METHANOL AS A VESSEL FUEL

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COO

9TH BIENNIAL BUNKERING IN ASIA
SEPTEMBER 3 – 4, 2019
ONE FARRER HOTEL, SINGAPORE

01 ABOUT MI

MEMBERS

Tier 1

MHTL

methanex the power of agility

سابك sabic

OCI

Tier 2

Qatar Fuel Additives Company Limited

MITSUBISHI GAS CHEMICAL AMERICA, INC.

ATLANTIC METHANOL

MITSUI & CO., LTD.

PETRONAS

Oman Methanol Company L.L.C.

Tier 3

Eni Ecofuel

سبكيم Sipchem EXCELLENCE everywhere

G2X ENERGY

Salalah Methanol Company L.L.C.

JM Johnson Matthey Inspiring science, enhancing life

Mitsubishi International Corporation

Tier 4

FiTech

Advent

HELM PROMAN METHANOL

azelis

MOL Mitsui O.S.K. Lines

Blue World Technologies

CARBON RECYCLING INTERNATIONAL

GasTechno ENERGY AND FUELS

HALDOR TOPSØE

SCC Southern Chemical Corporation

bse engineering

YCI METHANOL ONE

FUEL FREEDOM CHEAPER. CLEANER. AMERICAN-MADE.

Element 1 Powering Innovation

Palcan

IGP Methanol

Double Green Bridge NW INNOVATION WORKS

TRICON ENERGY

quantiam technologies

IMTT

NAKHODKA FERTILIZER PLANT

CLARIANT

Coogee Chemicals

OLAHMOTORS

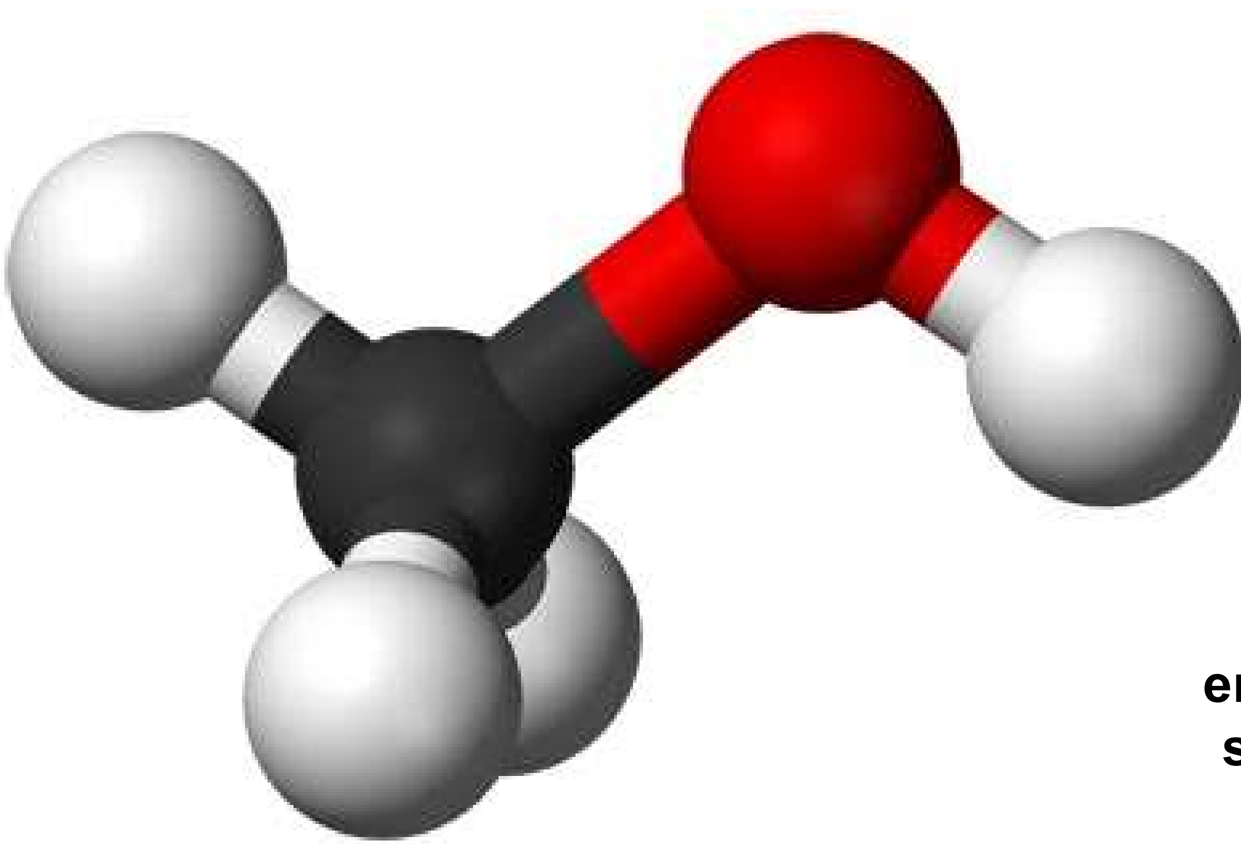
VITUSA PRODUCTS INCORPORATED

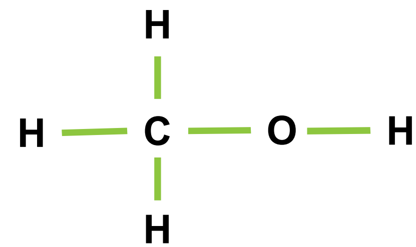
solvadis we do chemistry

Nebraska Public Power District Always there when you need us

02 WHAT IS METHANOL?

SIMPLEST MOLECULE OF ALCOHOLS GROUP





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

METHANOL

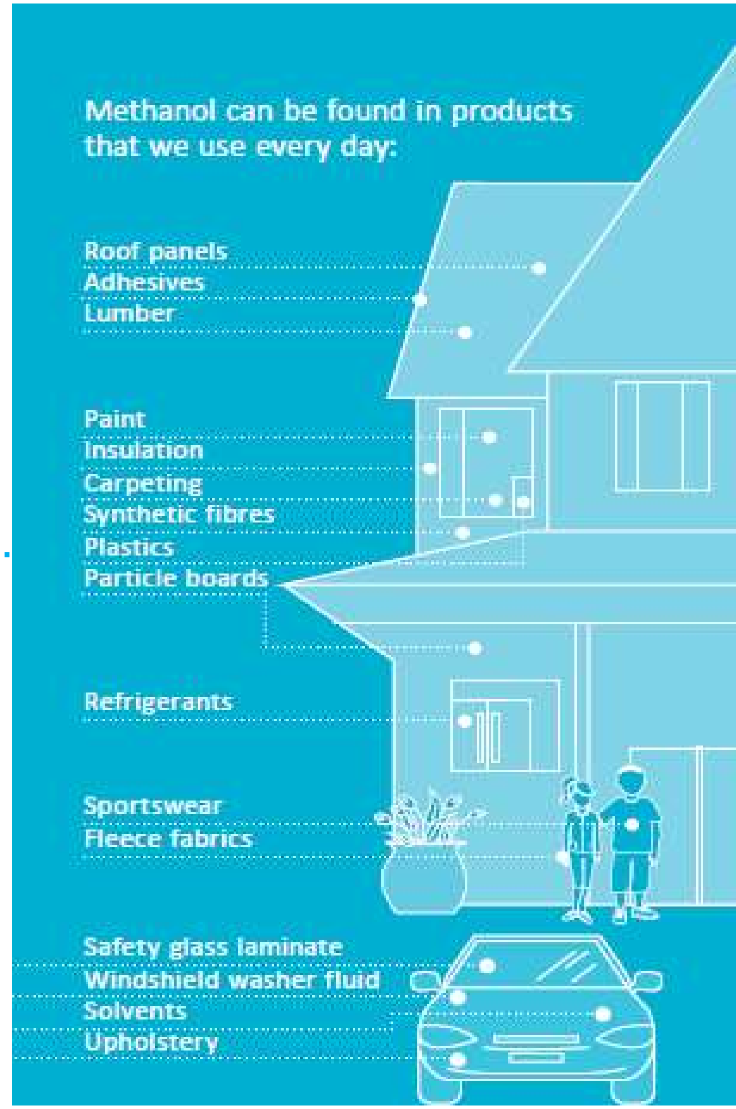
An essential ingredient of modern life

Energy/Fuel Substitution markets - represent the fastest growing demand segment for methanol (~45% demand)

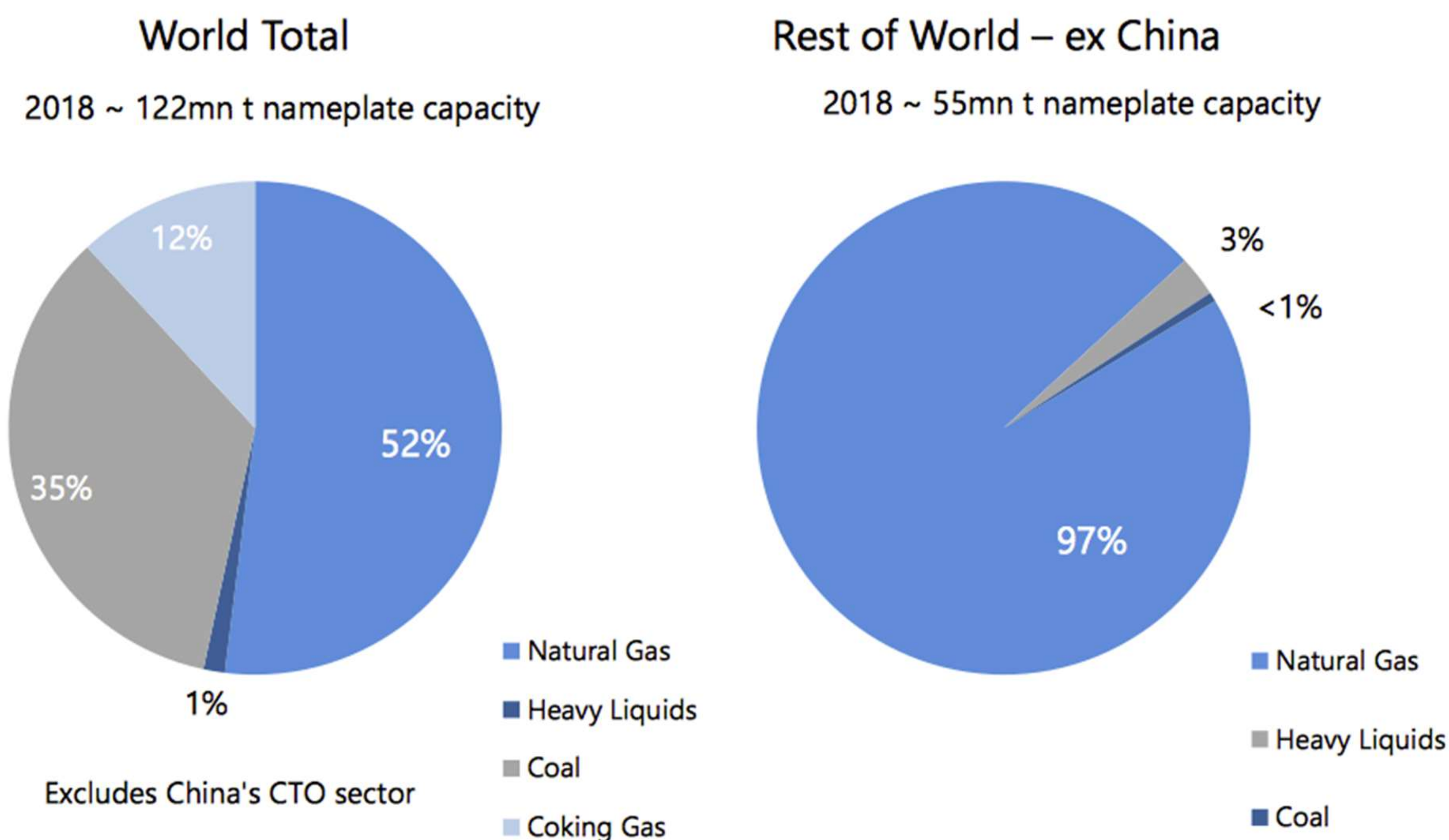
Chemical markets - essential ingredient used in countless industrial and consumer products (~55% demand)





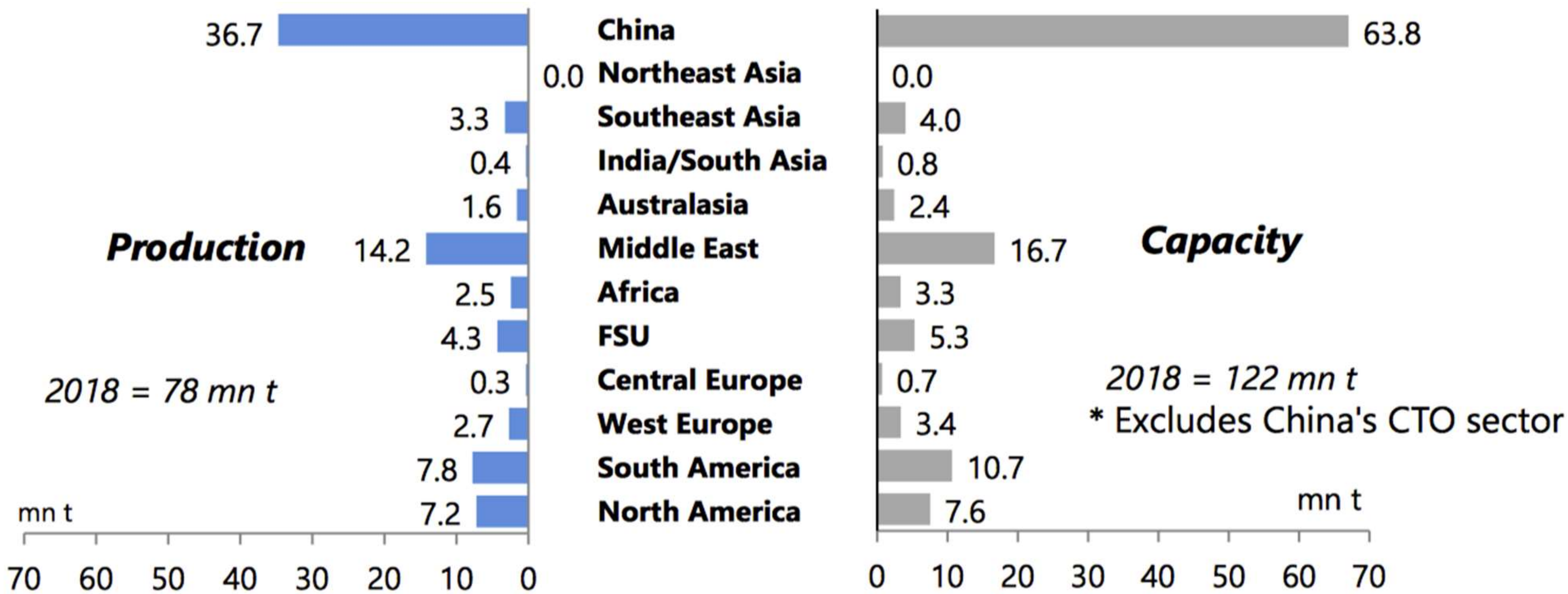


METHANOL PRODUCTION



Source: Argus

GLOBAL METHANOL PRODUCTION VS CAPACITY

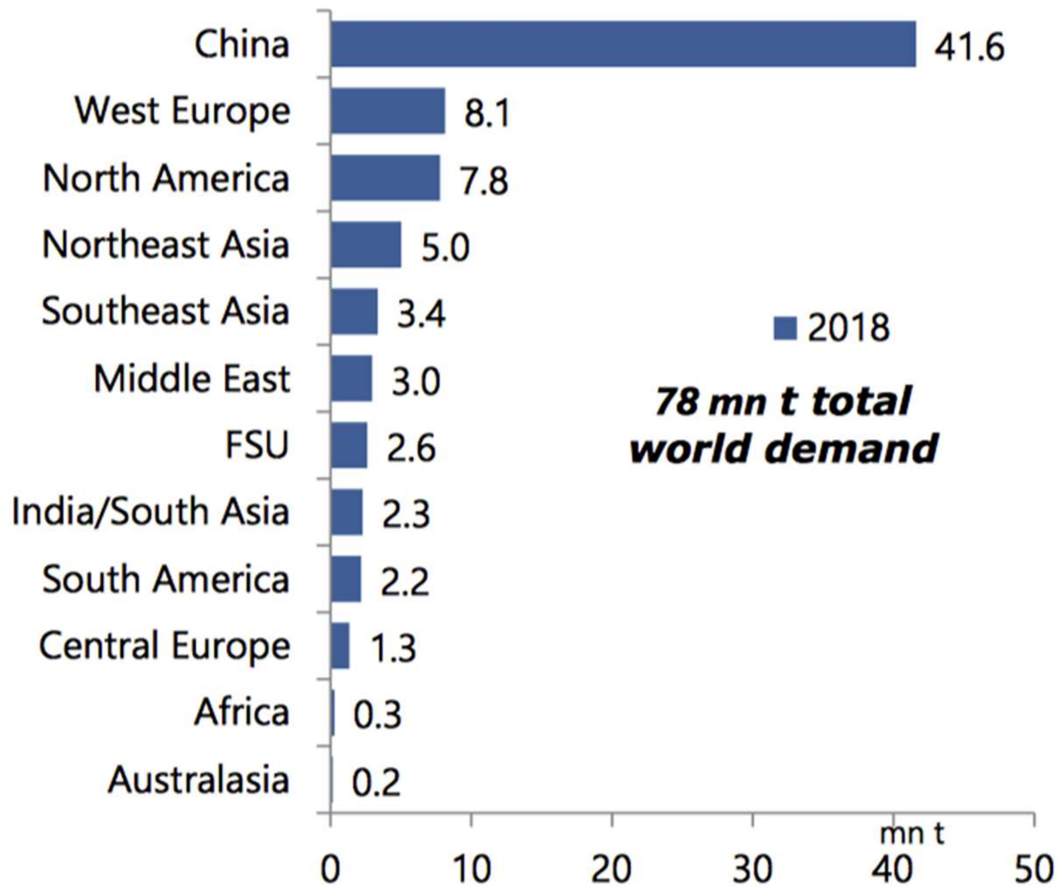


- Rest of world methanol production (excluding China) operates to best of abilities. Excess production from the rest of the world is exported to China
- China "generally" represents the high-cost methanol production bloc in the world and operates to meet China demand, less imports received from the rest of the world
- Industrial scale since 1923 (BASF)

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**



Source: Argus

Excludes China's CTO sector

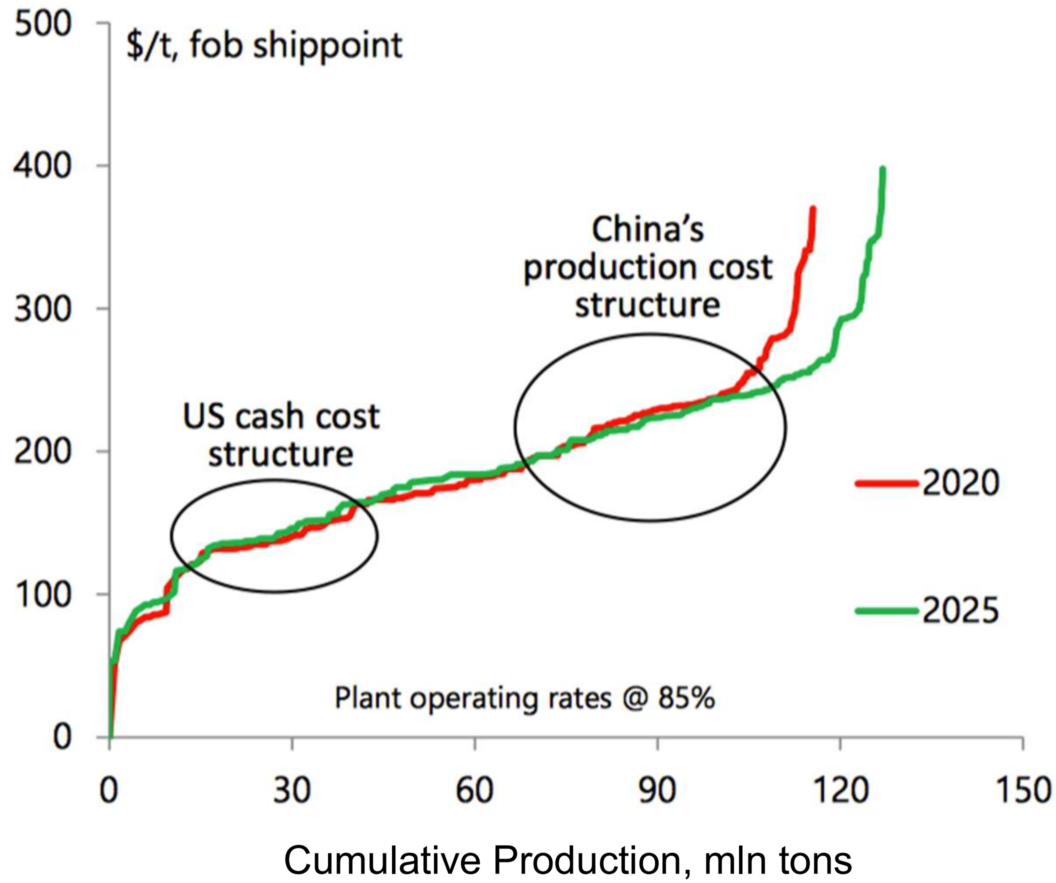
METHANOL INDUSTRY PRODUCTION CASH COST CURVES

- **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

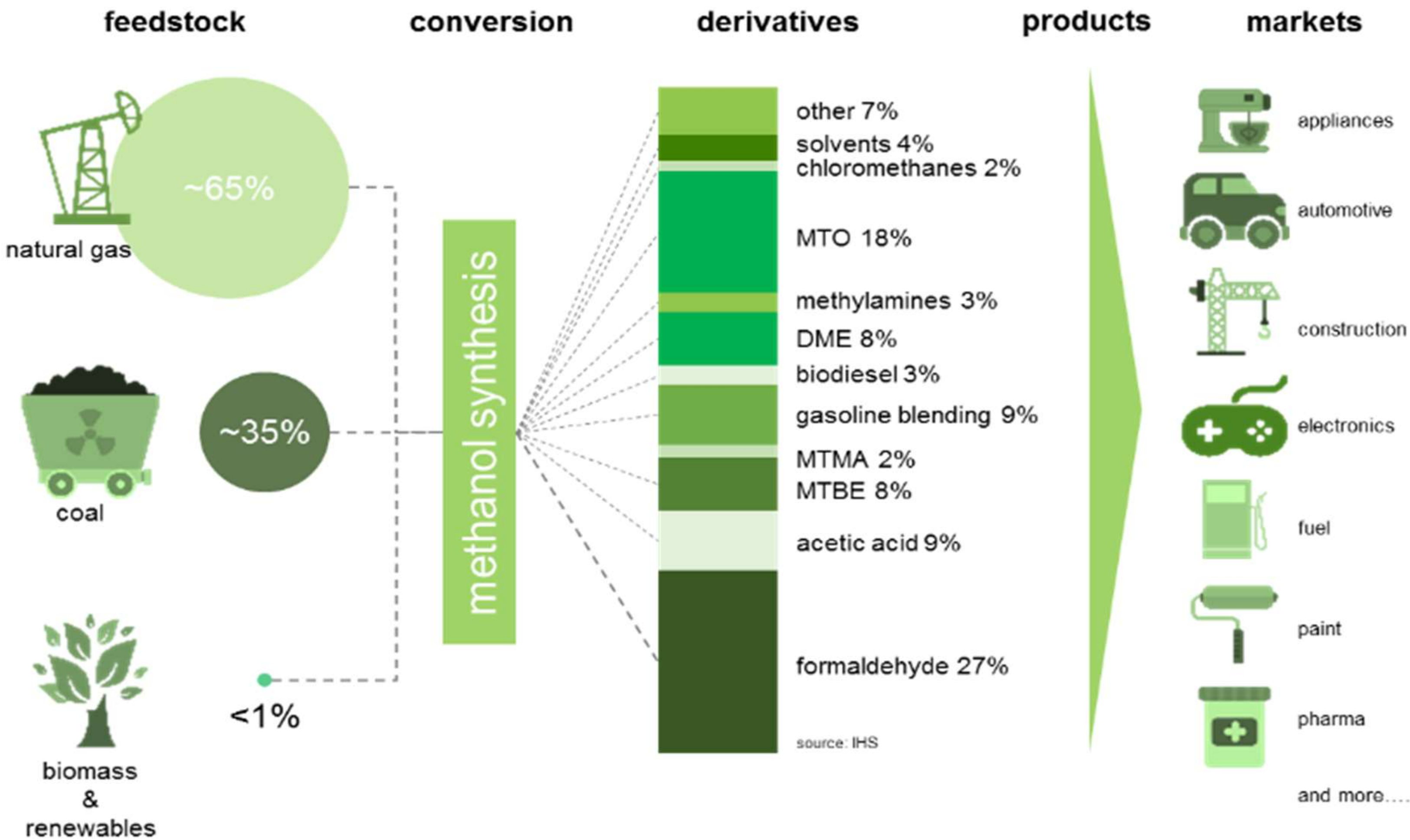
- **A slowly rising crude oil forecast drives little change in feedstock costs**
  - Industry incremental cash cost of production remains in a narrow band
  - Little opportunity to “driveup” the floor price of the high cost producer increment

- **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

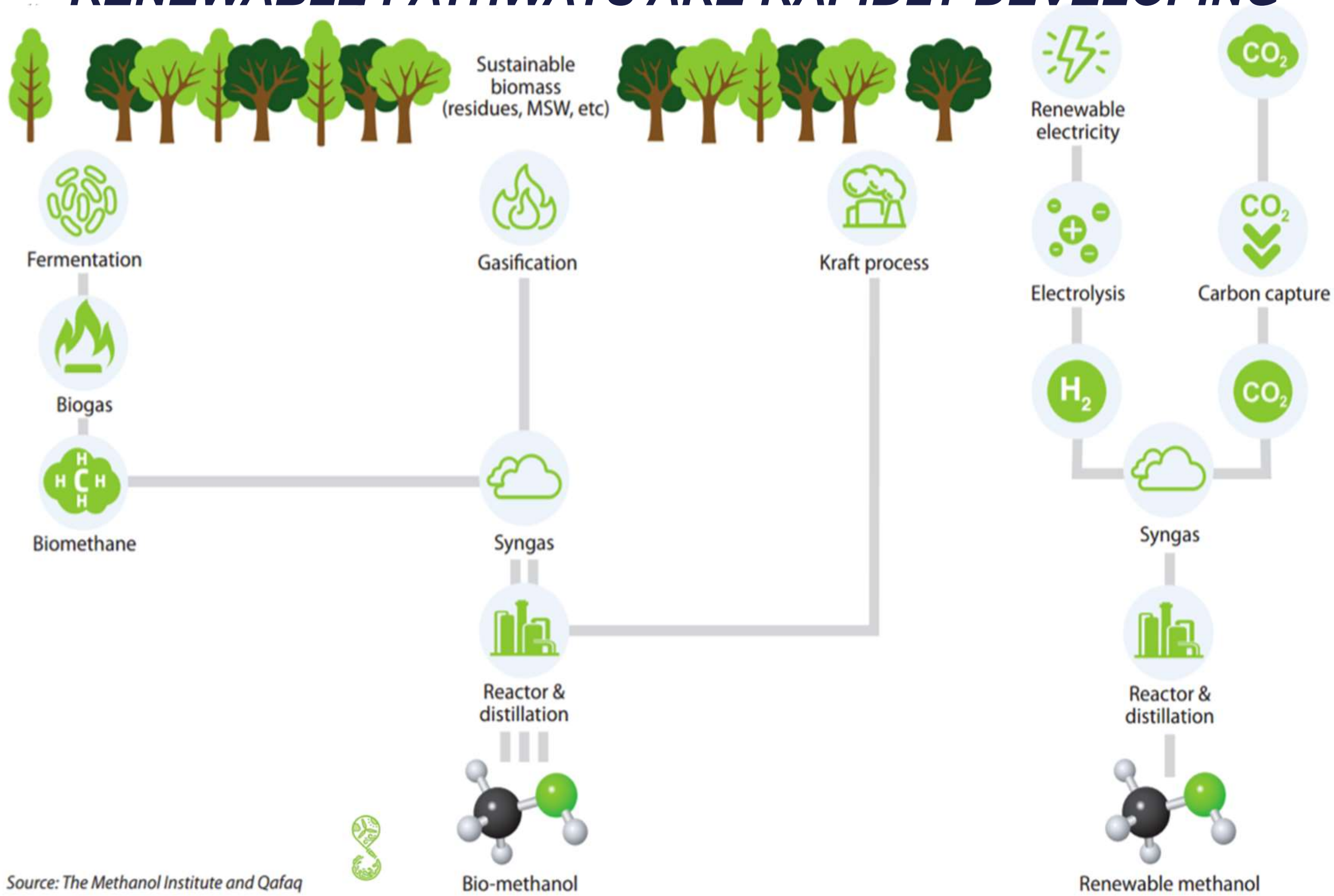
Source: Argus



BROAD FEEDSTOCK RANGE, MANY APPLICATIONS

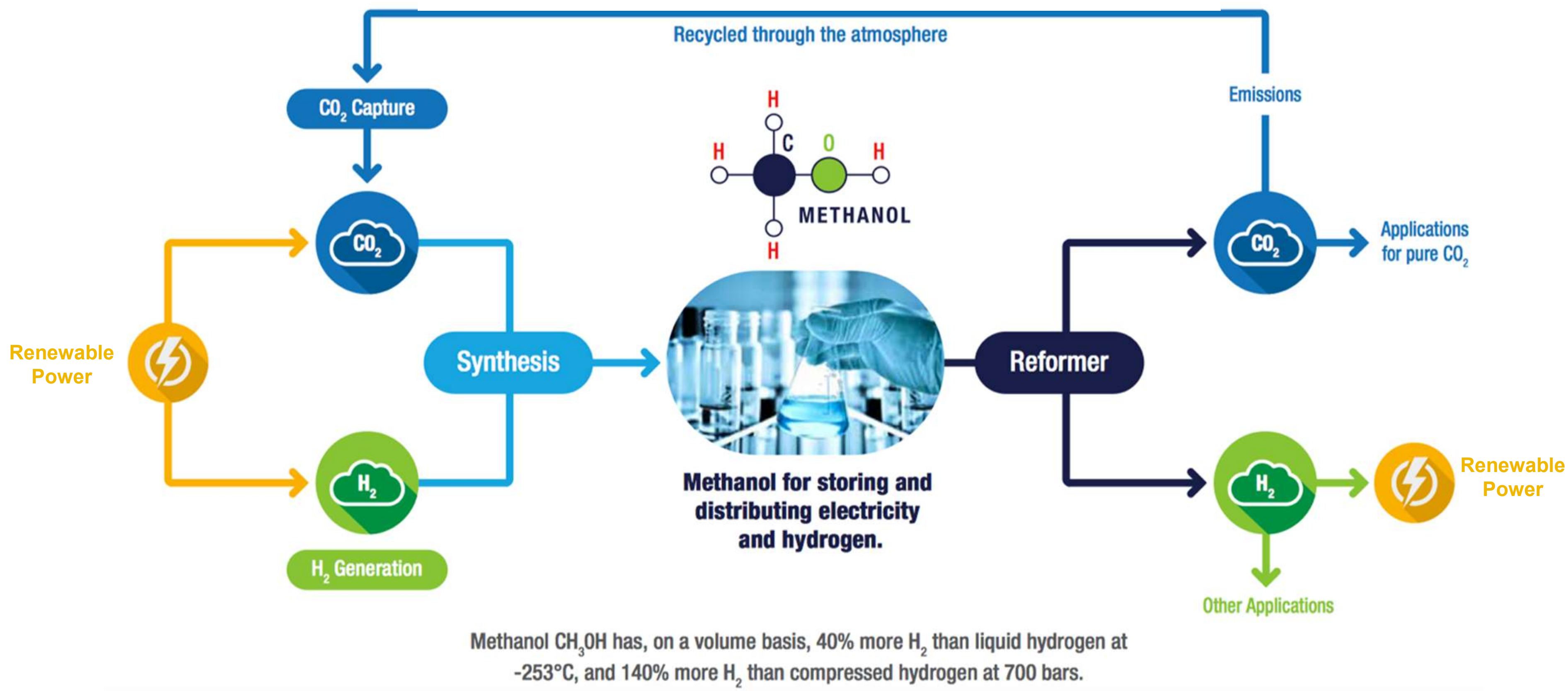


RENEWABLE PATHWAYS ARE RAPIDLY DEVELOPING



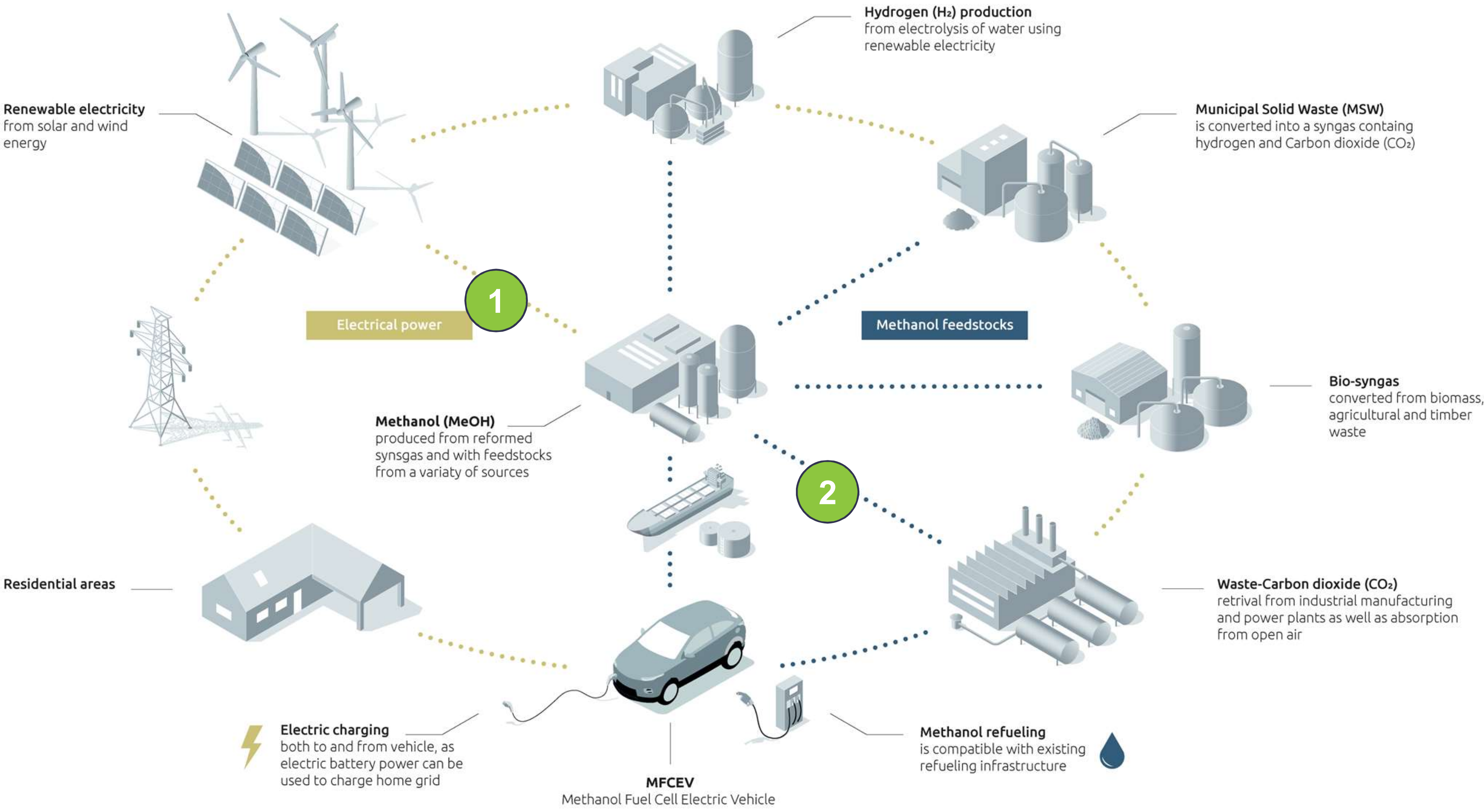
Source: The Methanol Institute and Qafaq

E-METHANOL: AN EFFICIENT ENERGY CARRIER



Source: Prof. SHIH Choon Fong, NTU, MI

E-METHANOL: IN PRACTICE



BROADLY, METHANOL IS…

- A 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, boilers and other power sources to methanol – minimal and economically viable without subsidies
- Widely available and alleviates many infrastructure and safety limitations both on land and at sea, trading within a narrower price range than competing fuels
- Not as well understood as a fuel, even though it has similar handling characteristics as distillate fuel

03

METHANOL: SAFE & AVAILABLE

HAZARD COMPARISON

	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 [illegible]	P201: Obtain special instructions before use P210: Keep away from heat/sparks/open flames/hot surfaces – No smoking [illegible]	P201: Obtain special instructions before use P202: Do not handle until all safety precautions have been read and understood [illegible]

Methanol classified as "not more dangerous" than other fuels such as gasoline or diesel – fuels largely familiar to most people

METHANOL POISONING CASE STUDY

Occupational Medicine, Volume 42, Issue 1, 1 January 1992, Pages 47–49, https://doi.org/10.1093/occmed/42.1.47
A. Downie ✉, T. M. Khattab, M. I. A. Malik, I. N. Samara
Published: 01 January 1992

Abstract

Methanol (CH_3OH) is a chemical feedstock of increasing importance as well as a commonly used solvent. In the early 1980s methanol production was introduced at a new petrochemical complex in the Saudi port of Jubail. A case is presented of a consultant supervising tank cleaning prior to methanol loading. He wore positive pressure breathing apparatus but no protective clothing. After 2–3 hours working in the confined space of the tank, he worked on deck and continued to wear his methanol-soaked clothing which eventually dried out. Visual symptoms of acute methanol toxicity presented some 8 hours after exposure. The appropriate treatment (with ethanol provided by the ship bond) was carried out in hospital and the individual recovered completely. Most reported cases of methanol toxicity are social in origin, arising from ingestion. This particular case, though unusual, does present some interesting lessons.

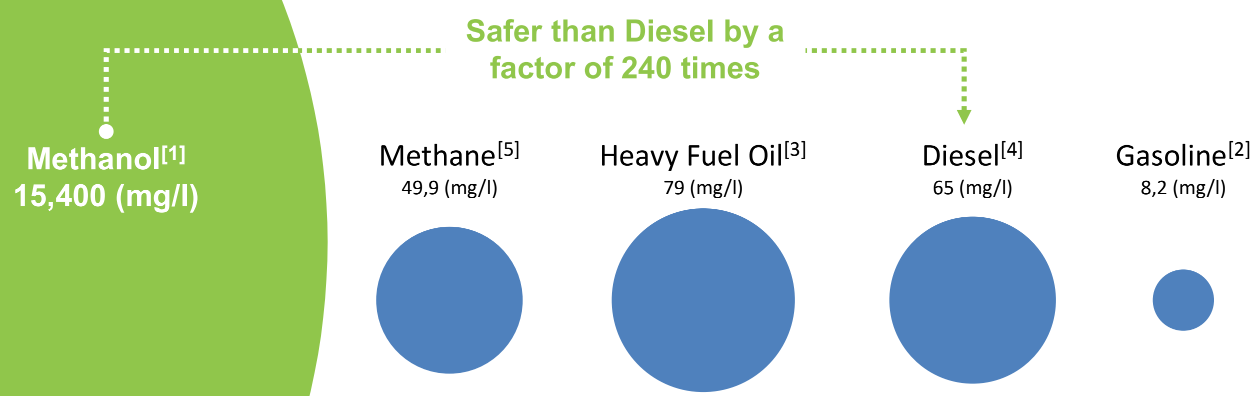
Easy and reliable treatment to full recovery with either ethanol (orally) or fomepizole (injected)

Source: Malcom Pirnie Inc

SAFER FOR THE ENVIRONMENT

LC50, LC = LETHAL CONCENTRATION FISH

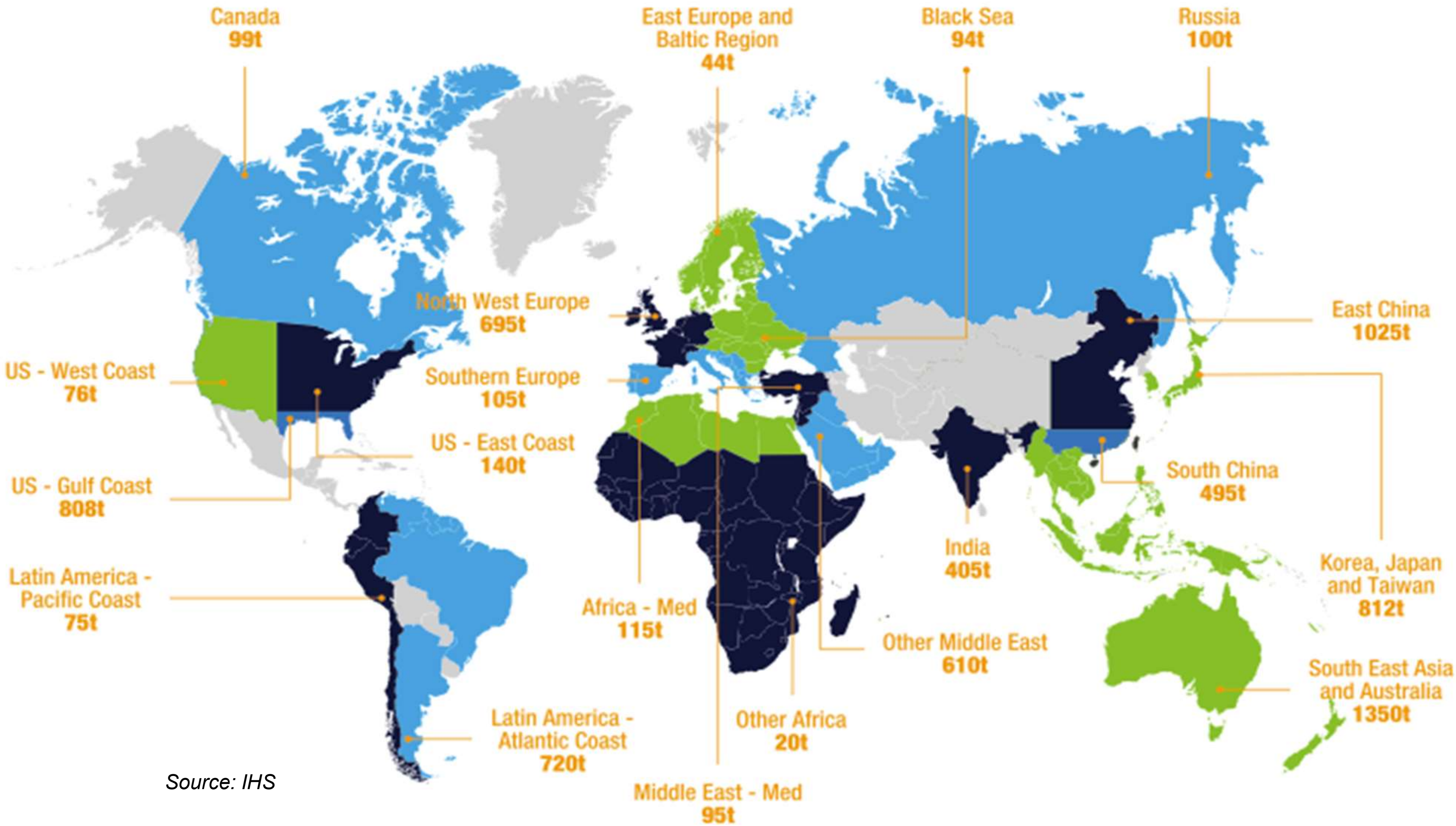
Concentration in water, at which half the marine population died within the specified test duration



[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

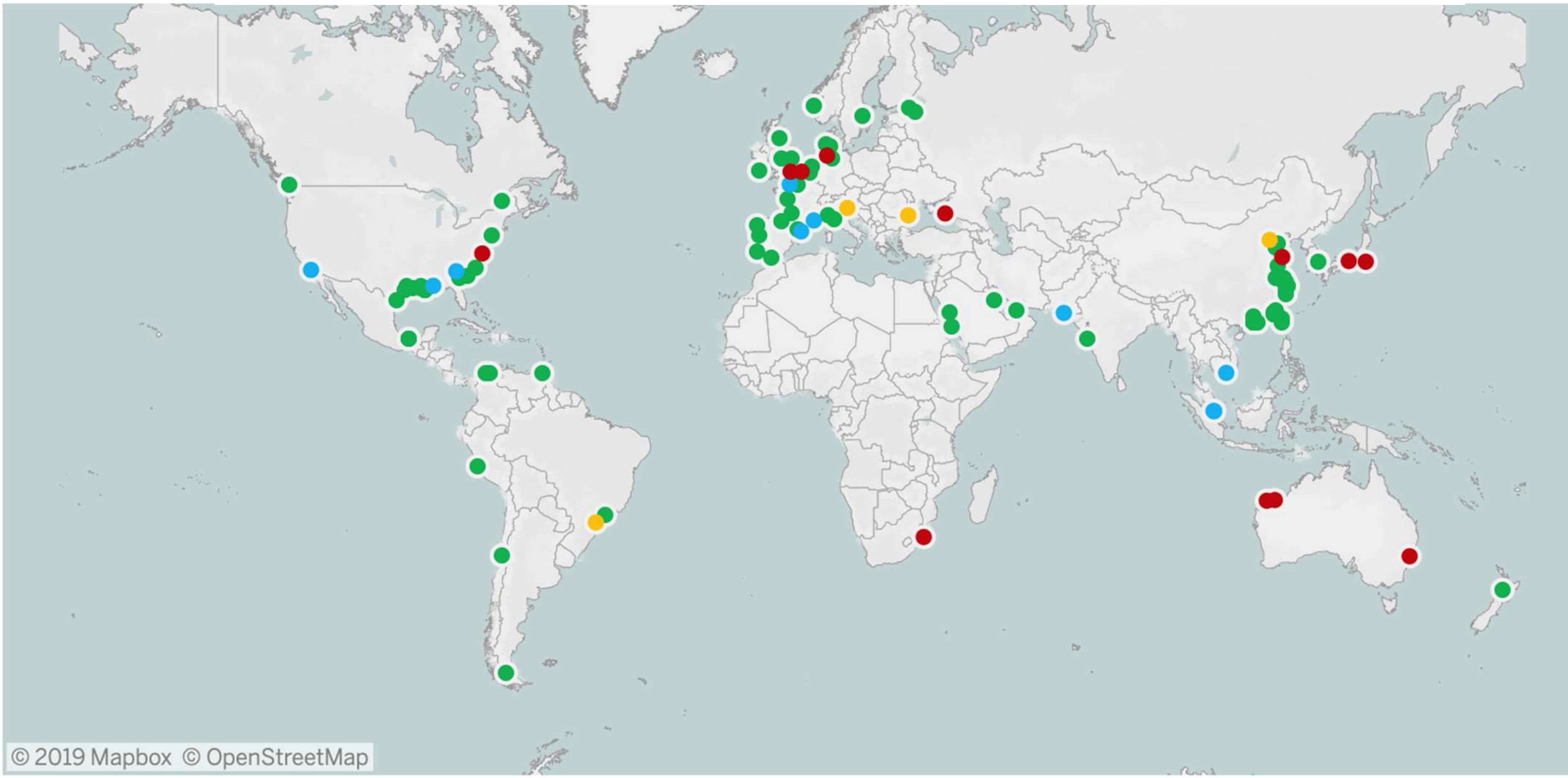
Additional Source: Meyer-Werft

METHANOL IS WIDELY AVAILABLE



Source: IHS

METHANOL AVAILABLE IN OVER 100 PORTS TODAY



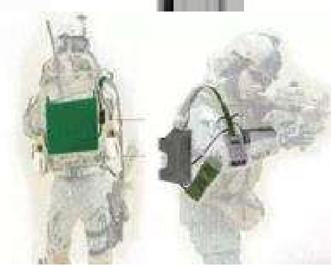
https://public.tableau.com/profile/quantzig#!/vizhome/MethanolAvailabilityDataTopGlobalMaritimePorts/MethanolFuelAvailabilityatPorts

04 METHANOL AS A HYDROGEN CARRIER

METHANOL: A HYDROGEN CARRIER FOR FUEL CELLS

- Blue World Technologies (Denmark)
- Palcan (China)
- Horizon Energy Systems (Singapore)
- Oneberry (Singapore)
- Altergy (USA)
- Serenegy (Denmark)
- SFC Energy (Germany)
- Toshiba (Japan)
- Ultracell (USA)
- e1 (USA)

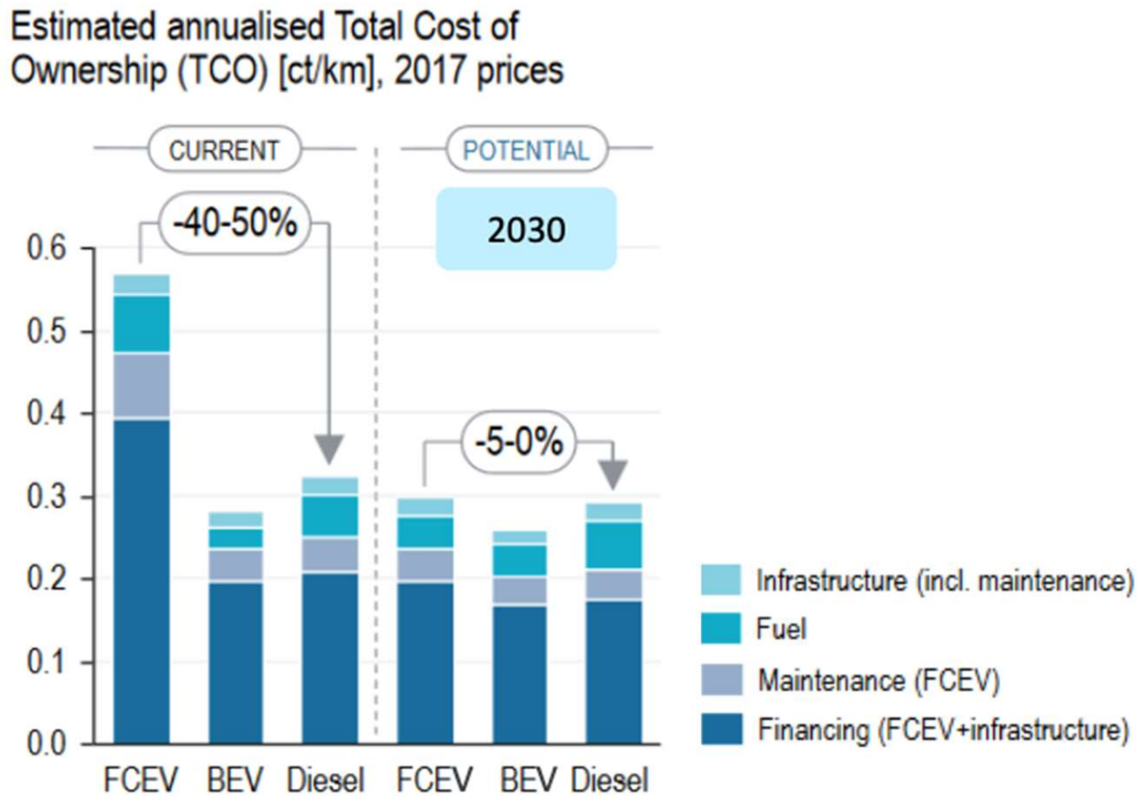



COST OF H_2 COMING DOWN BUT INFRA COSTS STILL HIGH

FC cars are projected to achieve cost parity with diesel at commercial production volumes at a H_2 cost of €5/kg

Clean H_2 as a feedstock can reach parity with fossil-based inputs once the cost of carbon is included



Adapted from "Development of business cases for Fuel Cell and Hydrogen applications for Regions and Cities", 2017, Roland Berger for the FCH-JU

CHINA FUEL CELL PIVOT

- March 2018: MIIT releases plans for hydrogen fuel cell promotion as “new energy vehicles”
- China now has just 1,500 FCVs and 23 hydrogen fuelling stations
- Targets: 2020 – 5,000 FCVs; 2025 – 50,000 FCVs; 2030 – 1 millon FCVs
- Pivot away from EV subsidies and moving support to hydrogen fuel cells
- Emphasis on commercial vehicles: buses & trucks, long-haul

HYBRID INNOVATION: AIWAYS/GUMPERT RG 'NATALIE'

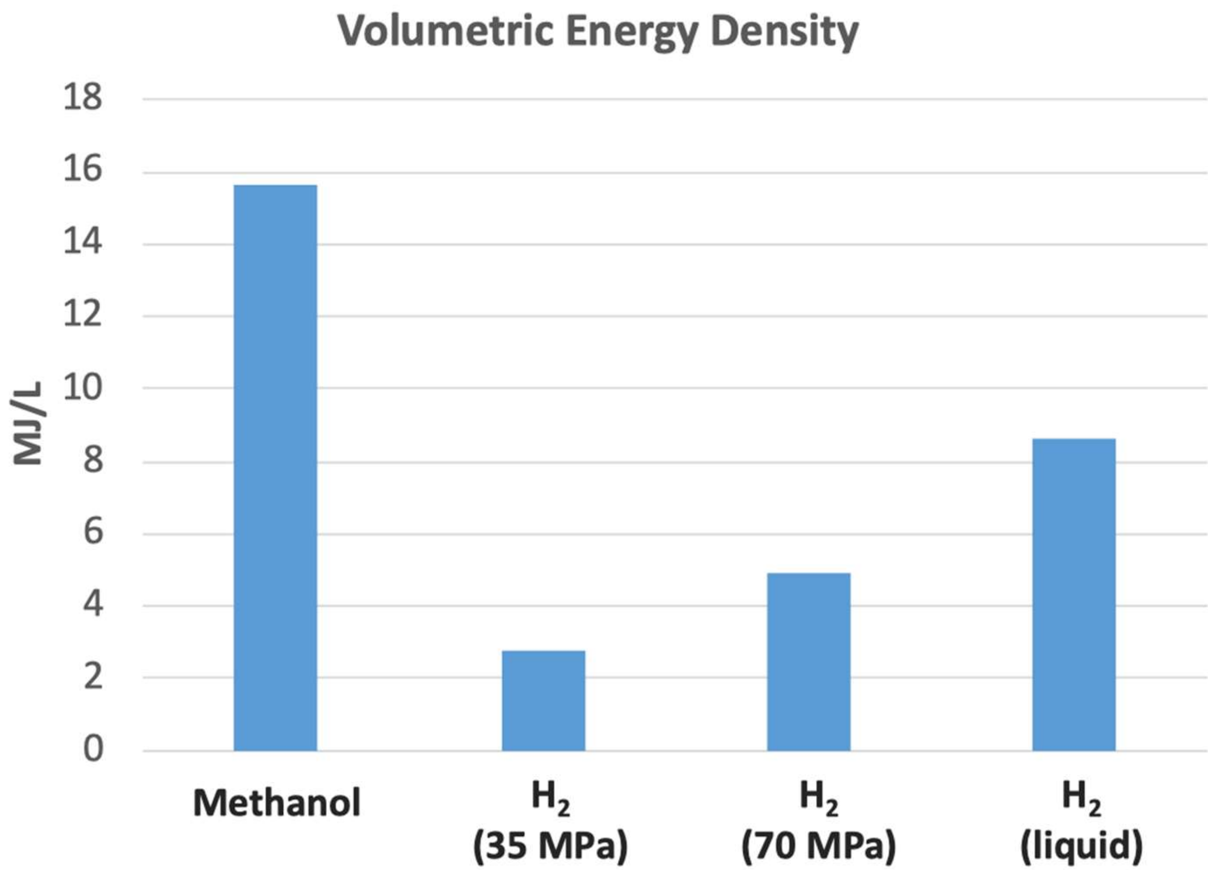
- AIWays: Gumpert RG Nathalie
- Reformed Methanol Fuel Cell electric supercar
- 1,200 km range
- top speed 300 kph

METHANOL ENERGY DENSITY

- High density H_2 storage remains a significant challenge for transportation solutions

- Storage options typically require large-volume systems that store H_2 in gaseous form

- On a volume basis, methanol has almost 6X the energy density of compressed H_2 (350 bar or 35 Mpa)



Source: MI, e1

ON-BOARD H_2 GENERATION FOR MARINE VESSELS

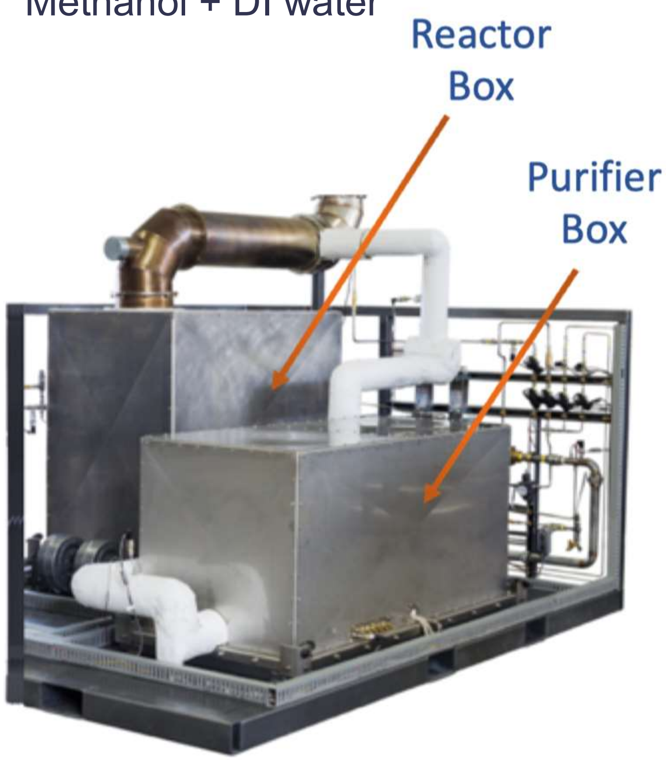
- **Storing compressed H_2 onboard a vessel requires 15X more space than liquid methanol paired with a hydrogen generator**

1 MW for 1 day	
Compressed Hydrogen	309 m^3
Liquid Methanol + M-Series	20 m^3

1 MW for 10 days	
Compressed Hydrogen	3,090 m^3
Liquid Methanol + M-Series	200 m^3

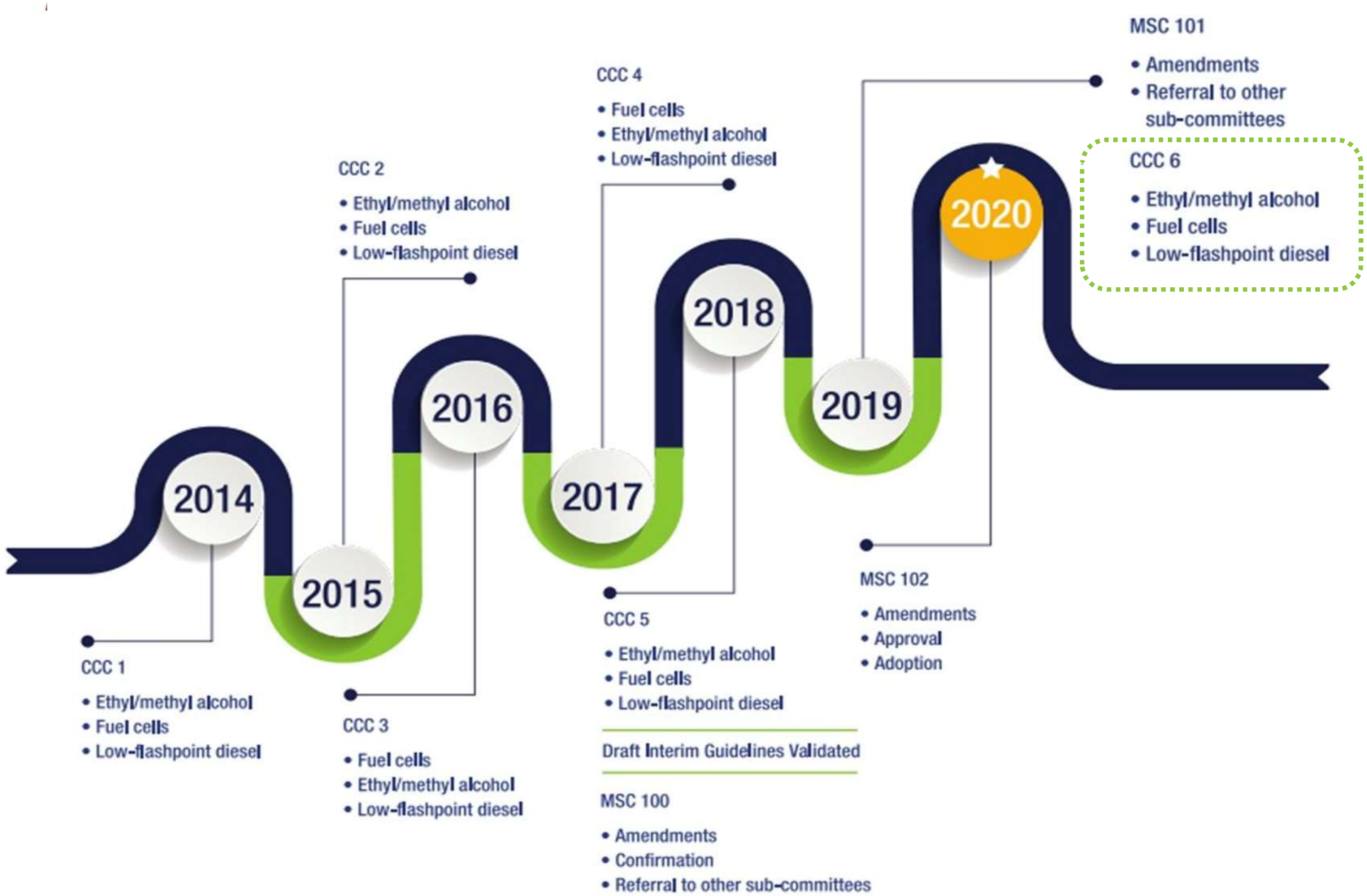
Source: e1

- **Mature technology:** 20 years, multiple lines
- **Scaleable:** to 300kW
- **>99.97% purity:** <0.2ppm CO & CO_2
- **Feed:** Methanol + DI water



05 METHANOL BUNKERING

PROGRESSION OF GUIDELINES FOR METHANOL



METHANOL FUELLED VESSELS AND PILOTS






	DUAL FUEL			FUEL CELL		PROJECT | R&D
Quantity	7 + 4	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	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	retrofit	retrofit	retrofit	new build & retrofit

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

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

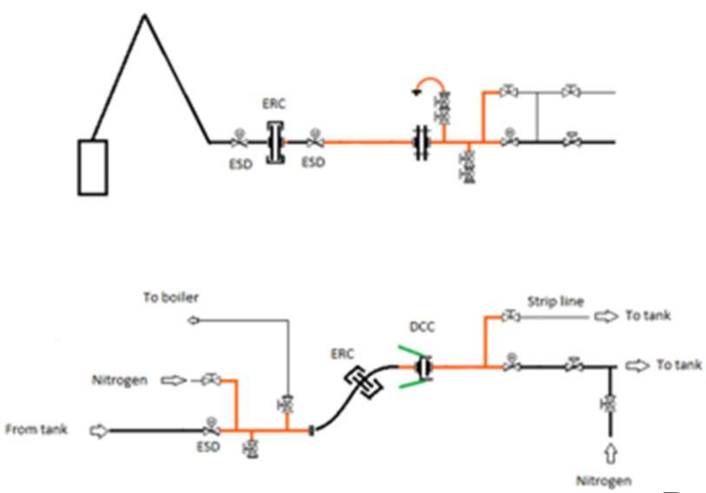
BUNKERING TECHNICAL CONSIDERATIONS

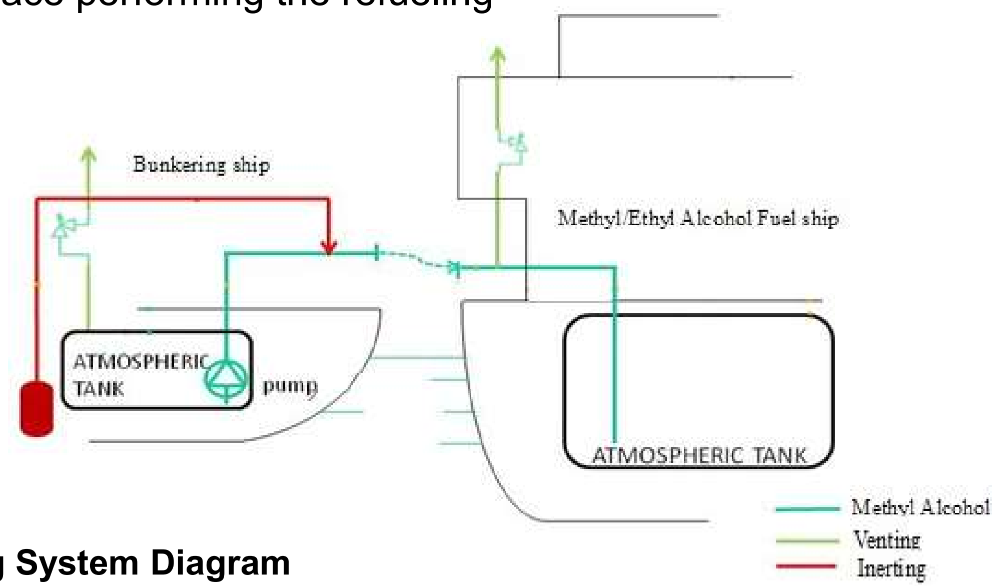
- **Refueling station**
  - Refueling station should be located on open deck for natural ventilation
  - There should be a device for safe disposal of leaked fuel, and skirting and collection tray below the joint for safe collection
  - Monitor and control the refueling from a safe location (equipped 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

- **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

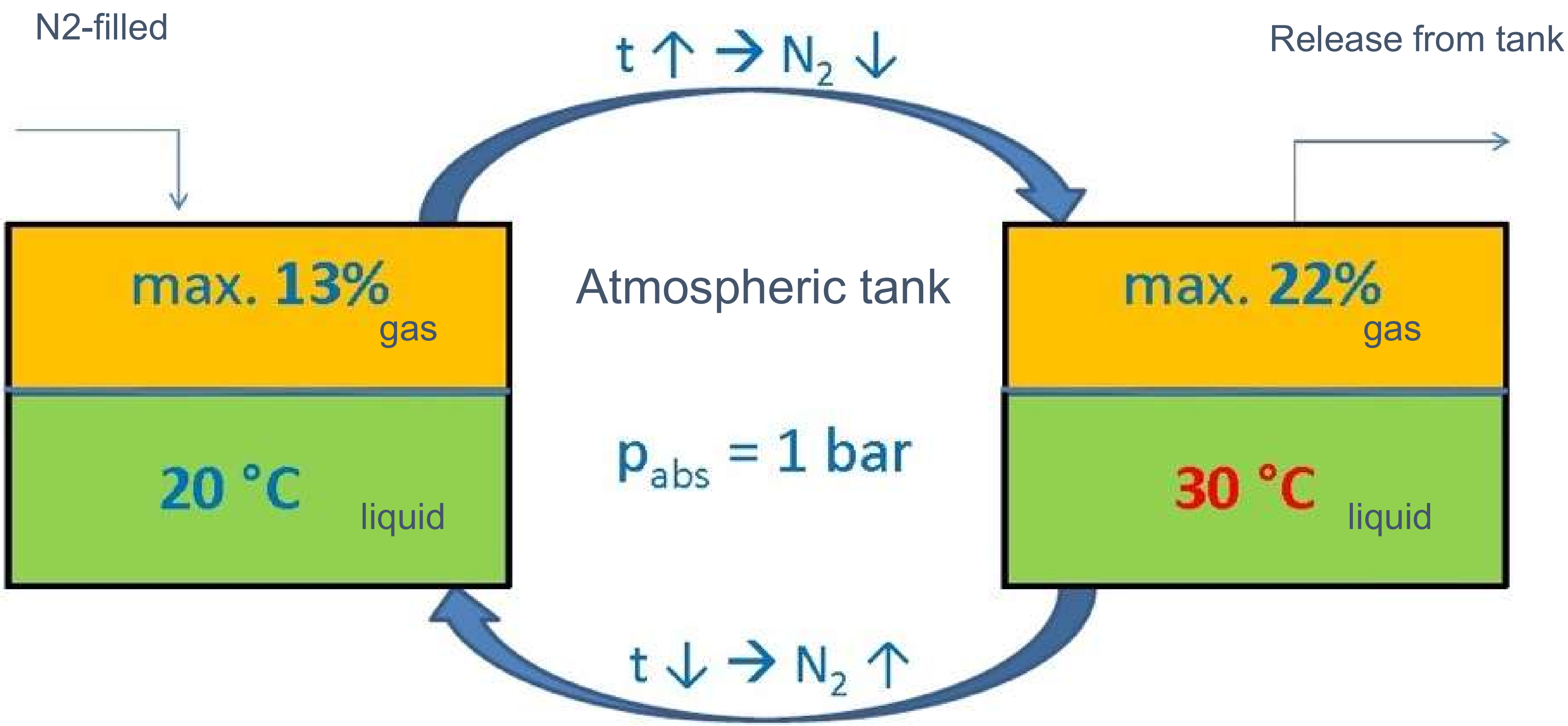




Refueling System Diagram

FUEL STORAGE

Proportion of gaseous methanol depends on the rate of evaporation



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

SUMMARY

- Physical characteristics of methanol are highly competitive or surpass other alternative fuels, across a range of applications
- Application design, whether retrofit or new build are simple, advantageous, practical and understandable – whether for ships, boilers, kilns, or cars
- Compelling emissions reduction properties in all cases
- Superior Life Cycle Analysis (LCA) advantage when combined with CCI technology or when renewably produced
- Infrastructure is a key enabler for methanol's uptake as a fuel due to storage and handling being no more complicated than other liquid fuels
- More visibility over long-term pricing than competitive fuels

THANK YOU

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