Methanol: A Future Proof Fuel

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14th Annual Marine Money Hong Kong Ship Finance Forum

Renaissance Harbour View Hotel, Hong Kong

March 28th, 2023

Singapore | Washington | Brussels | Beijing | New Delhi

Why Methanol

Carbon Neutrality

Pricing

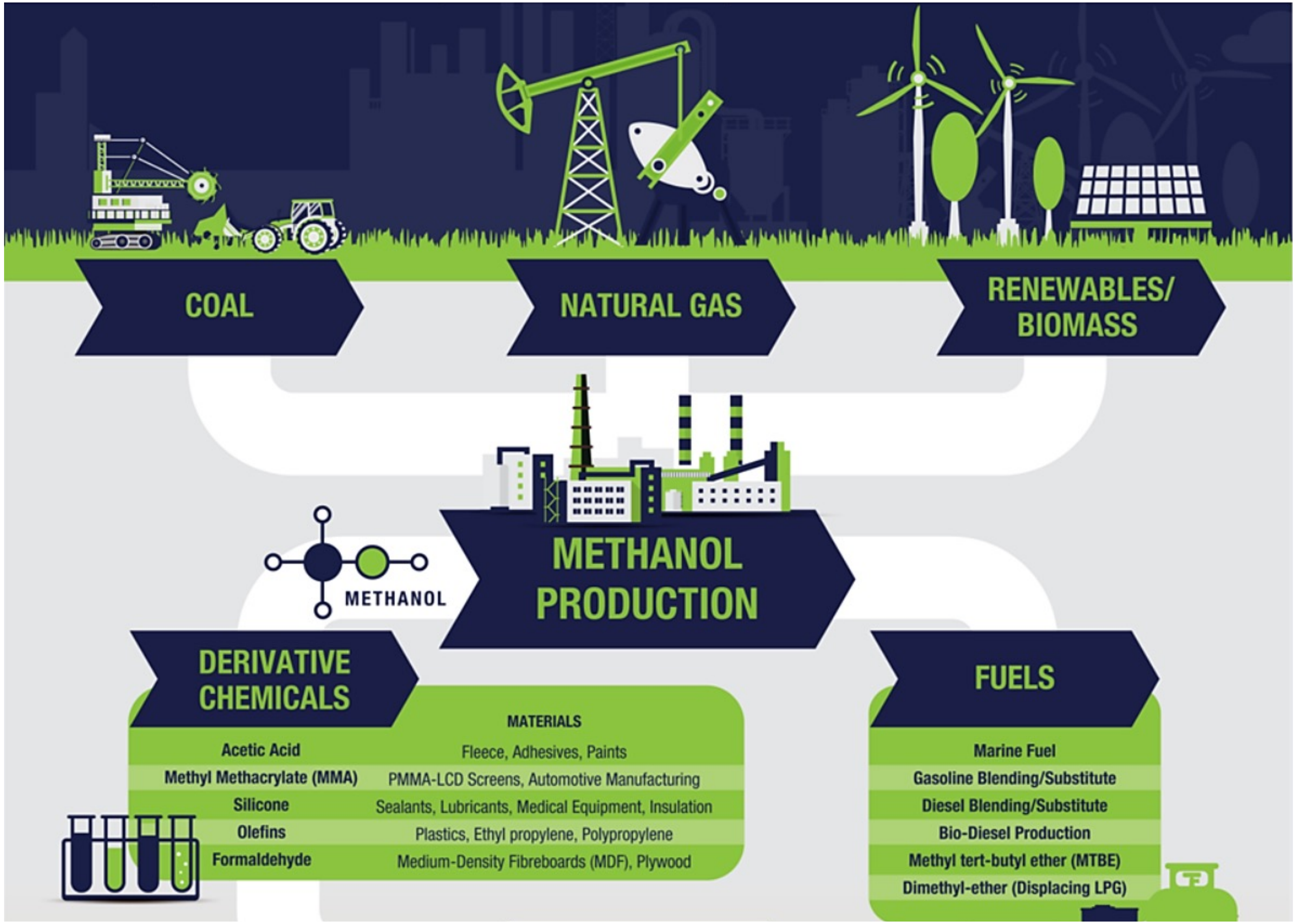
Design

Bunkering

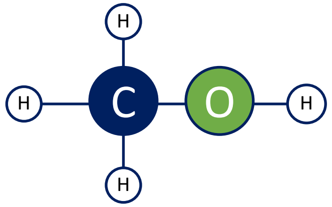
Standards

Why Methanol?

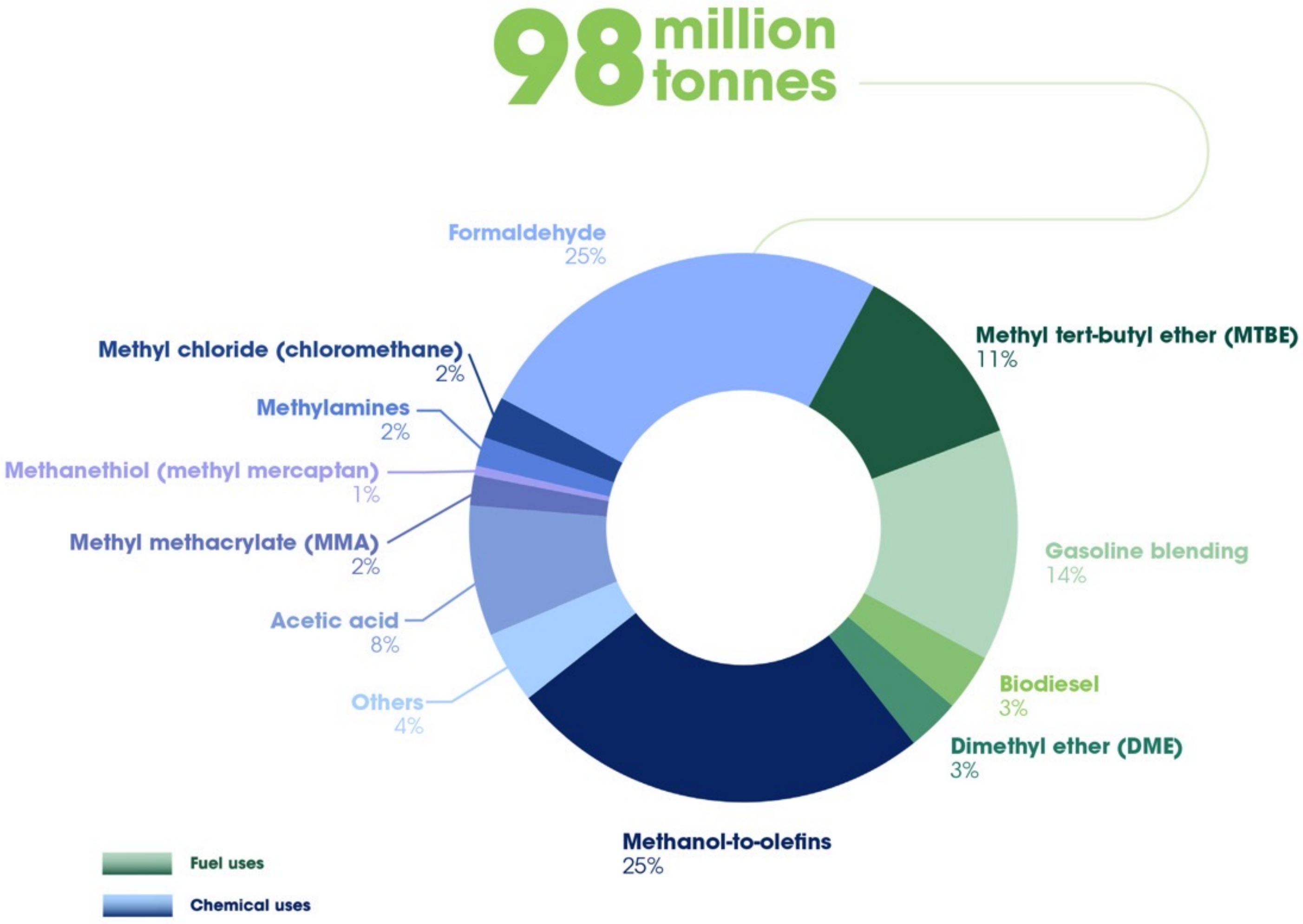
Feedstocks & Markets



- Natural gas is still the predominant feedstock for the methanol industry ex-China
- Increasing number of projects utilize sustainable feedstocks such as captured CO_2 from industrial emitters and green hydrogen produced from municipal solid waste (MSW), forestry residues or agricultural waste
- Conventionally methanol goes into the production of **downstream chemicals** (~55% of global consumption)
- Increasingly, the fastest growing segment is where it is consumed as a **fuel,** in numerous applications (~45%)



Demand



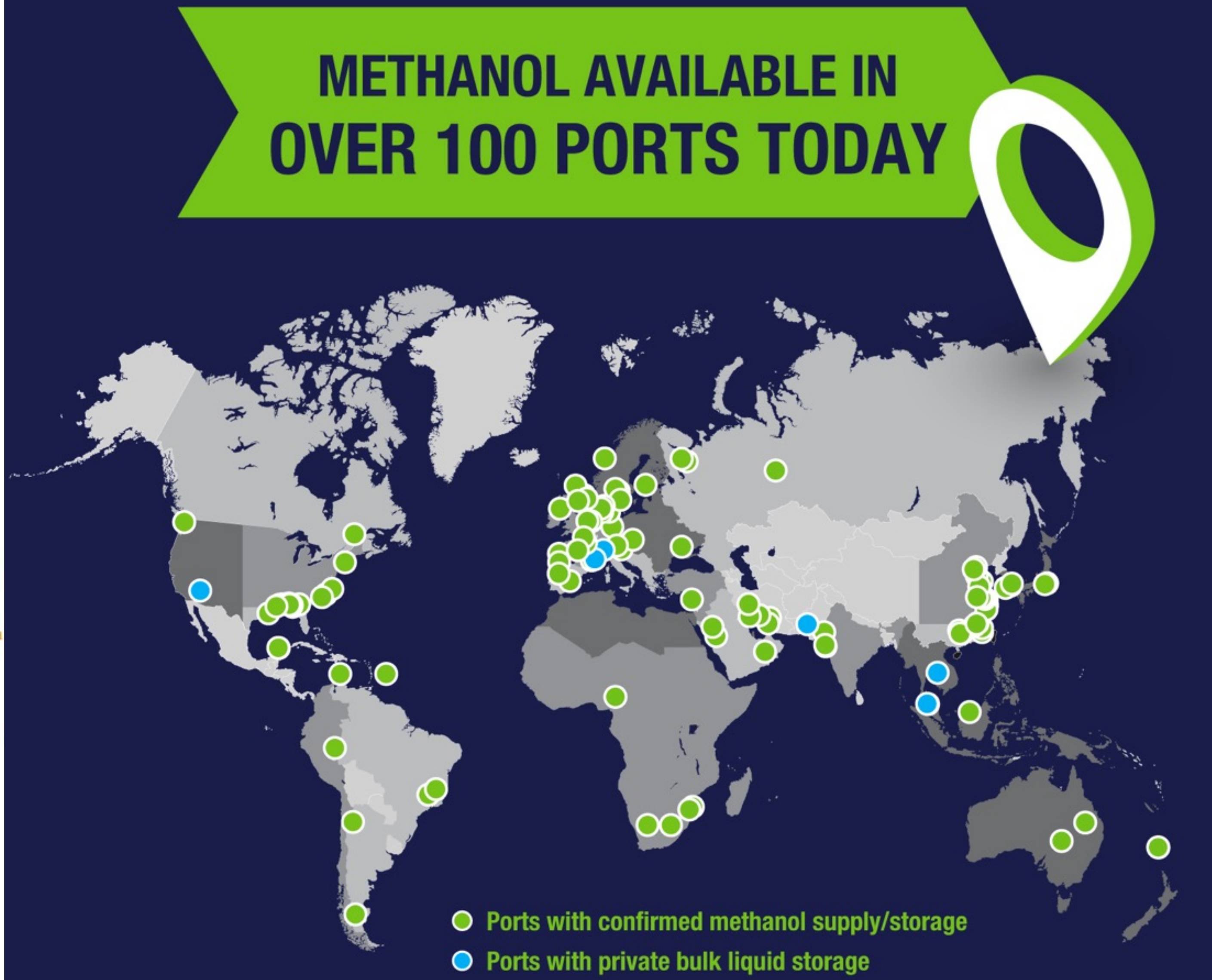
Source: *Based on data from MMSA (2020)*

- Demand and Supply have largely been in balance over the past 20 years
- ~32M mtpa traded internationally
  - China imports >10M mtpa
- Broad sub-vertical markets across both chemicals and fuel applications means
  - Less price volatility
  - Predictable supply
  - Consistent quality

Availability

ESTABLISHED TRADING HUBS

- Efficient break bulking, swaps, blending
- Transparent price assessments
- Standards and safe handling
- Lowers entry costs

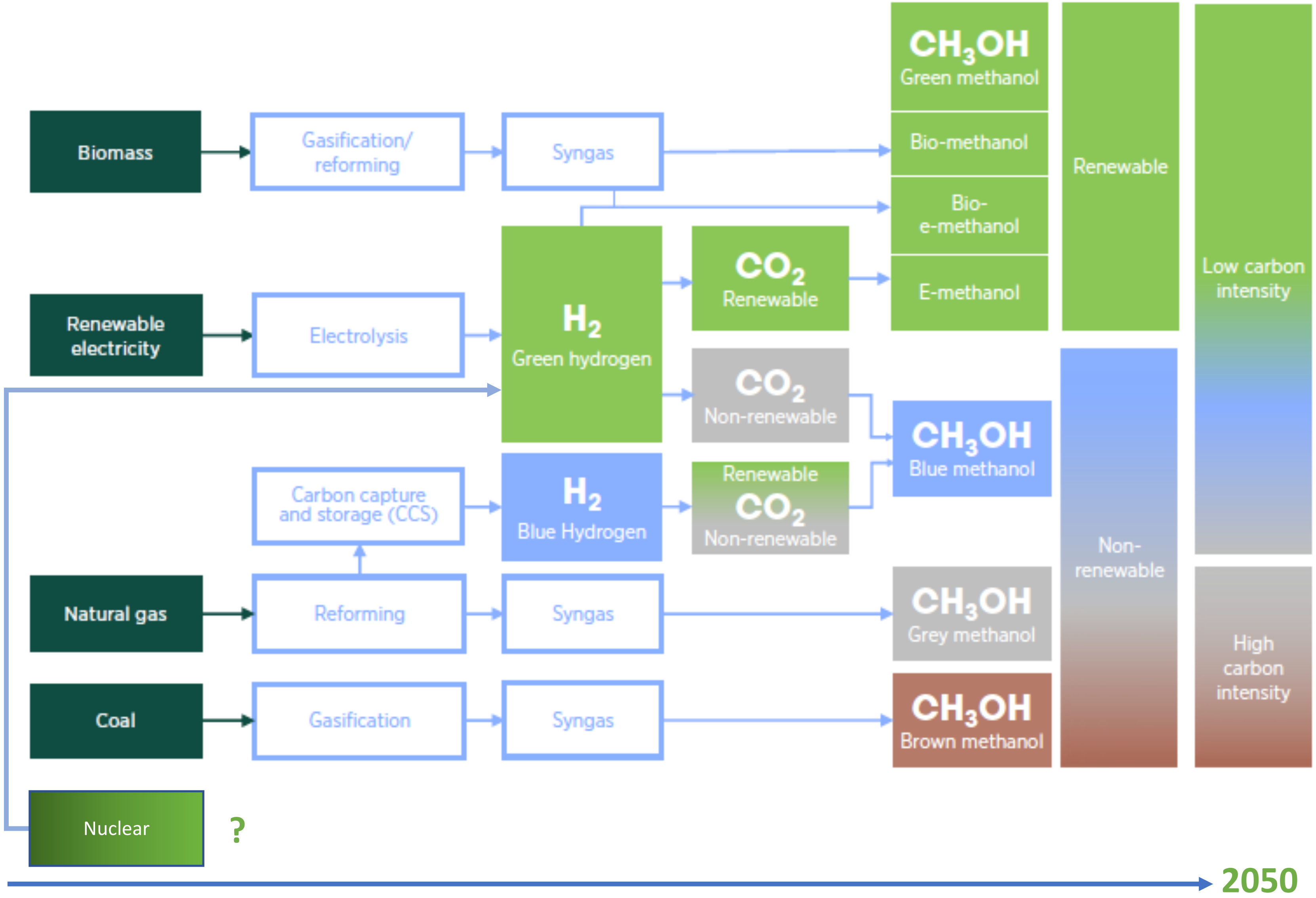


Carbon Neutrality

Transitional benchmarking & scaling

Year	Targeted reductions relative to reference year
2020	Reference year
2025	↓ 2%
2030	↓ 6%
2035	↓13%
2040	↓26%
2045	↓59%
2050	↓75%

Sources: IMO, IRENA



Renewable fuels play a critical role

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A 1.5° C Scenario featuring 80% decarbonisation is based on four key measures

Renewable Fuels

1. Indirect electrification via e-fuels
   - ➢ **60% decarbonization**
2. Direct employment of advanced biofuels
   - ➢ **3% decarbonization**

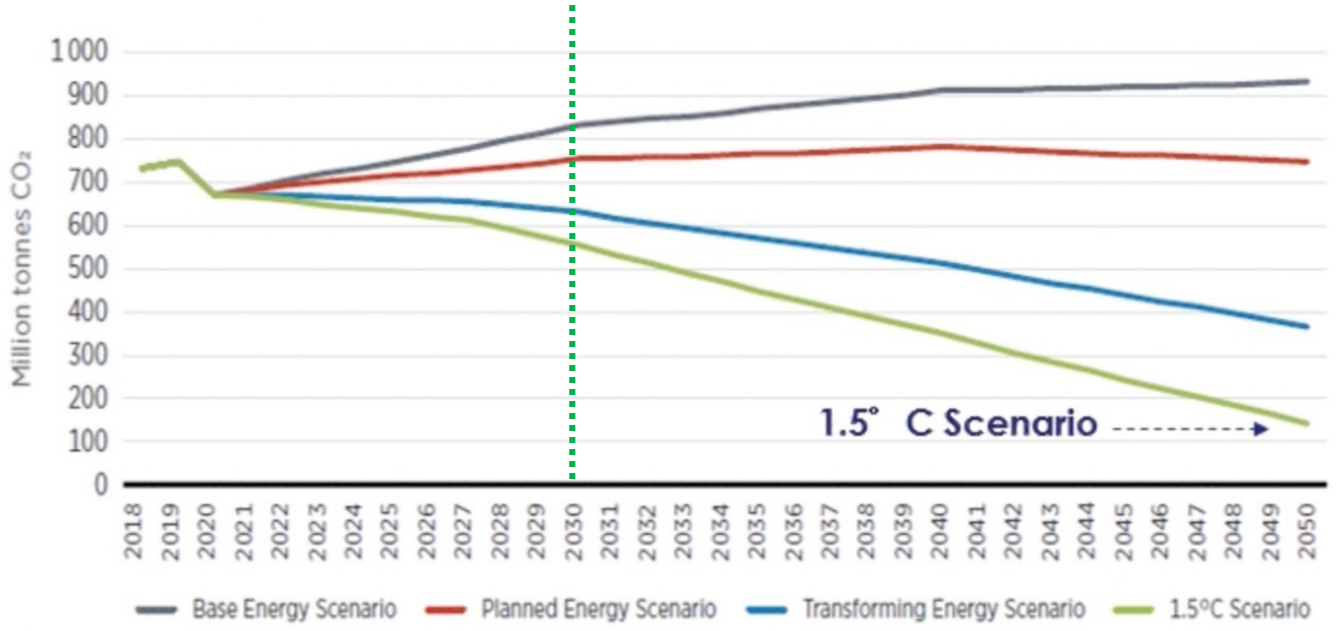
Energy Efficiency

3. Improvement of vessels' energy efficiency
   - ➢ **20% decarbonization**

Systemic changes in global trade dynamics

4. Reduction in final energy due to sectoral activity changes (reduced oil demand, circular economy)
   - ➢ **17% decarbonisation**

Comparison of CO_2 emissions associated with each scenario, 2018-2050



IRENA 2022

Options: Compliancy vs Competitiveness

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EVOLVING POLICY

Reduce energy consumption

LOGISTICS AND DIGITALIZATION
- Speed reduction
- Vessel utilization
- Vessel size
- Alternative routes

>20%

HYDRODYNAMICS
- Hull coating
- Hull-form optimization
- Air lubrication
- Cleaning

5%-15%

MACHINERY
- Machinery improvements
- Waste-heat recovery
- Engine de-rating
- Battery hybridization

5%-20%

$$$$$

Low-carbon energy

FUELS AND ENERGY
- LNG, LPG
- Biofuels
- Electrification
- Methanol
- Ammonia
- Hydrogen
- Harvesting from the surroundings

0%-100%

$$$$$

Clean up exhaust

AFTER TREATMENT MEASURE
- Carbon capture and storage

>30%

$$$$$

Source: DNV, MI

Potential pathway ahead

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Focus: Present
Energy Efficiency

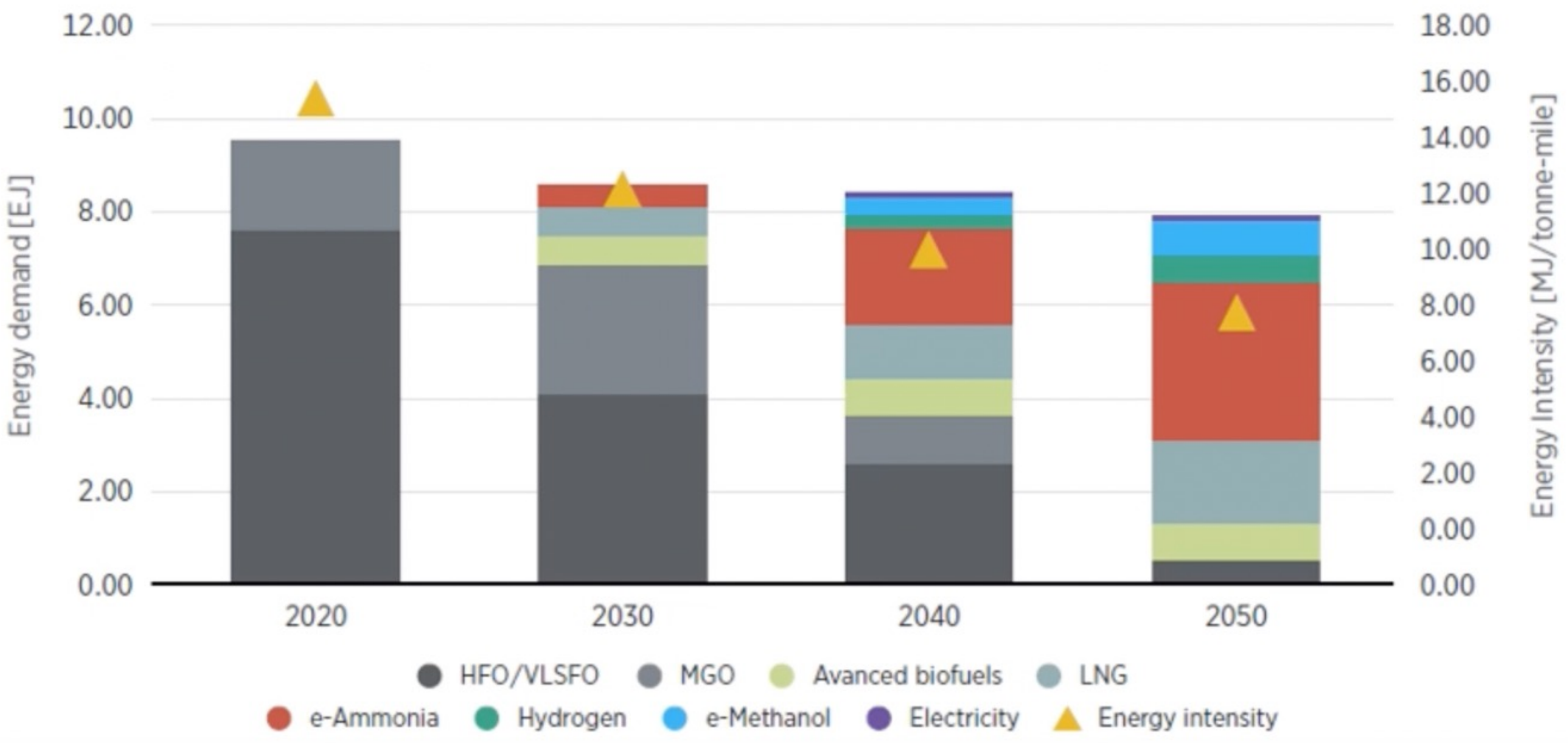
Focus: Short-Term
Biofuels/Renewables

Focus: Mid- to Long-Term
Reduced carbon and carbon neutral, “hydrogen dense” fuels are pivotal to maritime decarbonisation

By 2050, shipping will require a total of **46 MMT of carbon neutral hydrogen** for e-fuels production

- 73% e-ammonia
- 17% e-methanol 8M mt
- 10% liquid H_2

1.5° C scenario energy pathway, 2018-2050



Based on current technology, this equates to **500GW of electrolyser and 1,000 GW* of renewable electricity** capacity

Source: IRENA 2020

***1GW** = *3.125 million PV panels (based on a silicon model panel size of 320 watts) or;*
333 Utility-Scale Wind Turbines (based on the average utility-scale wind turbine size of 3MW installed)

Pricing

Cost scenario

		Estimated Costs in USD		
		2015 – 2018	2030	2050
Cost of green H_2 (\$/t H_2) [a]		4000 – 8000	1800 – 3200	900 – 2000
Cost of CO_2 (\$/t CO_2) [c]		50 – 100	50 – 100	50 – 100
Cost of Methanol (\$/t MeOH) [b]	No Carbon Credit	870 – 1690	460 – 790	290 – 560
	Carbon Credit of \$50/t CO_2 [d]	780 – 1610	370 – 700	200 – 480
	Carbon Credit of \$100/t CO_2 [d]	700 – 1520	290 – 620	$\boxed{120 – 390}$

(a) Source: (IRENA, 2020)

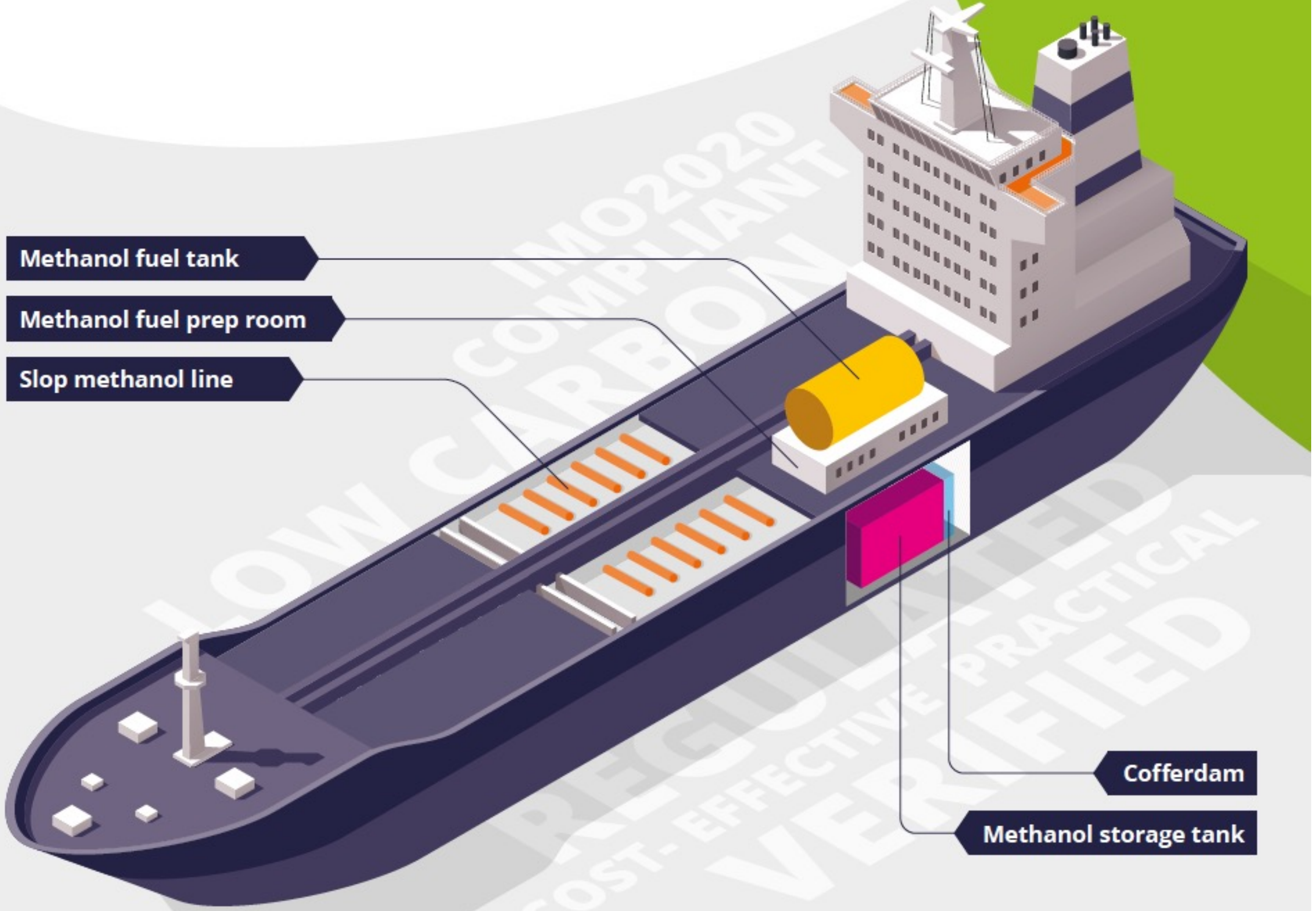
(b) assuming \$50 per ton synthesis cost for e-methanol once the raw material, H_2 and CO_2 are provided

(c) Origin of the CO_2 will change over time as volumes increase

(d) The carbon credit per ton of e-methanol is based on the difference between the average CO_2eq emissions from methanol production from natural gas (95.2 gCO_2eq/MJ) and average CO_2eq emissions from e-methanol production from renewable CO_2 and H_2 (8.645 gCO_2eq/MJ). Considering a LHV of 19.9 MJ/kg for methanol, this corresponds to a 1.72 tCO_2eq of emission avoided per ton of e-methanol, compared to traditional natural gas based methanol.

Design

Low Emission Advanced Products Tanker



Commercial

- A group of Industry Leaders joined forces to develop the **Low Emission Advanced Products Tanker (LEAP)** a standard design for a 50,000dwt Methanol-powered product tanker.
- The LEAP design has additional **newbuild costs of just 10%** compared to additional capex of 22% for LNG-dual fuel.
- Hyundai Mipo Dockyard, MAN Energy Solutions, and the Methanol Institute developed a design verified by DNV **that meets all prevailing safety requirements** with **no loss of range, neglible loss of cargo and low additional build costs**.

Technical

- Design features **Methanol fuel tank, fuel room and slop line with storage tank protected by cofferdam**.
- LEAP design provides an approximate **6% improvement in EEDI Phase 3 rating** compared to a diesel-only vessel.
- **No significant additional 'footprint' for the Methanol fuel system** as the service tank, methanol pipelines and methanol fuel supply room are located on deck.
- Cargo capacity is **54,000 cu m - a reduction of just 300 cu m or 0.5%** compared to a diesel-only vessel.

Environmental

- Using Methanol as fuel would have **CO_2 emissions of 54.7 tonnes per day** at service speed, compared to **64.7tpd for diesel,** even less with renewable or bio-methanol blends.
- Methanol as fuel has **no sulfur emissions, very low Particulate Matter – CO_2 emissions are 15% lower than conventional marine fuel oil**.
- Methanol can be **blended with water to meet IMO NOx Tier III** requirements removing the need for expensive exhaust gas treatment.

2016 the first Waterfront Shipping vessels entered service

Dalian Methanol DF VLCC


DNV

STATEMENT OF APPROVAL IN PRINCIPLE

Dalian Shipbuilding Industry Co., Ltd

COSCO SHIPPING Energy Transportation Co., Ltd

Concept Design of Methanol Fuelled VLCC


中国船级社

CHINA CLASSIFICATION SOCIETY

原则认可

APPROVAL IN PRINCIPLE

甲醇双燃料VLCC

Methanol Fuelled VLCC

大连船舶重工集团有限公司

Dalian Shipbuilding Industry Co., Ltd.

中远海运能源运输股份有限公司

COSCO SHIPPING Energy Transportation Co., Ltd.

MAIN PARTICULARS

Length over all	apprx.	332.95 m
Breadth		60.00 m
Depth		30.00 m
Designed Draught		20.50 m
Scantling Draught		21.80 m
Deadweight at Td		283,000 t
Deadweight at Ts		307,000 t

SPEED AND EEDI

Service speed	14.8 knots
EEDI	Phase III

CAPACITY

Cargo Tanks :	337,000 m^3
Ballast tanks:	99,000 m^3
Methanol tanks：	10,900 m^3
VLSFO tanks：	1,900 m^3
MGO tanks：	1,000 m^3

ENDURANCE (13.0 knots)

Cruising Range （MEOH）	23,000 NM

MAIN ENGINE

Type MAN 7G80ME-C10.5-LGIM-EGRTC

Feb 2022: Dalian Shipbuilding Industry Co., Ltd of CSSC and COSCO Energy Shipping received AIP from DNV and CCS

Dalian Methanol DF VLCC

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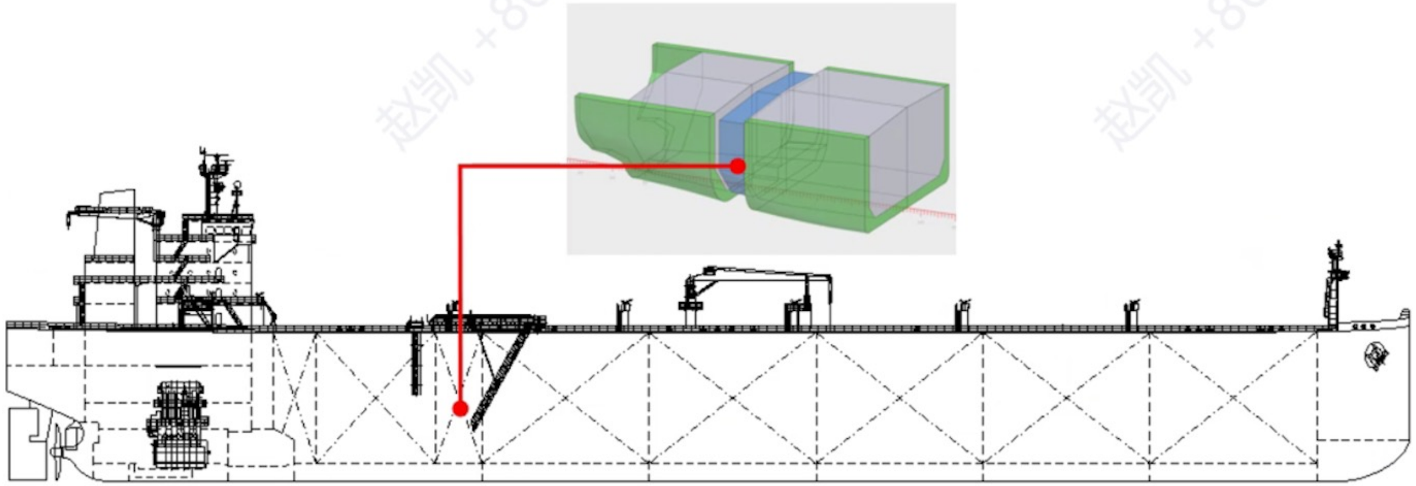


MAIN PARTICULARS

Length over all	apprx.	249.80 m
Breadth		44.00 m
Depth		22.50 m
Scantling Draught		15.35 m
Deadweight at Ts		115,000 t

CAPACITY

Cargo tanks (incl. slop tanks)	133,000 m^3
Water ballast tanks	39,000 m^3
Methanol storage tanks	4,000 m^3
HFO tanks	2,100 m^3
MGO tanks	800 m^3

MAIN ENGINE

MAN 6G60ME-C10.5 LGIM EGRBP

SPEED AND EEDI

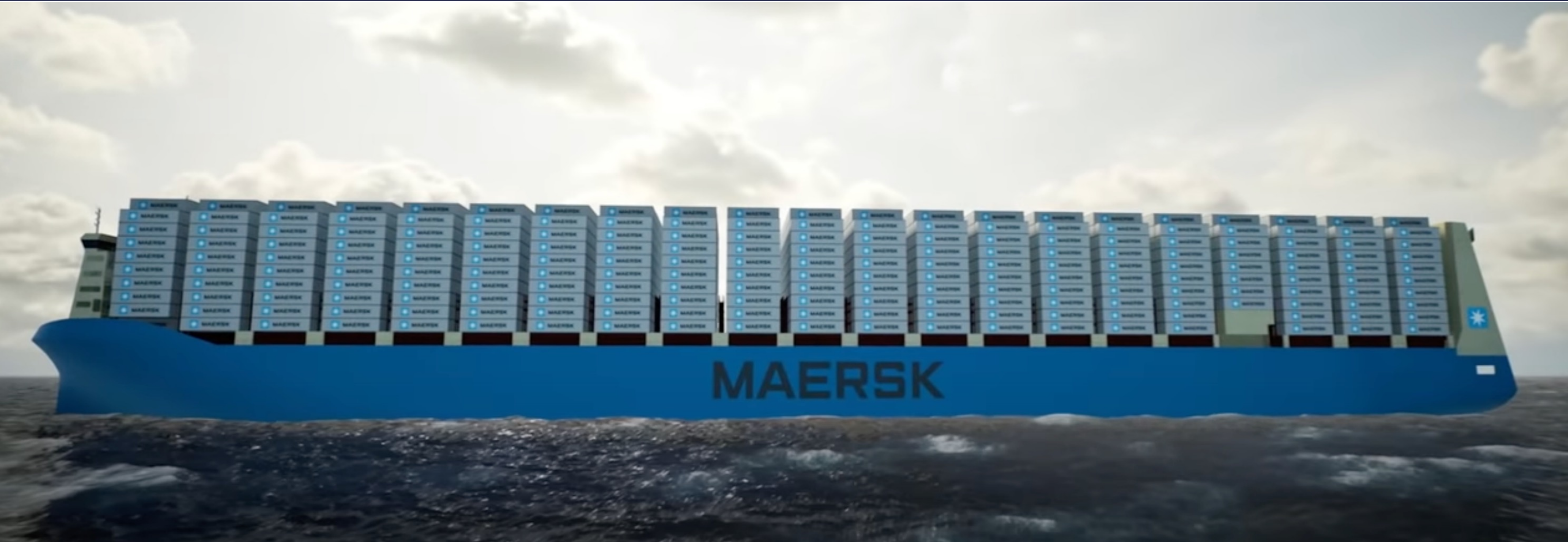
Service speed	14.5 knots
EEDI	Phase III

ENDURANCE (14.0 knots)

Cruising Range （MEOH） 16,000 nm

As of February, 2023 there are over 100 Methanol DF vessels on the order book of MAN

Maersk vessels

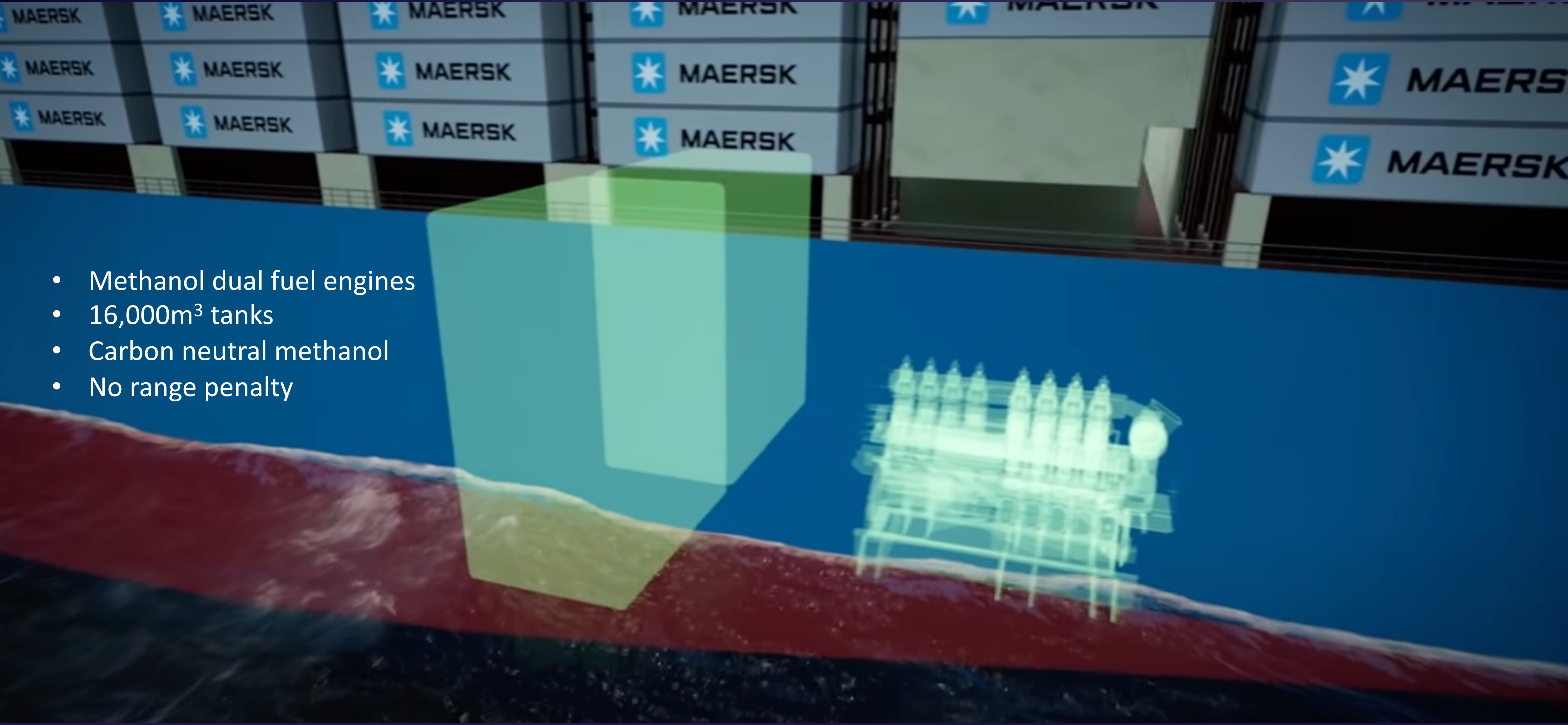


- 20% improved energy efficiency per transported container vs industry average

Maersk vessels

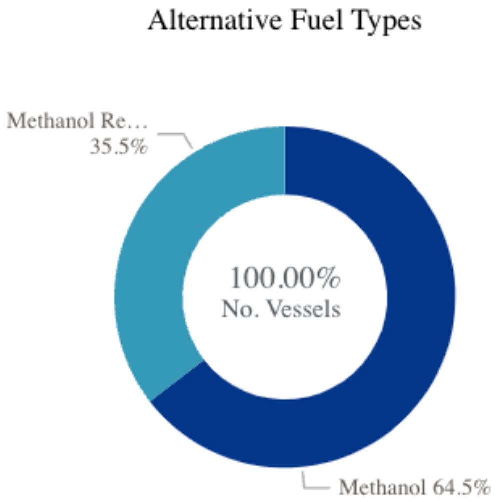
- Forward accommodation enables larger container capacity
- Separating accommodation and funnel improves port efficiency

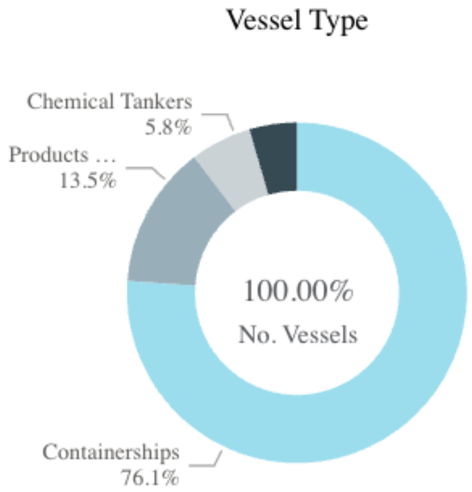
Maersk vessels

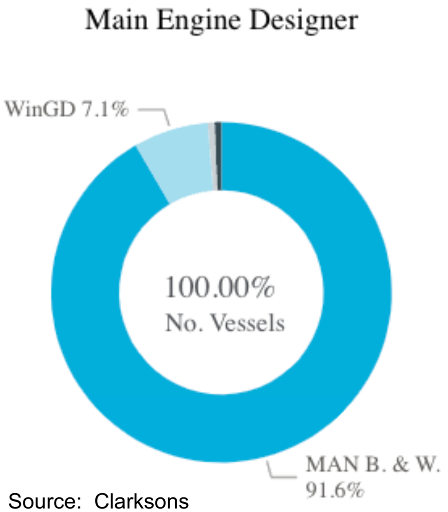


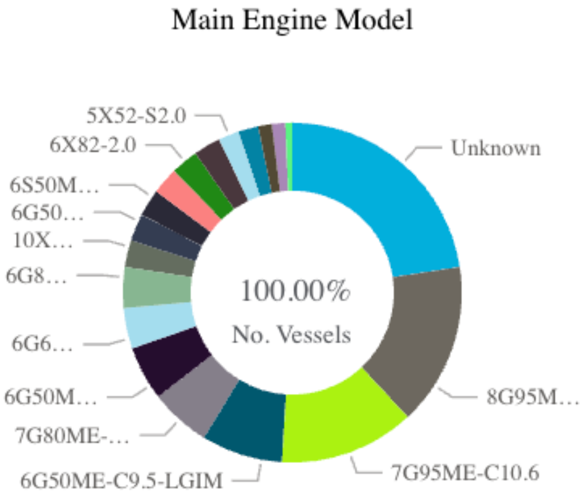
- Methanol dual fuel engines
- 16,000m^3 tanks
- Carbon neutral methanol
- No range penalty

Order book

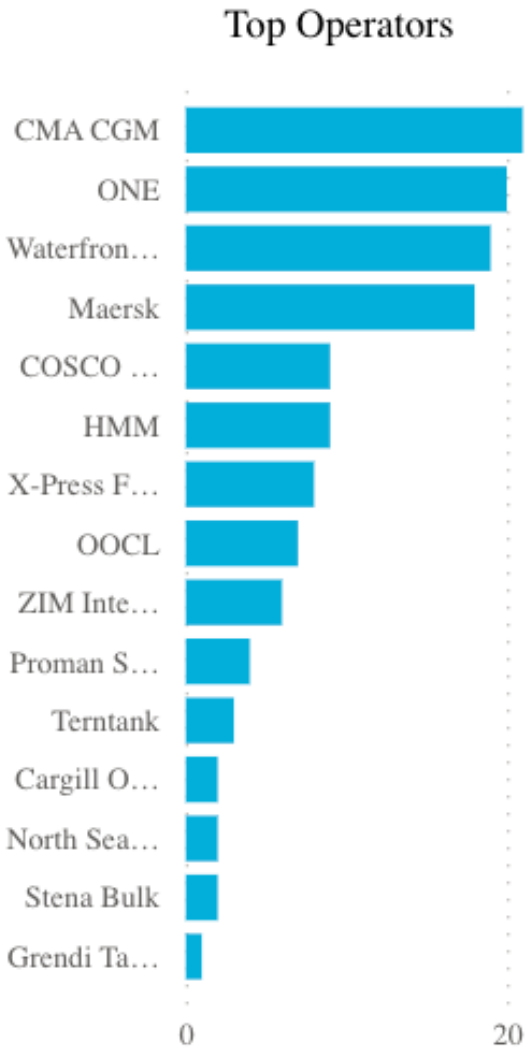








Source: Clarksons



Bunkering

Methanol bunkering demonstration

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- 300mt stem successfully delivered JUNE 2021
- Stem placed per LR/MI Methanol Bunkering TR
- Partners included:
  - Methanex
  - Port of Rotterdam
  - Vopak
  - NYK
  - TankMatch

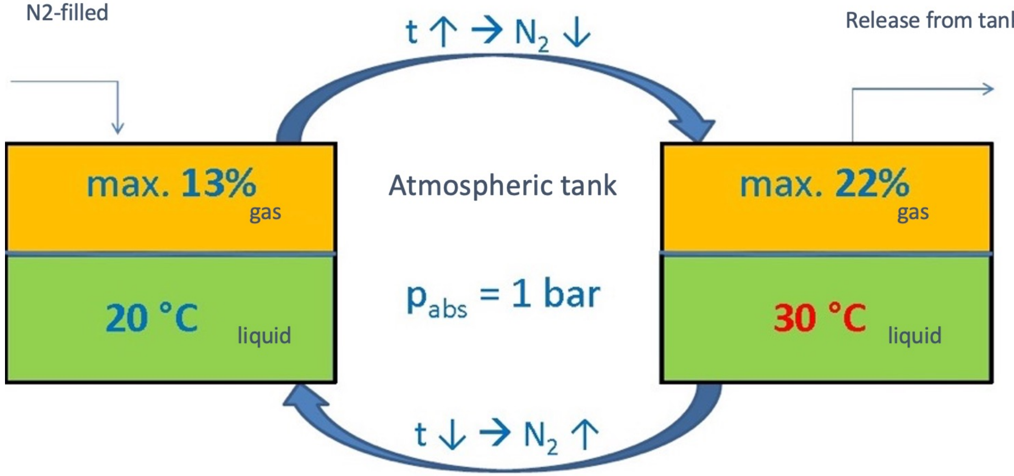
- Require more such demonstrations at leading ports
- Will support pilots and general uptake of methanol
- Ports of interest:
  - Antwerp, Rotterdam
  - Zhoushan, Ningbo
  - Singapore
  - Panama
  - Others

Methanol bunkering shore-to-ship

Refueling station

- Refueling station located on open deck for natural ventilation
- Collection facility for safe disposal of leaked fuel, and skirting with collection trays below couplings
- Monitoring and controlling the refueling from a safe location (equipped with overfill alarm and automatic cutoff to monitor bunker level and overfill) together with inerting and purging capacity
- Gas, flame detection and fire extinguishing systems
- **Personnel protection (shower and eyewash station for emergency use available)**

Proportion of gaseous methanol depends on the rate of evaporation



Evaporation is not the same as boil off – it is a very slow process

Stena Germanica Methanol Refueling

Stena Germanica

Why Methanol

Carbon Neutrality

Pricing

Design

Bunkering

Standards

Standards

Fuel standards

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ISO/AWI 6583 Specification of methanol as a fuel for marine application is <u>under development</u>

Chemical Grade Standards
- IMPCA
- ASTM D1152-06
- GB/T 683-2006

Industrial Grade Standards
- GB 338-2011
- AMS3004H

Purity and presence of impurities affecting downstream processes

Motor Vehicle Standard (M100)
- CCR§ 2292.1
- GB/T23510-2009

Conventional Marine Fuel Standards
- ISO8217:2017

Marine Fuel Specifications
- ISO/AWI 6583
- MAN

Purity, combustion properties, presence of impurities affecting engines and boilers, and emissions

Reference Documents

Fuel Cells | Fuel Blending | Internal Combustion Engines | Boilers & external combustion engines

Recommendations for key parameters for marine application

- IMPCA Methanol Reference Specifications
- ASTM D1152-06 Standard Specification for Methanol
- GB/T683-2006 中华人名共和国国家标准 化学试剂甲醇
- GB338-2011 MTO级甲醇检测项目、指标与方法的研究
- SAE AMS3004H Methyl Alcohol (Aeronautics industry)

- CCR 2292.1 Fuels Specifications for M100 Fuel Methanol, California, USA
- GB/T 23510-2009 中华人名共和国国家标准 车用燃料甲醇 (M100)
- ISO 8217:2017 Fuel Standard for marine distillate fuels and residual fuels
- ISO/AWI 6583 Specification of methanol as a fuel for marine applications
- Guiding Methanol Fuel Specification for MAN B&W ME-LGIM Engines

Source: NTU, METB Singapore

Fuel standards

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Chemical & Industrial

Physical Properties

Methanol Content, Density, Distillation Range, Water, Appearance, Colour

By-Products

Ethanol, Acetone, Aldehydes + Ketones, Carbonyl Compounds

Chemical Properties

Carbonizables, Permanganate Time/Content, Non-volatile Matter, Evaporation Residue, Total Acidity/Alkalinity

Contaminants

Sulphur, Chloride, Iron

Motor Vehicle

Physical Properties

Methanol Content, Density, Distillation Range, Water, Appearance

By-Products

Other Alcohol & Ethers, Other Hydrocarbons

Chemical Properties

Gum, Non-volatile Matter, Evaporation Residue, Total Acidity/Alkalinity

Contaminants

Sulphur, Chloride, Sodium, Lead, Phosphorous

Conventional Marine Fuel

Physical Properties

Viscosity, Density, Cetane Number / CCAI, Flash Point, Pour Point, Cloud Point, Water, Appearance, Lubricity

Fuel Stability

Acid Number, Total Sediment, Oxidation Stability, FAME

Combustion Residue

Carbon Residue, Ash

Contaminants

Sulphur, Hydrogen Sulphide, Sodium, Vanadium, Al + Si, Used Lubricating Oil, Ca + Zn, Ca + P

MAN Engine

Physical Properties

Methanol Content, Water, Lower Calorific Value, Appearance

By-Products

Ethanol, Acetone

Chemical Properties

Acidity

Contaminants

Sulphur, Chloride

Source: NTU, METB Singapore

MAN ME-LGIM methanol fuel standard

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- IMPCA specification used but there is potential to create a specification which will be more ‘fit for purpose’
- IMO has mandated ISO to create a **methanol marine specification**
- IMPCA 99.85% purity
- MAN currently incorporating emulsification technology for Tier III compliance on-board to 50% blend at full engine load (80%)
- Methanol is 100% miscible in water

Source: MAN

MAN Energy Solutions

MAN

Info. No.: 316800	Item Name: FUEL Specification				Item Id.: 5741809-8	
Scale:	Size: A4	Product Type: ME-LGIM			Projection:	Page No.: 1 (2)
Date	Des.	Chk.	A.C.	Revision Change	Chg. Not.	Rev.
20160428	DFA	JUSV				00
20210621	DFA	JUSV	Z4	Text update, acid number. Ethanol and water content.		01
						02
						03

Guiding Methanol Fuel Specification for MAN B&W ME-LGIM Engines

This fuel specification is aimed for ME-LGIM engines that will operate:

1. mainly on pure methanol,
2. on crude methanol or pure methanol,
3. mainly on crude methanol.

Methanol is a clear, colourless, water soluble liquid which boils at 65°C. It is also known as methyl alcohol and is often abbreviated MeOH. It is most commonly produced from natural gas but can also be made from bio-feed stocks and gasification of coal.

Methanol is flammable and can form explosive mixtures with air. It burns with a non-luminous flame and is highly toxic. For information on health and safe handling, please refer to *Methanol Safe Handling Manual* [1] or other equivalent information.

Table 1 Guiding methanol fuel specification for MAN B&W ME-LGIM engines. Values refer to the methanol as delivered to the ship.

Designation	Unit	Limit	Value	Test method reference (latest edition to be applied)
Lower calorific value (LCV)	MJ/kg	Min.	19	
Methanol (CH_3OH)	%w/w	Min.	95	IMPCA 001-14
Ethanol (C_2H_5OH)	%w/w	Max.	5	IMPCA 001-14
Water (H_2O)	%w/w	Max.	5*	ASTM E1064**
Acetone (CH_3COCH_3)	mg/kg	Max.	30	IMPCA 001-14
Chloride as Cl^-	mg/kg	Max.	0.5	IMPCA 002-98
Acidity as acetic acid	mg NaOH/ g sample	Max.	30	ASTM D1613-17
Sulphur (S)	mg/kg	Max.	0.5	ASTM D3961-98 or ASTM D5453-12
Appearance	N/A	Clear, uncoloured and free of suspended solids		IMPCA 003-98
Sampling	N/A	IMPCA Methanol Sampling Methods [2]		

* A water content up to 30% w/w can be accepted under certain conditions and after agreement with MAN ES. Please note that this will affect the possibility to reach max. power.
**ASTM E1064 is valid up to max 2% water.

Sampling and test methods of methanol shall be in accordance with applicable methanol sampling and test methods from standard organisations such as IMPCA [2, 3], ASTM or ISO. Other methods can also apply.

In case the engine is to be operated on methanol with higher water content. Please contact your

MAN Energy Solutions

MAN

Info. No.: 316800	Item Name: FUEL Specification				Item Id.: 5741809-8	
Scale:	Size: A4	Product Type: ME-LGIM			Projection:	Page No.: 2 (2)
Date	Des.	Chk.	A.C.	Revision Change	Chg. Not.	Rev.
20210621	DFA	JUSV	Z4	Text update, acid number. Ethanol and water		01

MAN Energy Solution two-stroke representative for more information.

Contaminants such as metal shavings, welding debris, insulation, sand, wood, cloth and oil must be removed from the methanol. It is important to note that the quality and impurity degree can vary among the suppliers due to production and handling differences and the type of bunkering/transfer process (for example: terminal tank to vessel, truck to vessel).

References

[1] Methanol Safe Handling Manual, Methanol Institute, www.methanol.org, January 2013.
[2] IMPCA Methanol Sampling Methods, International Methanol Producers & Consumers Association (IMPCA), www.impca.eu, October 2014.
[3] IMPCA Methanol Reference Specifications, International Methanol Producers & Consumers Association (IMPCA), www.impca.eu, December 2015.

THANK YOU

SCAN ME