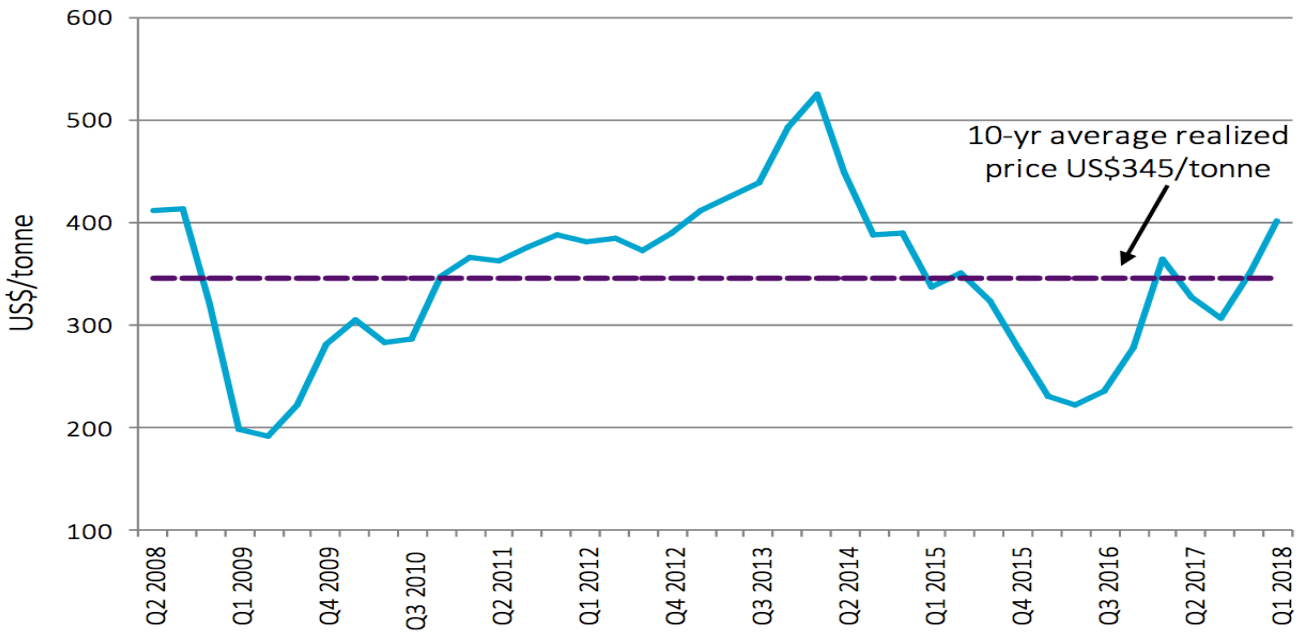
METHANOL INDUSTRY PRODUCTION CASH COST CURVES

- **Methanol industry cash cost curves well compressed**
  - Cash cost only, no depreciation, capital recovery or return
  - fob plant gate basis
  - Shipping to destinations can add $20-$60/t, depending on origin and destination
- **A slowly rising crude oil forecast drives little change in feedstock costs**
  - Industry incremental cash cost of production remains in a narrow band
  - Little opportunity to “driveup” the floor price of the high cost producer increment
- **The methanol industry continues to see robust growth**
  - ~4-5% into the next decade
  - China continues to dominate industry demand and production
  - Nominal 2-3 “world scale” methanol units needed per year to keep pace with demand growth



Source: Argus

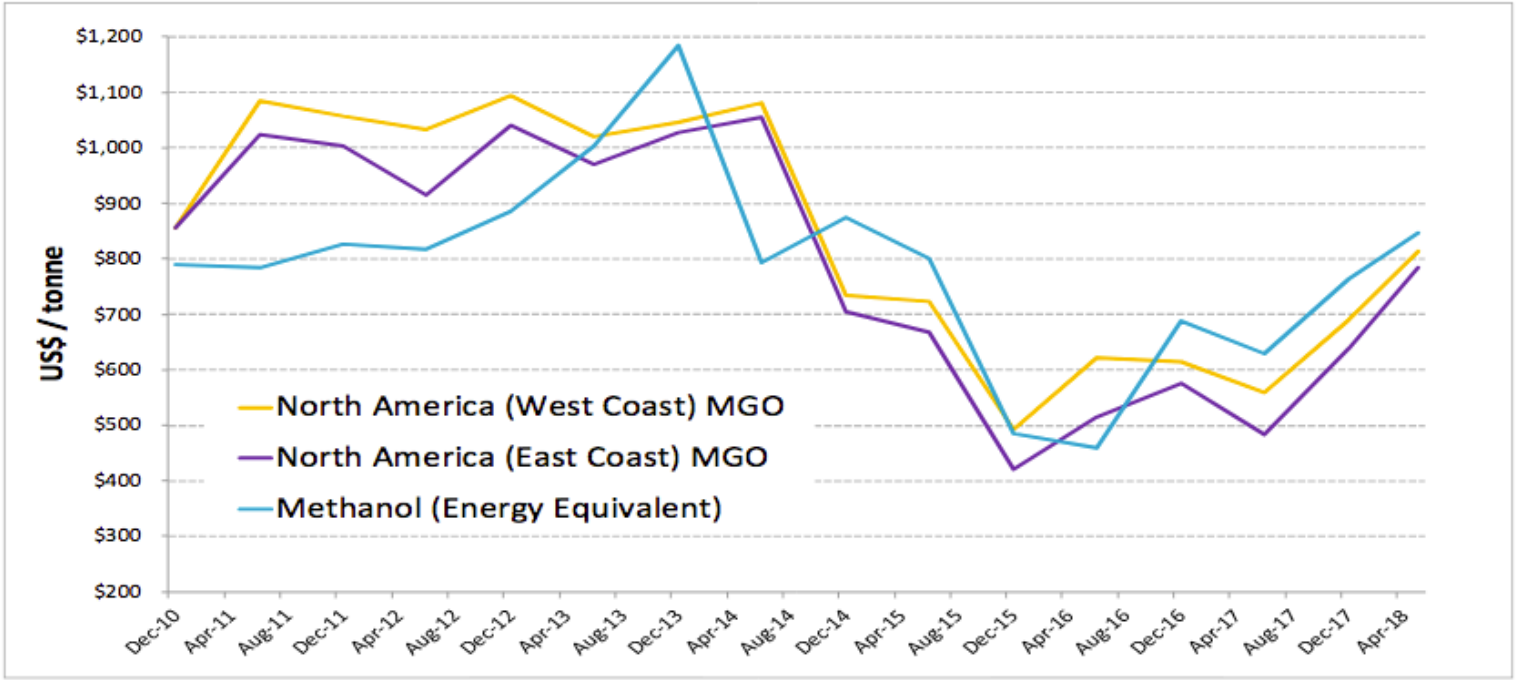
METHANEX 10-YR AVG REALIZED PRICE



- Methanex posts reference prices monthly in Asia and North America and quarterly in Europe
- Realized pricing is lower than reference prices due to discounts specified in contracts
- Higher visibility over fuel costs which lowers the risk profile

Source: Methanex Corporation

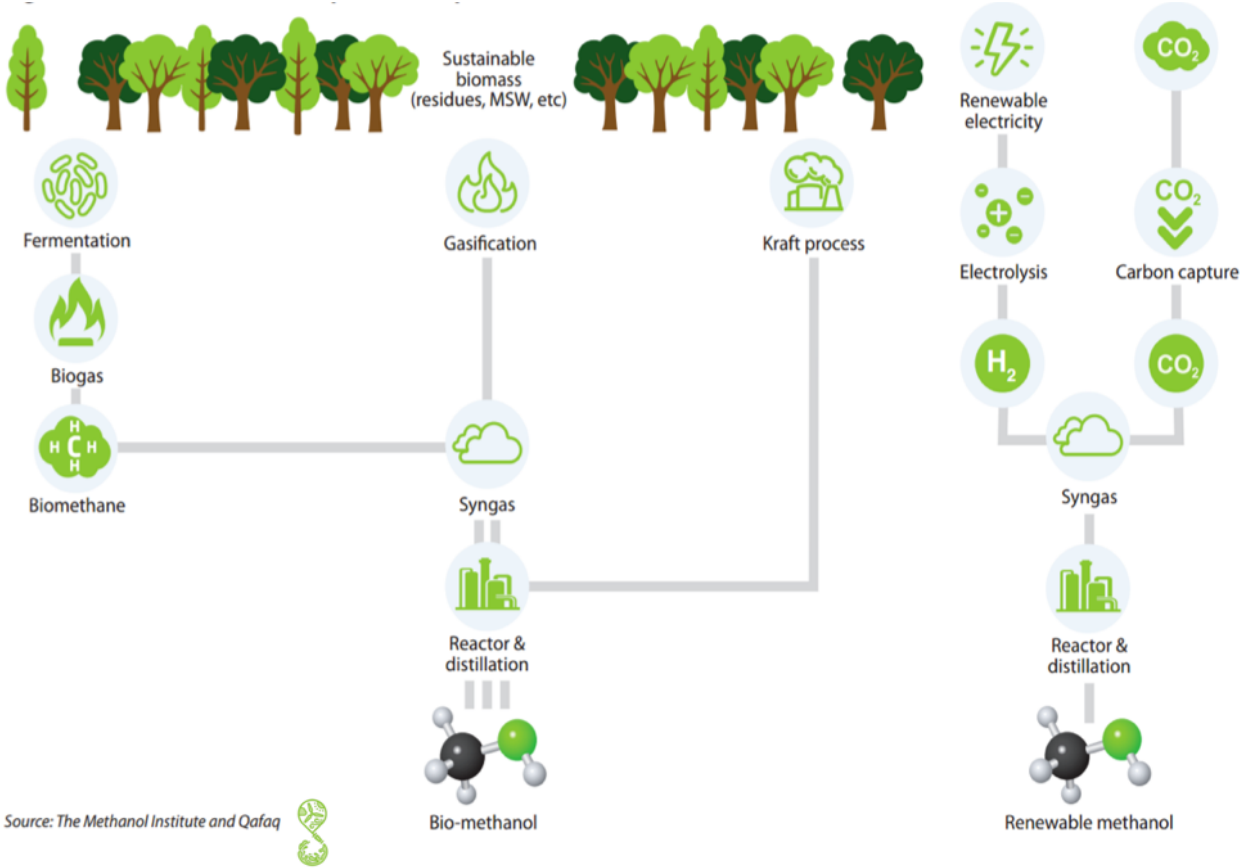
METHANOL COMPETITIVE ON AN ENERGY EQUIVALENT BASIS



- MGO West Coast Avg: LA, San Francisco, Seatle, Vancouver;
- MGO East Coast Avg: New York, Philadelphia, Norfolk, Montreal, Charleston
- Methanol: adjusted to energy equivalent of MGO (2.16 factor)

Source: Platts and IHS Chemical

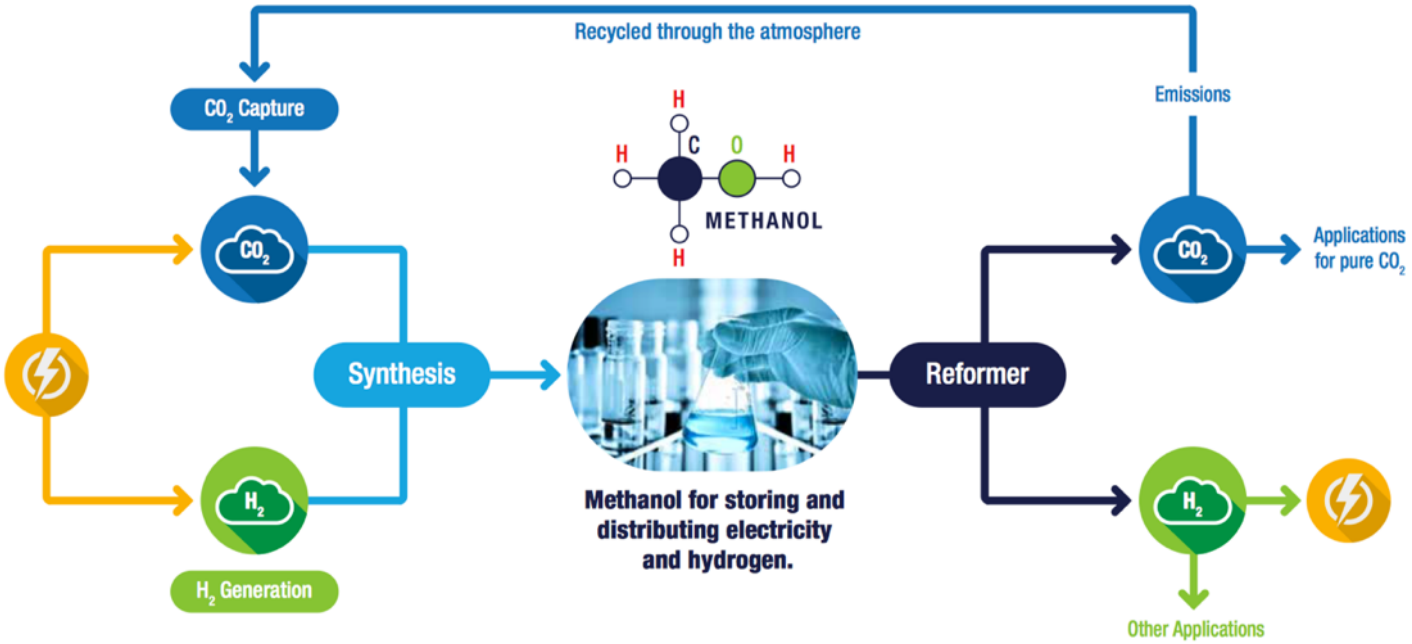
RENEWABLE PATHWAYS ARE RAPIDLY DEVELOPING



Source: The Methanol Institute and Qafaq

AN EFFICIENT ENERGY CARRIER

LIQUID STORAGE MEDIUM FOR ELECTRICITY & HYDROGEN



Methanol for storing and distributing electricity and hydrogen.

Methanol CH_3OH has, on a volume basis, 40% more H_2 than liquid hydrogen at -253°C, and 140% more H_2 than compressed hydrogen at 700 bars.

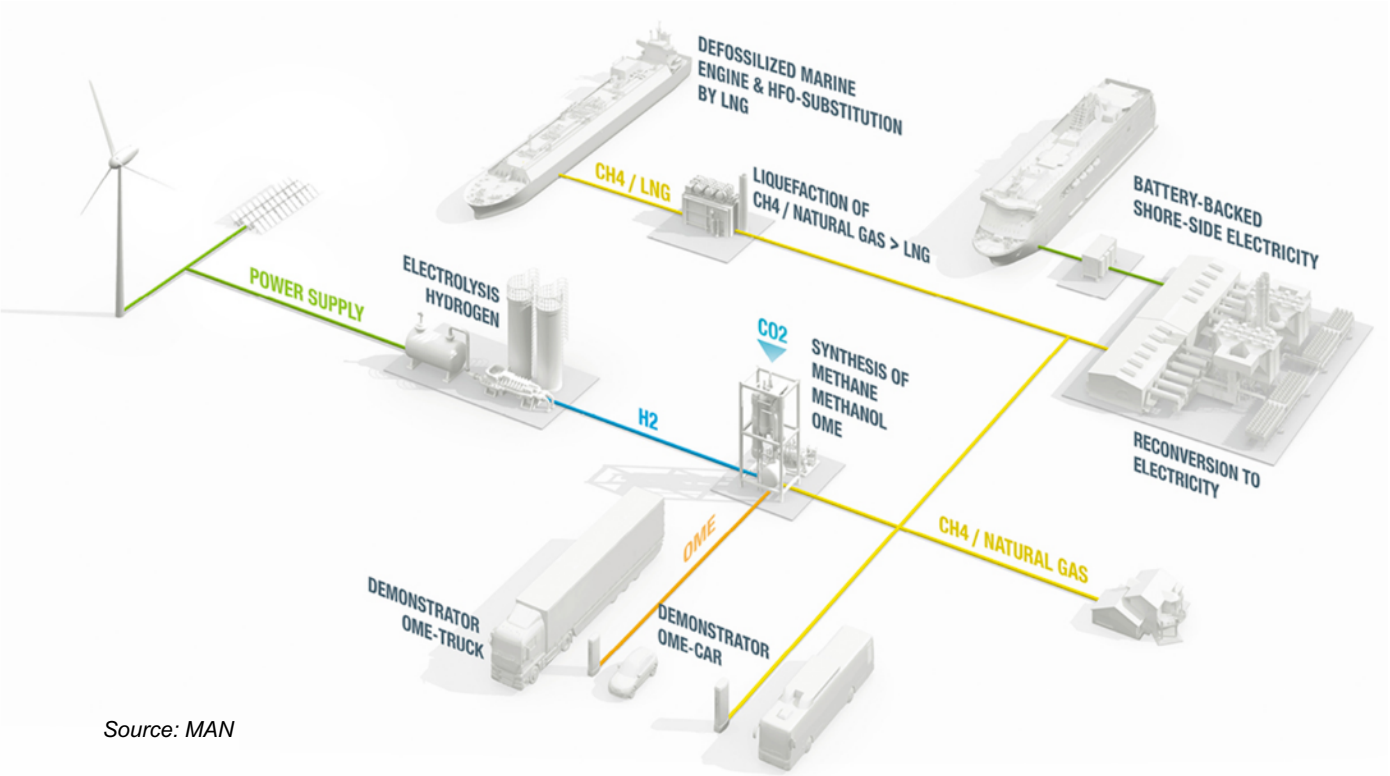
Source: Prof. SHIH Choon Fong, NTU, MI

STAGES OF RENEWABLE METHANOL 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) • NREL (USA) • Heveskes Energy (NL)	• BioMCN (glycerine) (NL) • Chemrec (SE) • Range Fuels (USA) • Schwarze Pumpe (GER) • Värmlands Metanol (SE) • Woodspirit (NL)
Renewable methanol	• CRI (IC) • Innogy (GER)	• bse Engineering (GER) • Blue Fuel Energy (CAN) • CRI (CN/GER) • MefCO2 (GER) • Infraserv (GER) • Liquid Wind (SE) • Port of Antwerp (BE) • STEAG (GER) • Swiss Liquid Future (CH) • ZASt (GER) • USC (USA) • Gensoric (GER) • Neo-H2 (USA)	
Hybrid methanol		• Haldor Topsoe (DEN) • OPTIMeoH (GER)	
Low carbon methanol	• GPIC (BAH) • Methanex (CAN) • QAFAC (QAT) • SABIC (KSA)	• Carbon2Chem (GER) • FRESME (SE) • NCF (CN) • GasTechno (USA) • Maverick Synfuels (USA)	

POWER-2-X

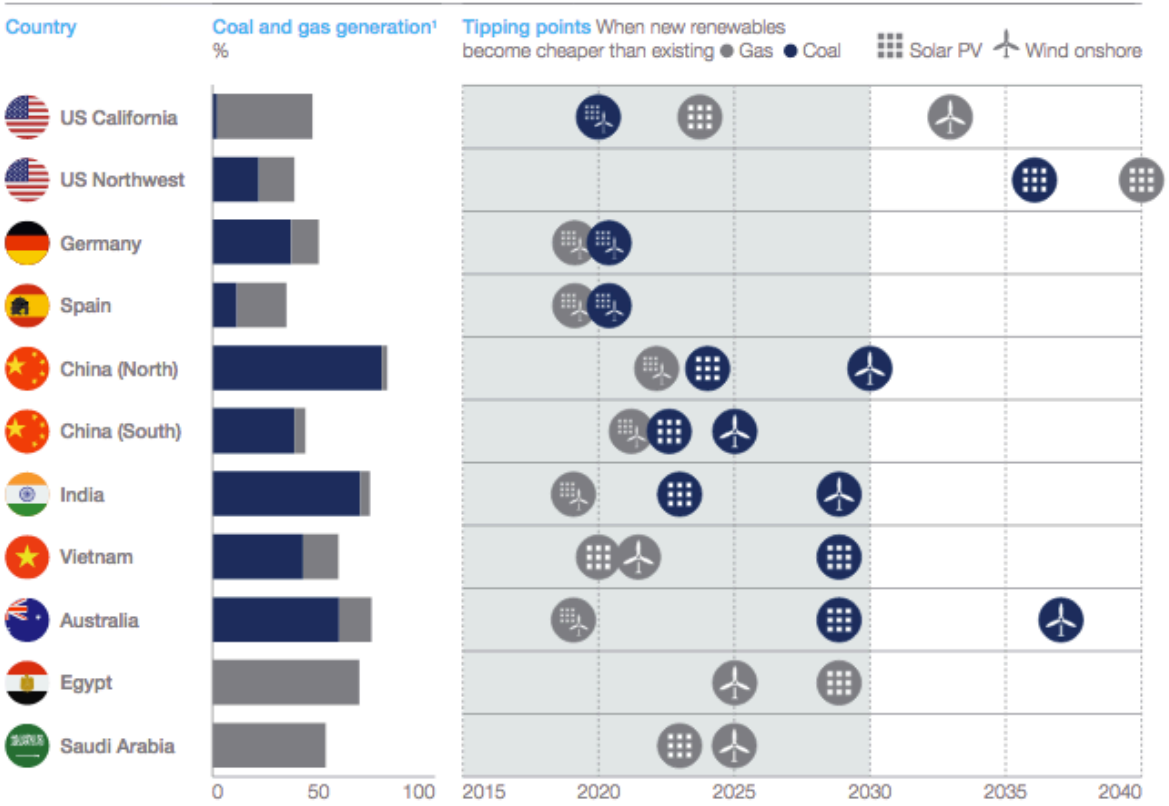
The World Energy Council recently estimated a global demand for carbon-neutral synthetic fuels of 10,000-20,000 terawatt hours by 2050, equivalent to 50% of current fossil fuel consumption



Source: MAN

RENEWABLES WILL BECOME CHEAPER THAN EXISTING COAL & GAS IN MOST REGIONS BEFORE 2030

- By 2030, new-build renewables will outcompete existing fossil fuel generation on energy cost in most countries—one of the key tipping points in the energy transition
- The majority of countries will reach this tipping point in the next ~5 years
- US Northwest is the exception to this with tipping points post-2035, driven by relatively low fossil fuel prices as well as low solar potential



A tipping point represents a year when new renewables (solar PV, onshore wind, or both) become cheaper than existing fossil fuel plants

1 Power generation from existing coal and gas power plants in 2018, as share of total
Source: McKinsey Energy Insights' Global Energy Perspective, January 2019

FOUR MAJOR SHIFTS AND ONE CONTINUITY ARE SHAPING GAS DEMAND UNTIL 2035

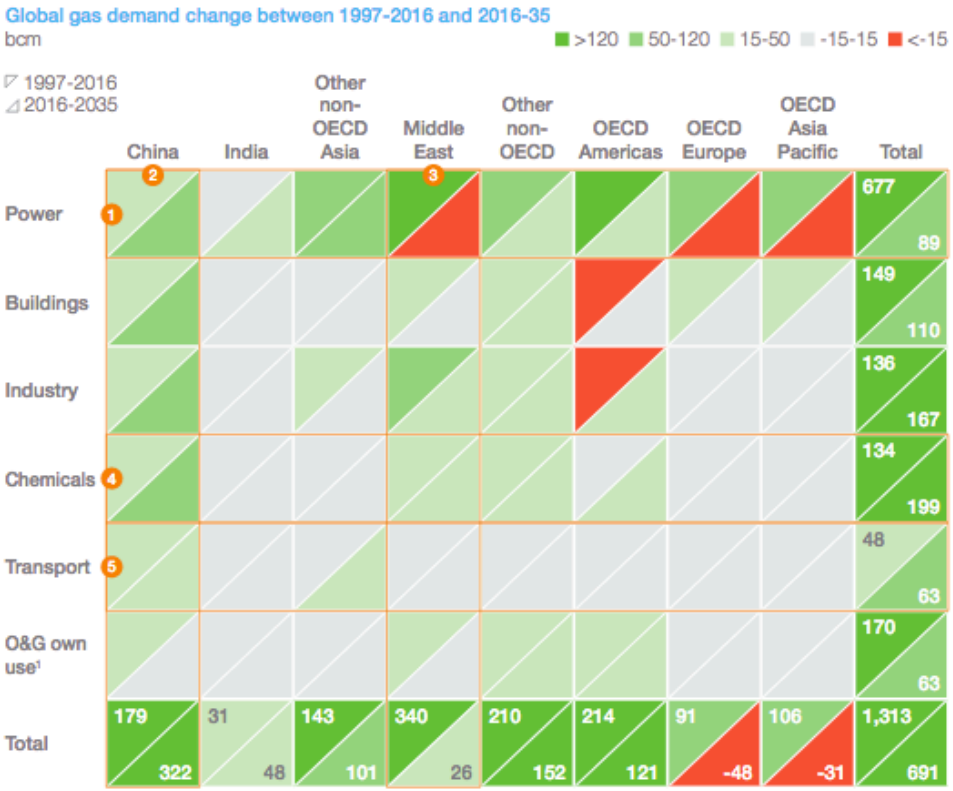
1. **Power:** Further gas demand growth in power will be limited to less than 100 bcm due to increasing competitiveness of renewables. Investments in new renewable generation capacity outpaces gas by roughly a factor of 4

2. **China:** China's gas demand growth is greater than that of the next 10 largest growth countries combined, including the US, and represents nearly half of global demand growth through 2035. This growth is driven by an ambitious 5-year plan of the Chinese government that is focused on pushing gas across sectors to replace coal (e.g., boiler switches in buildings)

3. **Middle East:** Previously the growth region, gas demand in the Middle East peaks before 2030 despite continued industry growth, primarily driven by the improving economics of renewables in power and the opportunity cost of exporting gas rather than using it for domestic power generation• The current growth of gas demand as it replaces oil in power is thus short-term in the 2020s

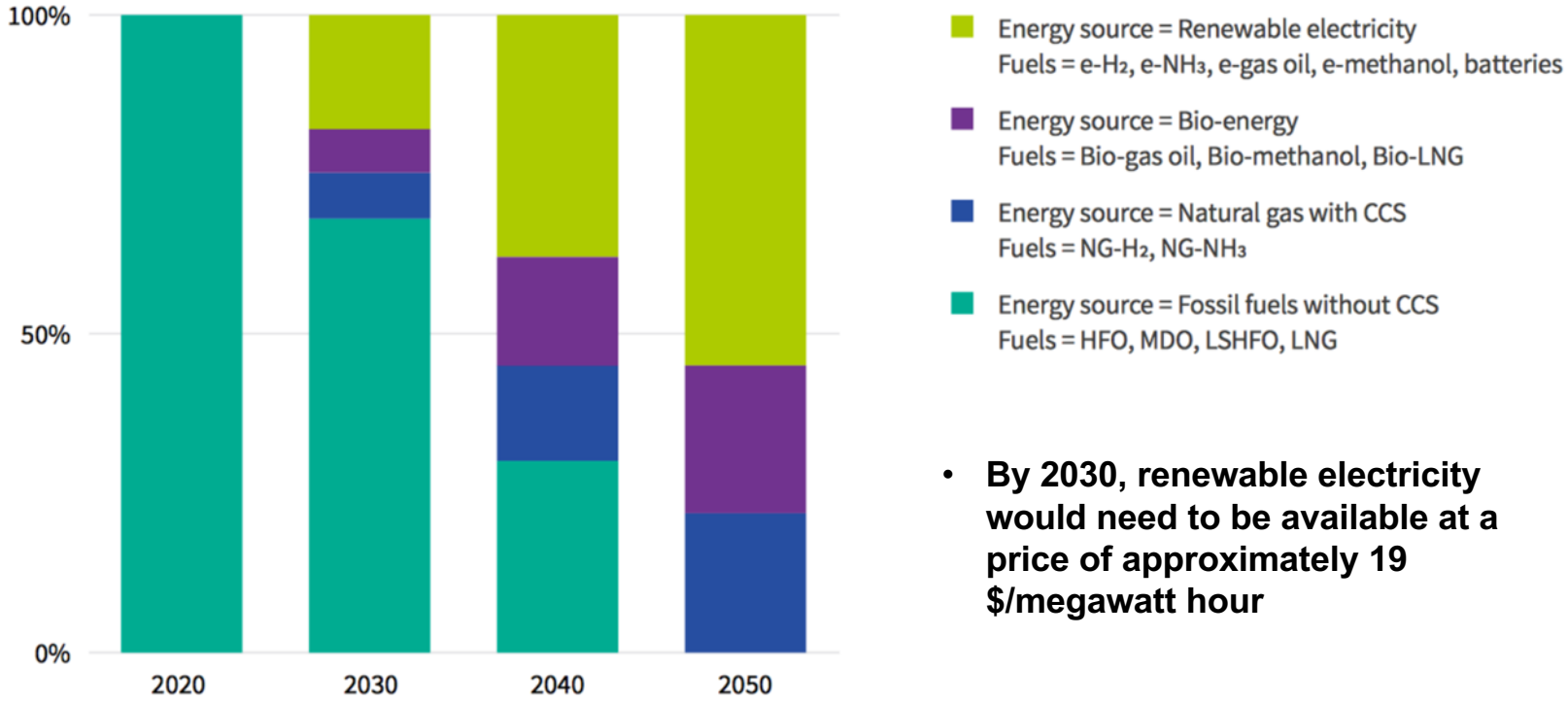
4. **Chemicals:** The fundamental growth of chemicals demand, in combination with low gas prices in key markets like the US, Russia, and Iran, enable accelerated growth that adds ~200 bcm—significant growth from gas as feedstock for ammonia and methanol

5. **Transport:** Will continue to see very high growth rates in transport demand enabled by emissions regulation for marine fuels. However, the small base means transport cannot offset the trends in all other sectors



1 The decline in growth of O&G own use is following largely the development of production levels in the respective countries
Source: McKinsey Energy Insights' Global Energy Perspective, January 2019

ENERGY SOURCE AND MARINE FUELS MIX ASSUMED IN A RENEWABLES DOMINATED PATHWAY

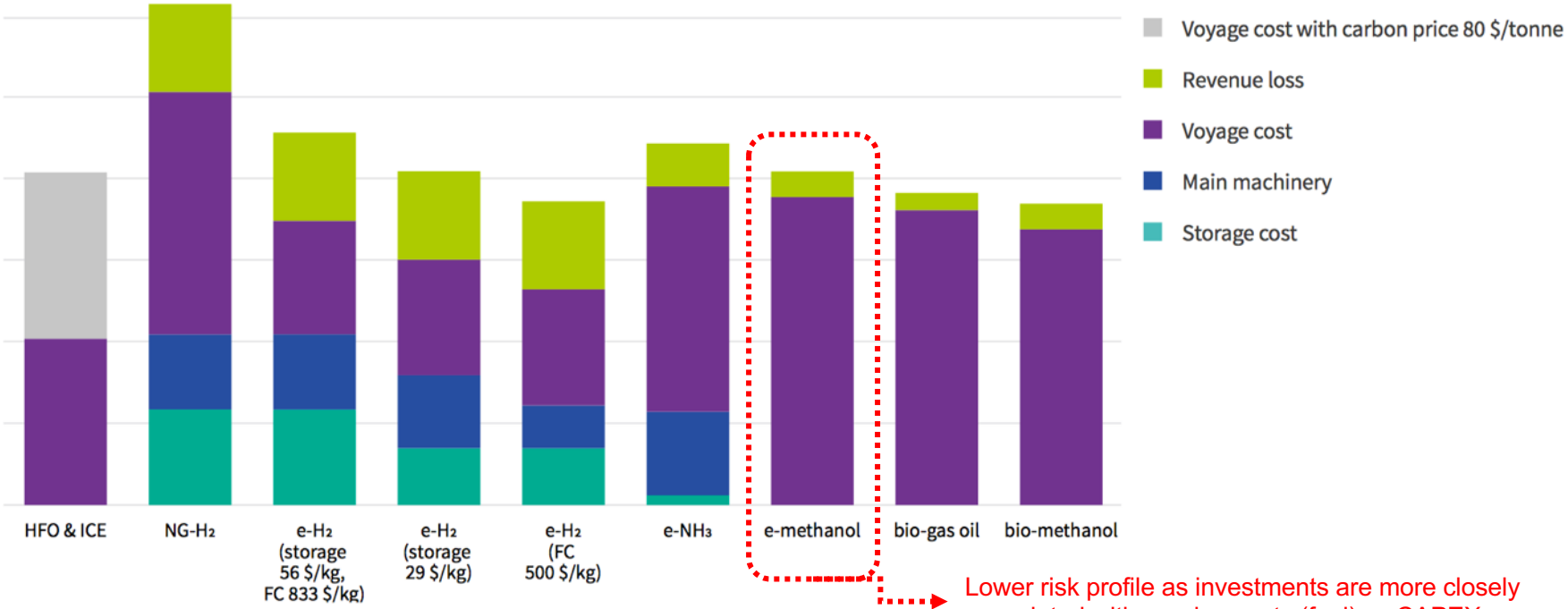


- **By 2030, renewable electricity would need to be available at a price of approximately 19 $/megawatt hour**

Source: Lloyd's Register Report

RELATIVE COMPETITIVENESS OF ZEVS USING ELECTRO-FUELS FOR A SMALL-MEDIUM SIZED CONTAINER SHIP

Project annual costs in 2030



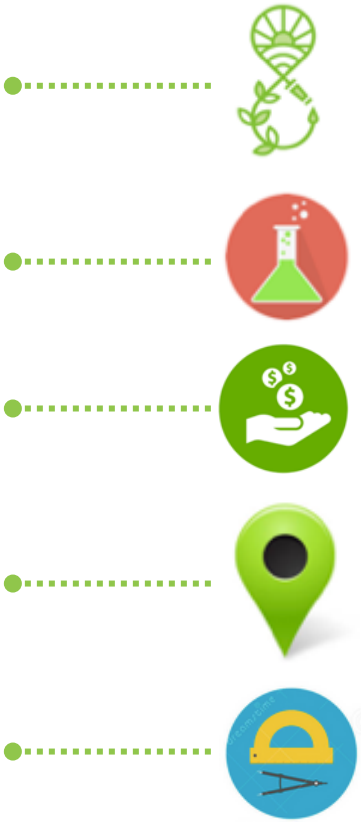
Lower risk profile as investments are more closely associated with running costs (fuel) vs CAPEX

Source: Lloyd's Register Report

03 POTENTIAL OF METHANOL AS A MARINE FUEL

BROADLY, METHANOL IS…

- Cost effective and “future proof” fuel which can be produced from a variety of feedstocks – to include renewables
- One of the top 5 seaborne chemical commodities – safely handled for over 50 years
- A lower cost alternative for converting vessels to methanol – minimal and economically viable without subsidies
- Widely available and alleviates many infrastructure limitations both on land and at sea, trading within a narrower price range than competing fuels
- Not as well understood as a vessel fuel, even though it has similar handling characteristics as distillate fuel

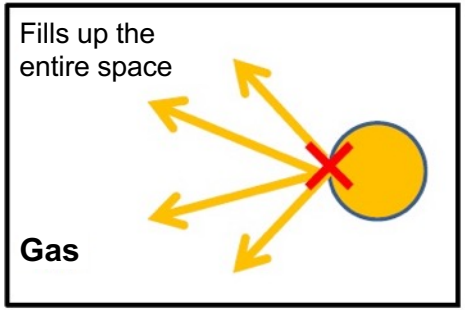


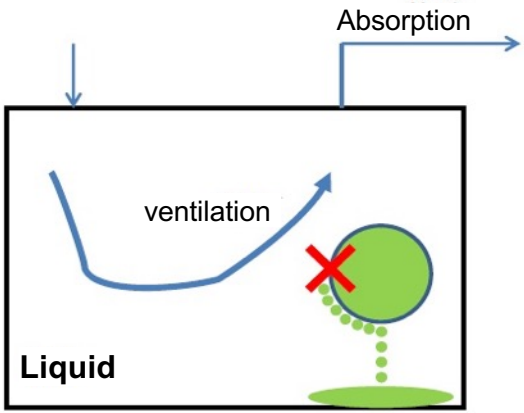
METHANOL FUEL CHARACTERISTICS

Parameters		Petrol C_5-C_{12} Hydrocarbon	Diesel C_{10}-C_{21} Hydrocarbon	Natural Gas CH_4	Methanol CH_3OH	Ethanol C_2H_5OH
Mass Fraction	C	85	86	75	37.5	52.2
	H	15	14	25	12.5	13.0
	O	0	0	0	50	34.8
Density (liquid)(kg/L)		0.72-0.78	0.82-0.86	0.42-0.46	0.79	0.81
Boiling point (^{0}C)		30-190	180-360	-162	65	78
Flash point (^{0}C)		-50 ~-20	>55	-188	11	9
Auto-ignition point (^{0}C)		420	250	650	465	426
Lower heating value (MJ/kg)		44.0	42.5	50	19.5	25
Octane number		70-97	20-30	130	111	108
Cetane number		-15	40-55	Low	3-5	8
Flammability limits (%)		1.1-5.9	1.58-8.2	5-15	6-36.5	4-19
Vapour pressure at 37^{0}C/kPa		55-103	<1.37		31.6	15.8

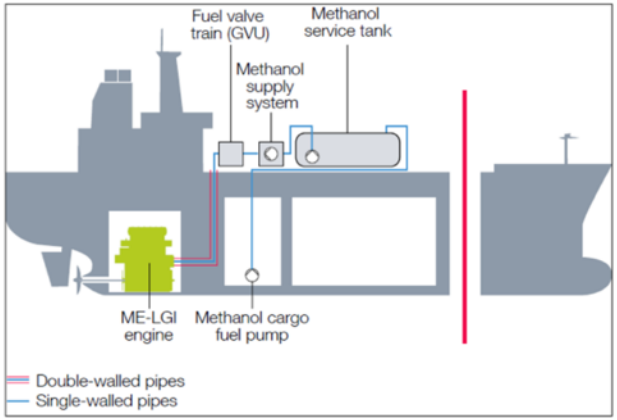
KEY DIFFERENCES BETWEEEN GAS & LIQUIDS

- **Compared to gaseous fuels, the key differences with liquids are:**
  - Faster pressure release
  - Less product release
  - Localised diffusion
  - Ease of detection and cleaning





PRACTICAL SOLUTION



- **Multi – fuel engines will be the norm going forward**
- **Methanol can be readily and safely applied in both new build and conversion**

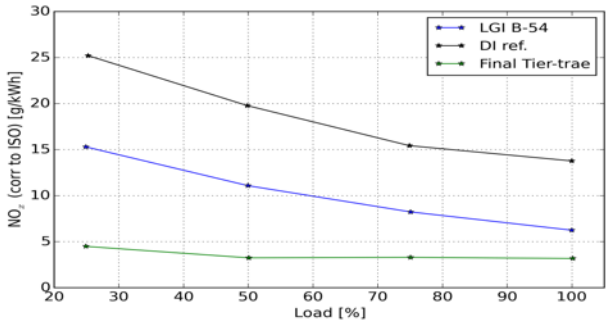
- **Methanol can be a practical solution for dual fuel applications, to include other alternative fuels such as LPG and LNG**

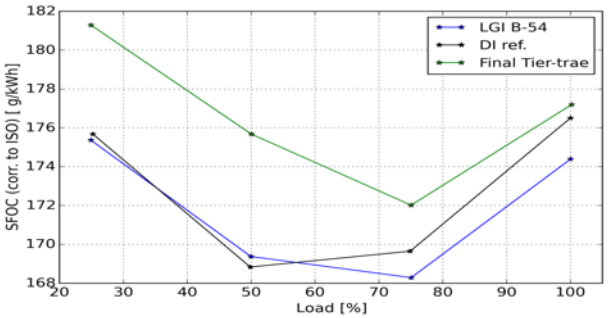
Source: Westfal-Larsen

CONVENTIONAL MeOH EMISSIONS SCORECARD

Methanol (MeOH) achieves low emissions & acts as a bridge in lowering CO_2 now and in the future (blending renewable or bio methanol)

METHANOL / WATER BLENDING (EMULSIFICATION)



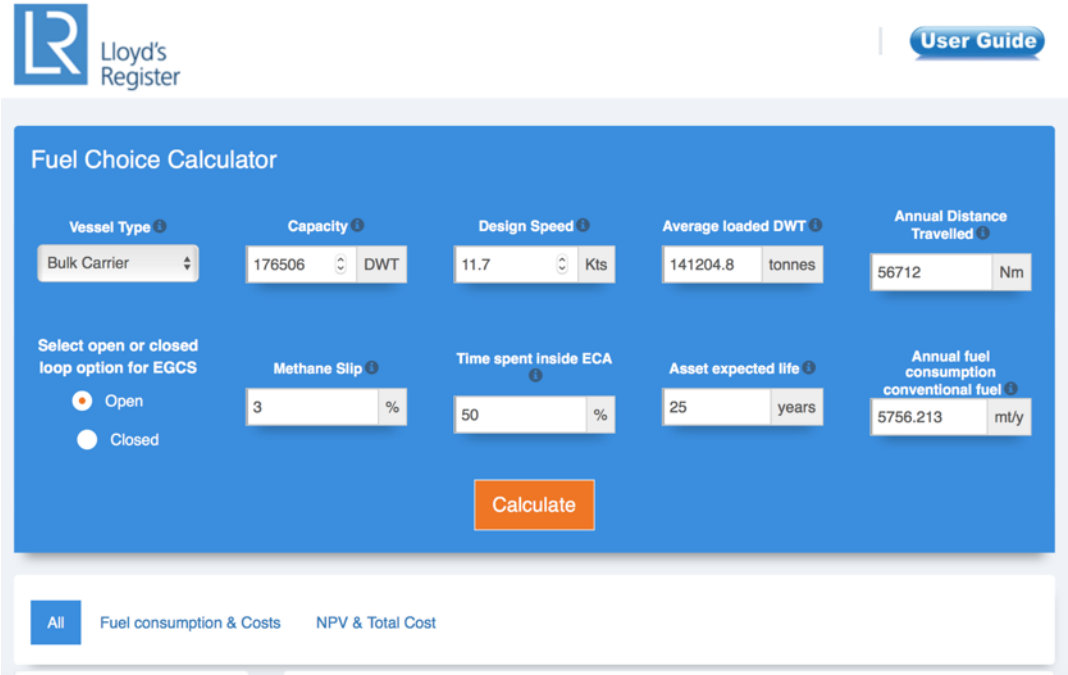


- Approximately 25-40% water is added to the methanol to achieve a new, Tier III solution
- NOx decreases almost linearly with water content, to approximately 2 g/kWh at 50% and 75% load
- Similar system is being planned for fuel oil, so the Tier III compliant technology will be available as a dual fuel solution
- R&D testing completed - service test is under preparation

Source: MAN

ONLINE FUEL EVALUATOR

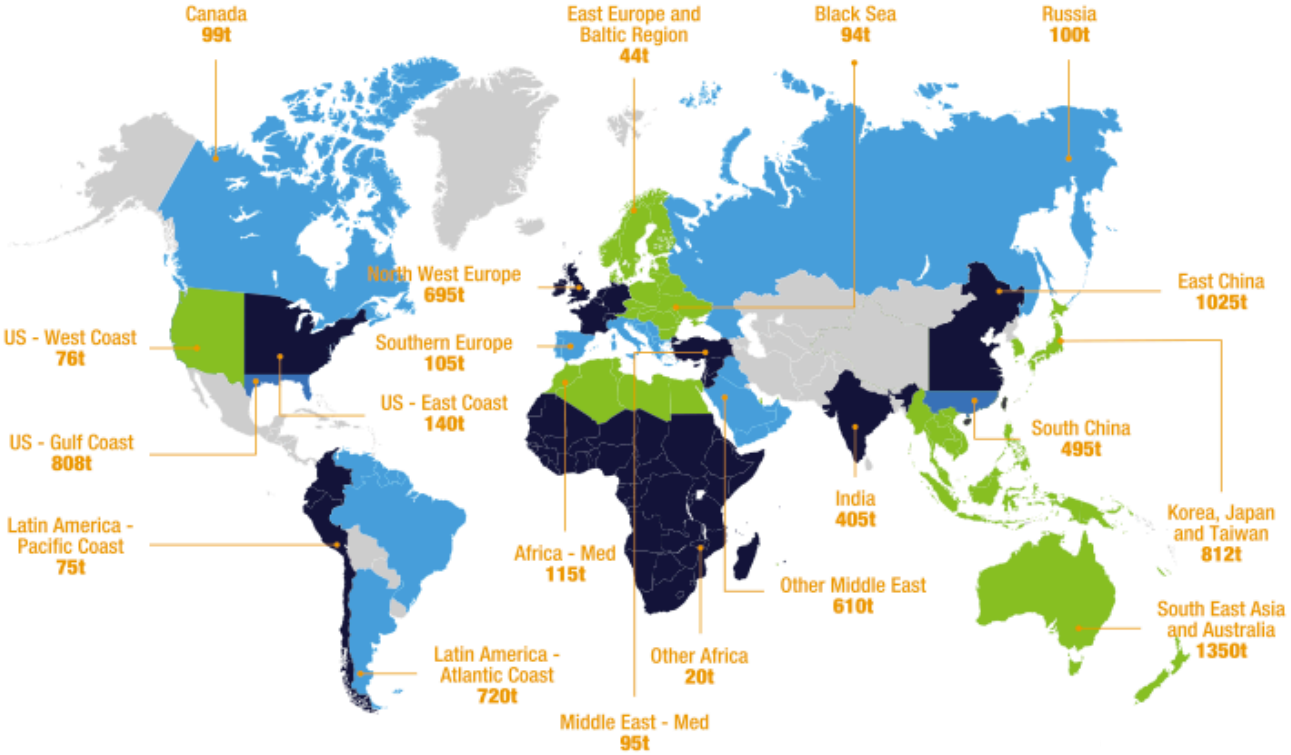
Co-developed with LR, has proved to be a valuable tool in comparing economic viability across a range of vessel types, voyages and fuel price scenarios



https://www.lr.org/en/latest-news/online-tool-to-help-evaluate-options-for-sulphur-2020-compliance/

METHANOL IS ALREADY WIDELY AVAILABLE

MI is currently developing an availability platform together with DNV GL, to highlight the existing availability of methanol globally at more than 100 locations



PROVEN EXPERIENCE

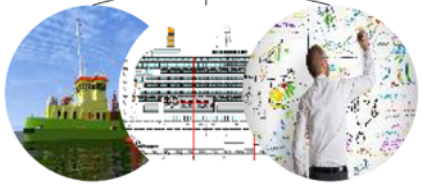
DUAL FUEL

7x +4	1x	1x
chemical tankers	ROPAX ferry	Pilot boat
MOL, WL, Marinvest	Stena Line	Swedish Maritime Admin
2 stroke MAN	4 stroke Wärtsila	high speed Scania, Weichai, a.o.
new build	retrofit	retrofit

FUEL CELL

1x	1x
Tourist boat	Ferry
Innogy	Viking Line
Serenergy fuel cells	
propulsion	hotel load
retrofit	retrofit

PROJECT and R&D



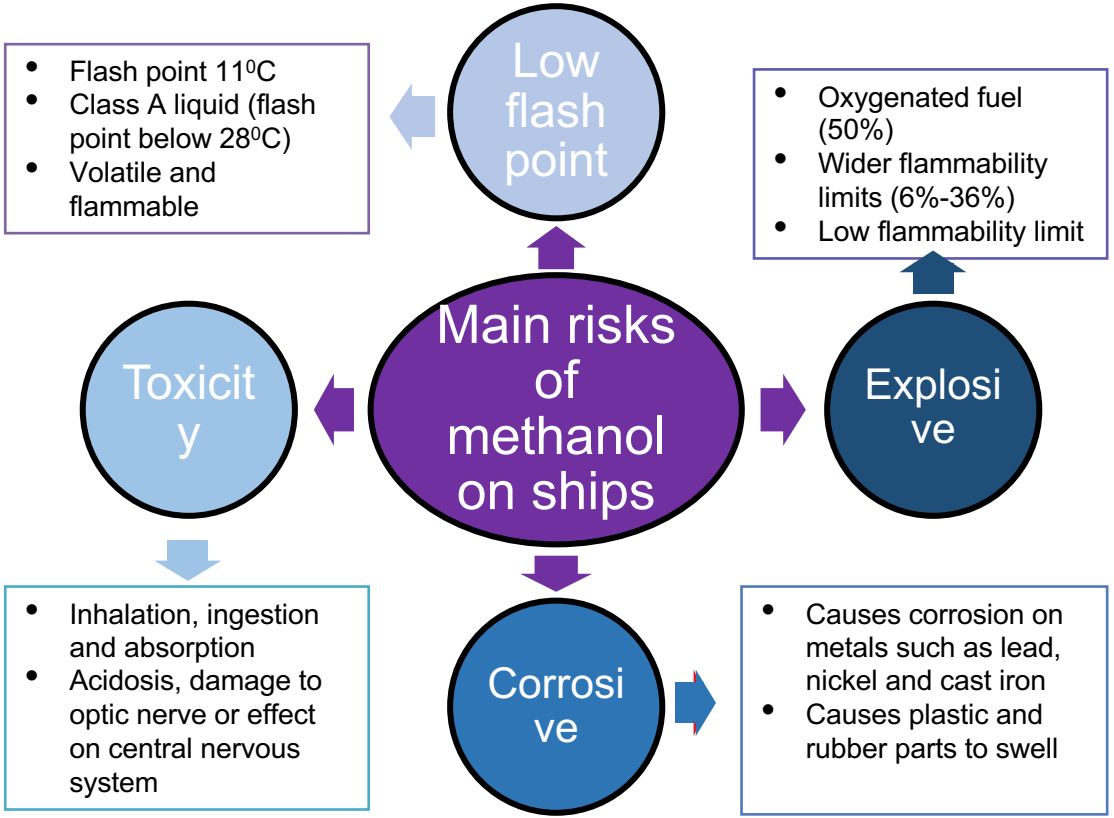
Cruise ships, fishing boat, barge, dredge, a.o.

SUMMETH/MARTEC, Lean Ships, Methaship, Billion Miles, FiTech, India, PCG Product Vessel, NTU Test Bed Green Maritime Methanol, FastWater

SI hybrid, dual fuel, etc.

new build & retrofit

MAIN RISKS OF METHANOL AS A FUEL (1 of 2)



METHANOL BUNKERING RISKS

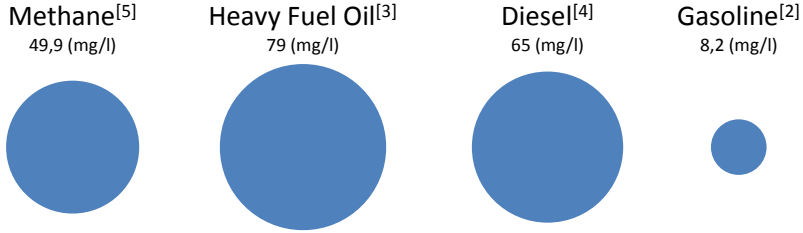
Risks	Countermeasures
Fire	• Fire caused by static electricity: Anti-static measures such as grounding of the pipeline between fueling party and party receiving the fuel • Use of explosion-prevention equipment • Vapour detection • Prohibiting smoking as flame is invisible
Explosion	• Refueling station should be located on an open deck • Purging and inerting of the pipeline
Fuel leakage	• Use of qualified and certified refueling equipment, including qualified hose • Approved emergency cutoff procedures • Automatic emergency cutoff system
Toxicity	• Personnel protection equipment
Overfilling	• Fuel tank maximum level alarm to immediately close the refueling valve • Should be equipped with a pair of sensors on the fuel tank
System failure	• Manual shutoff valve to shutoff the fuel tank (primary valves)
Power outage	• Mechanical closure of refueling valve (ESD)

SIGNIFICANTLY SAFER FOR THE ENVIRONMENT

LC50, LC = LETHAL CONCENTRATION

Concentration in water, at which half the marine population died within the specified test duration

Safer than Diesel by a factor of 240 times



[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

BUNKERING TECHNICAL CONSIDERATIONS

(1) Refueling station

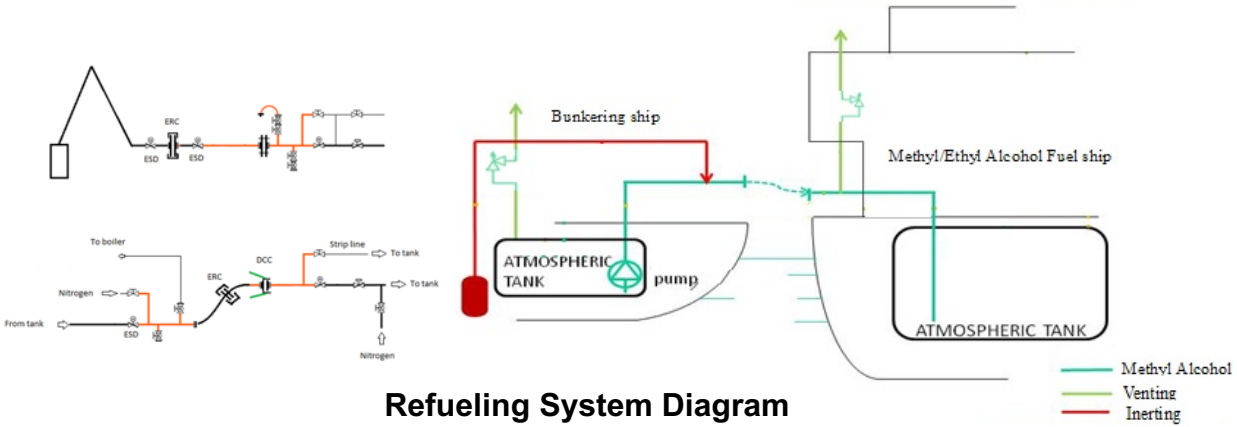
- Refueling station should be located on open deck for natural ventilation
- There should be a device for safe disposal of leaked fuel, and skirting and collection tray below the joint for safe collection
- Monitor and control the refueling from a safe location (equipped with overfill alarm and automatic cutoff to monitor bunker level and overfill)
- **Personnel protection (shower and eyewash station for emergency use must be available)**

Stena Germanica Methanol Refueling

BUNKERING TECHNICAL CONSIDERATIONS

(2) Refueling system

- Every refueling line near the shore connector should be fitted with a manual shutoff valve and a remote shutoff valve connected in series
- Should be able to perform gas inerting and degassing of the refueling line
- Should be equipped to purge the fuel from the refueling line after refueling
- The ship should be equipped with refueling ESD cut-off system, which can be operated from the ship to be refueled or from the place performing the refueling



Refueling System Diagram

FUEL STORAGE (1 of 3)

Methanol Liquid Tank (IBC)

Cargo	Pollution category	Hazard	Ship type	Tank type
Methanol	Y	P	3	2G

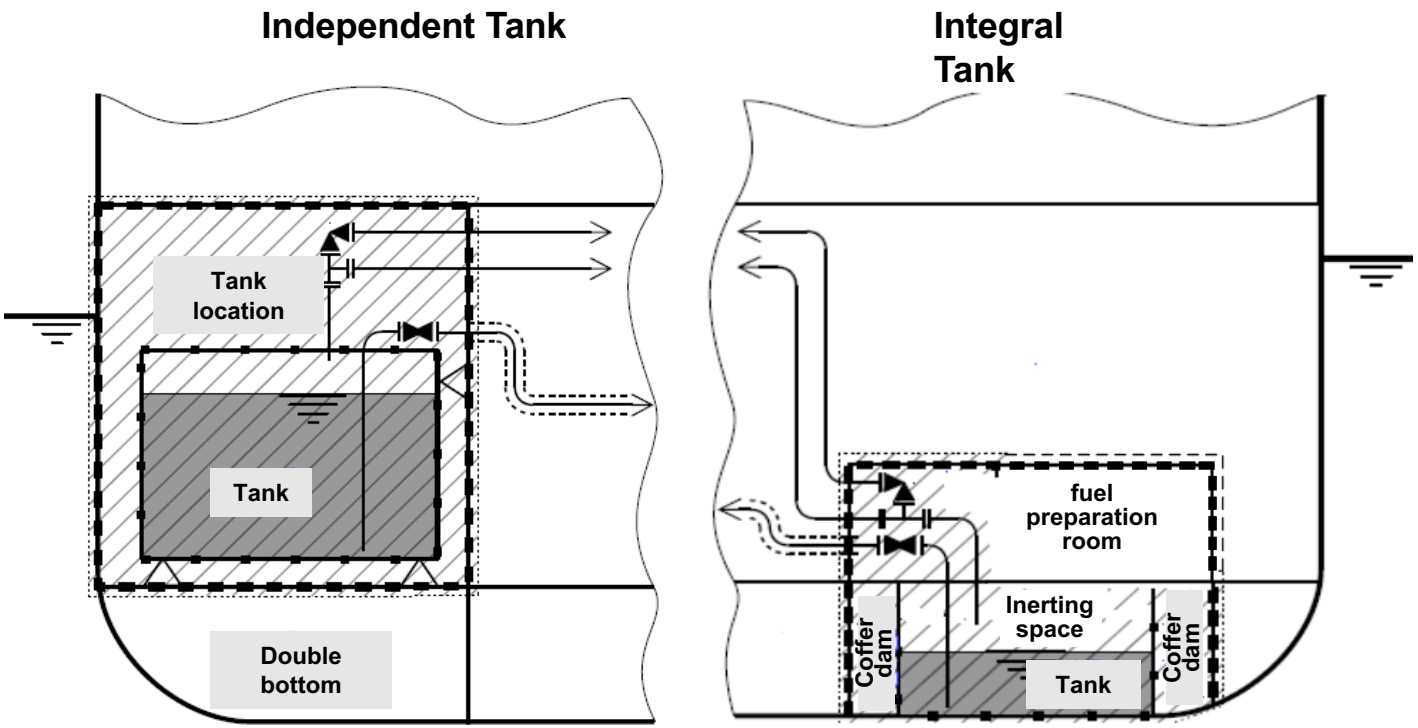
- **Y** - Release of tank washing water and ballast water into the sea harms marine resources or human health
- **P** - Hazardous and causes pollution
- **3** - Type 3 ship (single-hull)
- **2G** - Type 2G tank, lowest available integral gravity tank

Methanol Tanks

Solution

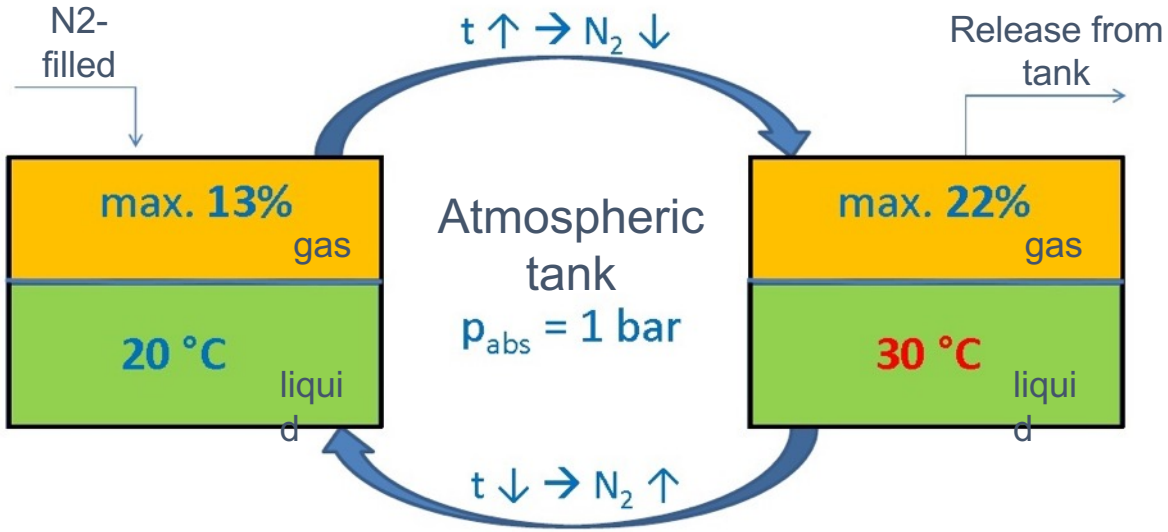
Tank type	Tank location
■ Integral ✓	Below open deck
■ Independent ✓ (including portables)	Enclosed space on open deck

FUEL STORAGE (2 of 3)



FUEL STORAGE (3 of 3)

Proportion of gaseous methanol depends on the rate of evaporation

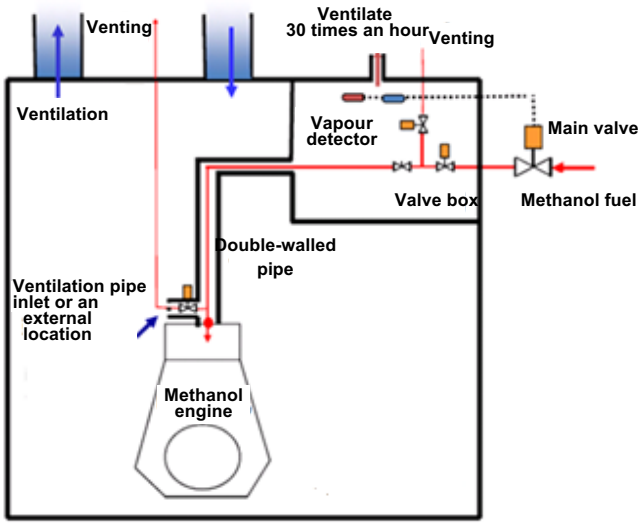


Evaporation is not boiling; it is a very slow process!

FUEL SUPPLY (1 of 3)

1. Fuel pipeline inside the machine area

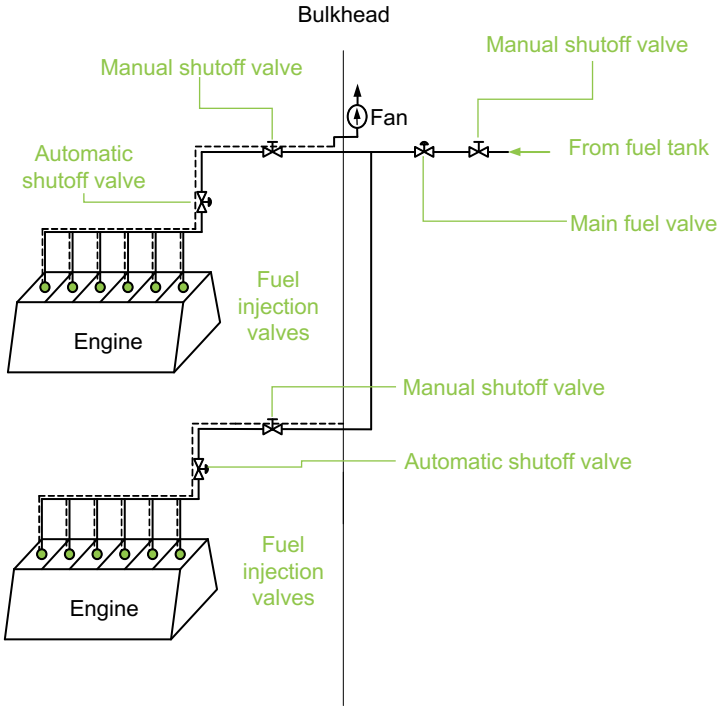
- Use of double-walled pipe with fuel in the inner pipe and outer pipe being watertight and airtight
- Mechanical ventilation is performed between the inner pipe and outer pipe, where air is changed at least 30 times an hour
- A suitable fuel vapour detector is installed between the inner and outer pipes
- **Double-walled pipe should be connected to a suitable collection tank, which has a liquid fuel detector, to collect leaked fuel**



FUEL SUPPLY (2 of 3)

2. Valve layout

- The main fuel line leading to each engine location should be fitted with a manual shutoff valve and an automatic shutoff valve (main fuel valve) connected either in series or integrated together
- The fuel line leading to each engine should be fitted with a manual shutoff valve (to ensure shutoff during maintenance) and an automatic shutoff valve
- **Venting valve does not require dual shutoffs**

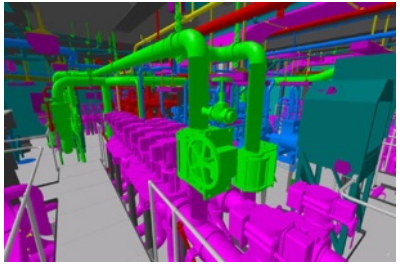


FUEL SUPPLY (3 of 3)

3. Fuel line outside the engine location

- Prohibited from passing through accommodation areas, service locations, between electrical equipment or control stations
- When passing through enclosed areas other than those described above (except the fuel preparation rooms), double-walled pipes should be used
- **For methanol/ethanol carriers, the fuel lines in the cargo areas need not conform to the above requirements but should at least conform to IBC**

4. Fuel preparation rooms



- Should be airtight and watertight
- Should be mechanically ventilated
- **Should be fitted with both fuel vapour detection and liquid fuel detection**

VENTILATION

Location		Ventilation Requirements
Double-walled pipes		○ Negative pressure mechanical ventilation ○ Ventilate 30 times/hour ○ Power and number of fans: ventilation capacity should not fall by more than 50% when a fan powered by a separate line from a main switchboard or an emergency switchboard fails or when a group of fans powered by a utility line from a main switchboard or an emergency switchboard fails
Fuel preparation rooms		
Fuel valve units		
Fuel tanks		
Refueling stations	Open deck	Good and natural ventilation
	Enclosed or semi-enclosed	When natural ventilation is inadequate, mechanical ventilation systems should be considered

CONTROL, MONITORING & SAFETY SYSTEMS

	Fuel vapour detector	Liquid fuel leakage detector
Between inner and out pipes of double-walled pipes	√	√
Fuel preparation room	√	√
Location of fuel tanks	√	√
Isolation cabin adjacent to the fuel tanks	√	√
Other enclosures that contain fuel lines but do not have double-walled pipes	√	√
Other locations with fuel installations	√	√
Other enclosures/semi-enclosures where fuel vapour may accumulate	√	
Airlock	√	
Based on risk analysis, the ventilation inlets in the accommodation area and machine area where fuel vapour may enter	√	

CONCLUSION

POTENTIAL OF METHANOL AS A MARINE FUEL

- *Capital costs for ship conversion less than LNG and similar to after treatment technologies*
- *Methanol is already easily and cost effectively stored at any port in the world*
- *Methanol is one of the top 5 seaborne chemical commodities accounting for 35% of the world seaborne chemical and vegoil trade*
- *Major engine OEMs confident engines can meet SOx and NOx requirements*
- *Produced renewably, methanol is a future-proof fuel*

THANK YOU