

Beyond fossil fuels: Navigating the future of marine alternative fuels

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4 Summary

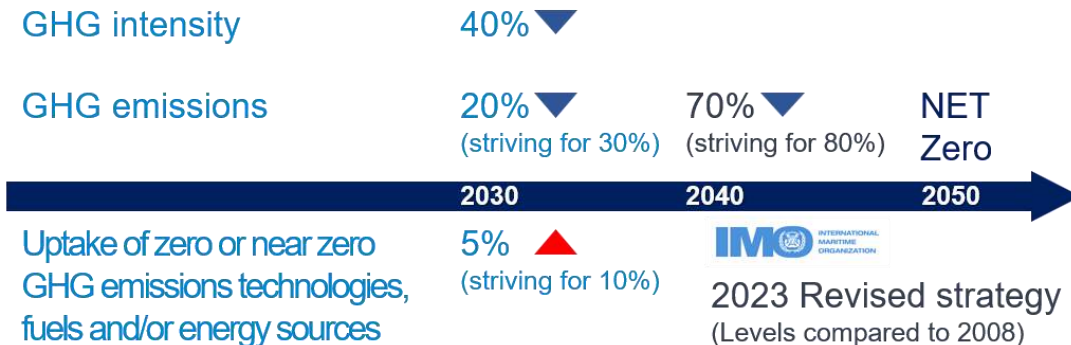
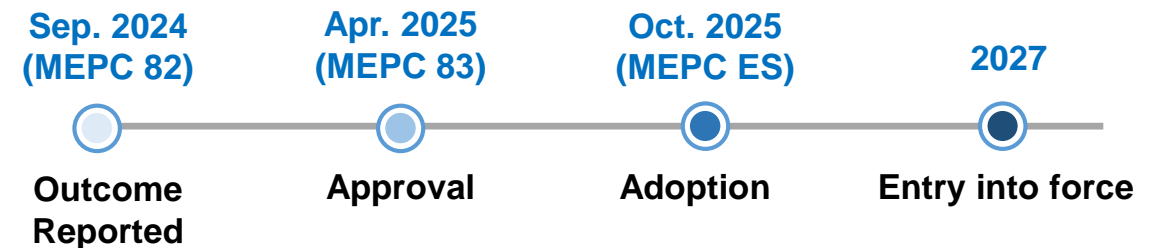
Global(IMO) GHG regulations

- ✓ IMO GHG strategy(through MEPC 80th sessions):
GHG emissions to reach net zero by (close to) 2050
 - Indicative checkpoints:
 - Reduce GHG emissions by at least 20% by 2030
 - Reduce GHG emissions by at least 70% by 2040
- ✓ Zero/near zero tech./fuel/energy source uptake at least 5% by 2030 (striving for 10%)
- ✓ Agreement of a plan to develop and finalize mid-term GHG emissions reduction measures

Short term measures for IMO GHG strategy

$$\frac{\text{Annual fuel consumption} \times \text{fuel carbon emission factor}}{\text{Annual distance traveled} \times \text{capacity}}$$

Mid-term measures for IMO GHG strategy



Local (EU) GHG regulations

EU ETS

From non-EU port to EU port

Source: BBC chartering, March 2024, EU-ETS

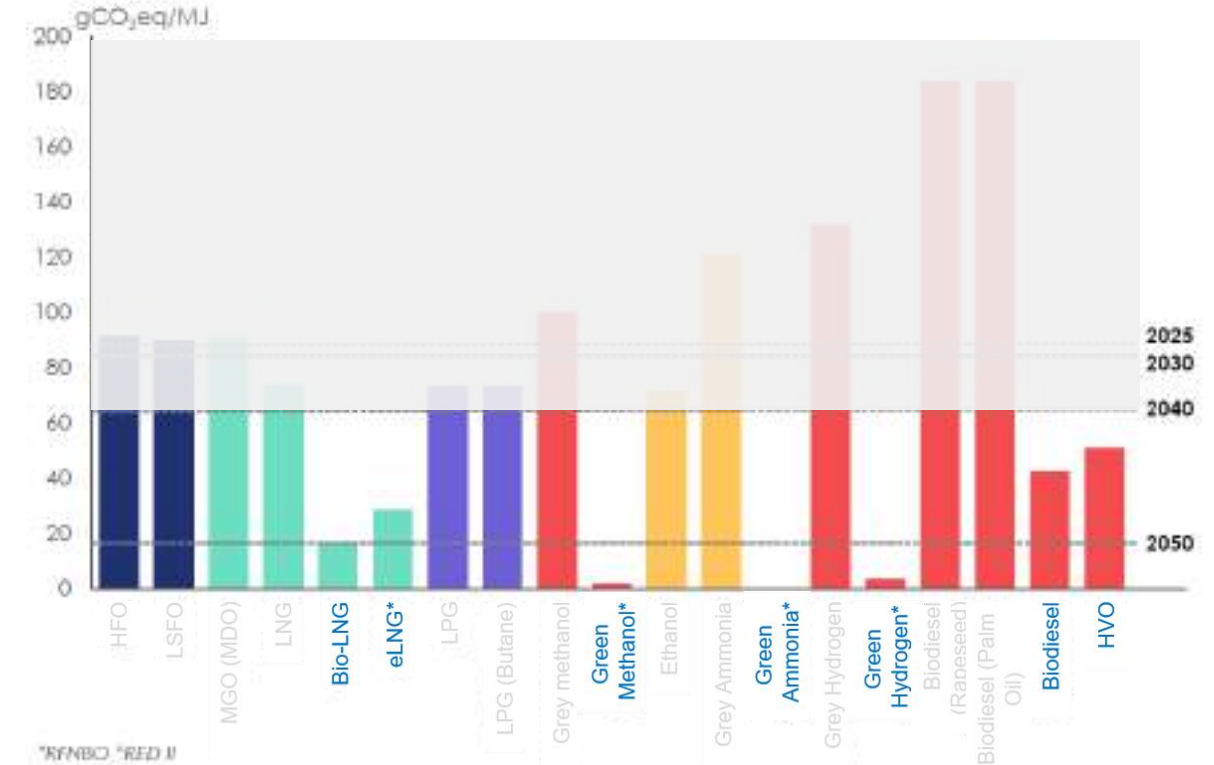


3 days loading at SHANGHAI | 3 days discharging at ANTWERP | total distance: 10.530 NM

	FUEL CONSUMED	x	EMISSION FACTOR	x	TRADE AREA RATE	x	EUA PRICE	=	EUA COSTS
Shanghai	7,5 t	x	3,16	x	0 %	x	85 €	=	0 €
sea passage	607,5 t	x	3,16	x	50 %	x	85 €	=	81.587 €
Antwerp	7,5 t	x	3,16	x	100 %	x	85 €	=	2.015 €

Year	EUA cost (phase in allowance in total)
2024	33,441 euro (40%)
2025	58,521 euro (70%)
2026	83,602 euro (100%)

FuelEU maritime

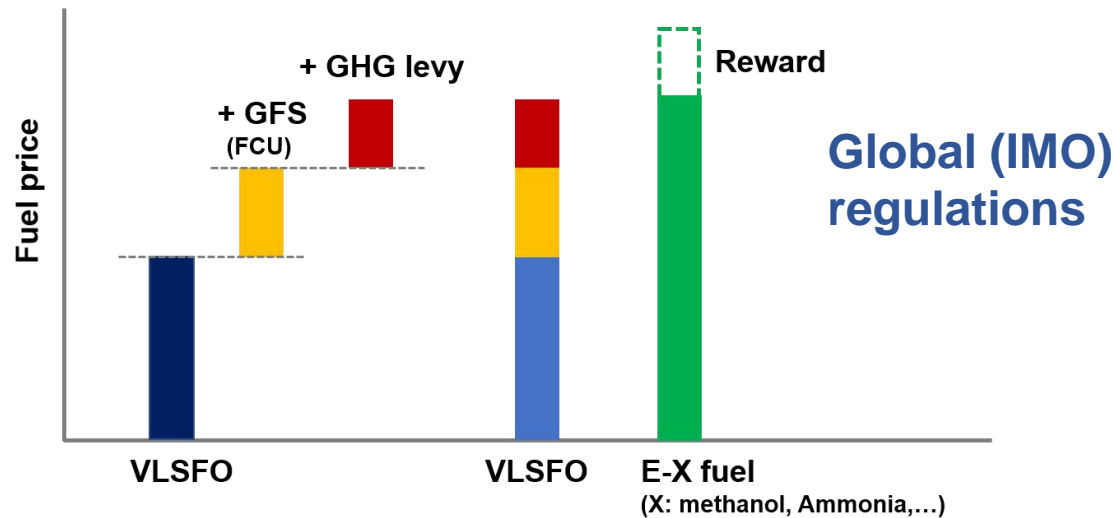


Source: Clarksons Research, March 2024, Fuelling Transition: Tracking the economic impact of emission reductions and fuel changes

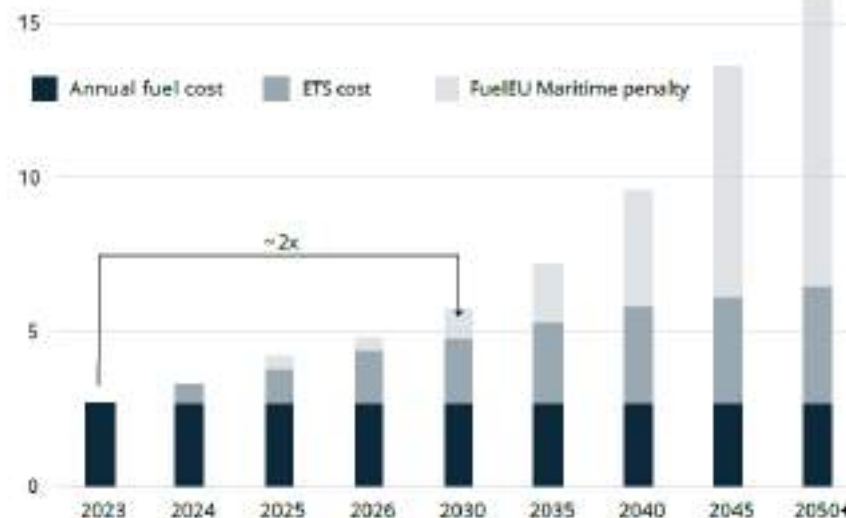
- **Post 2040 compliant fuel without penalty**
 - (neat) Bio-LNG, E-LNG
 - (neat) Green X, (X: methanol, ammonia and hydrogen)
 - (neat) Biodiesel & HVO

Transition from fossil-based fuels to green fuels

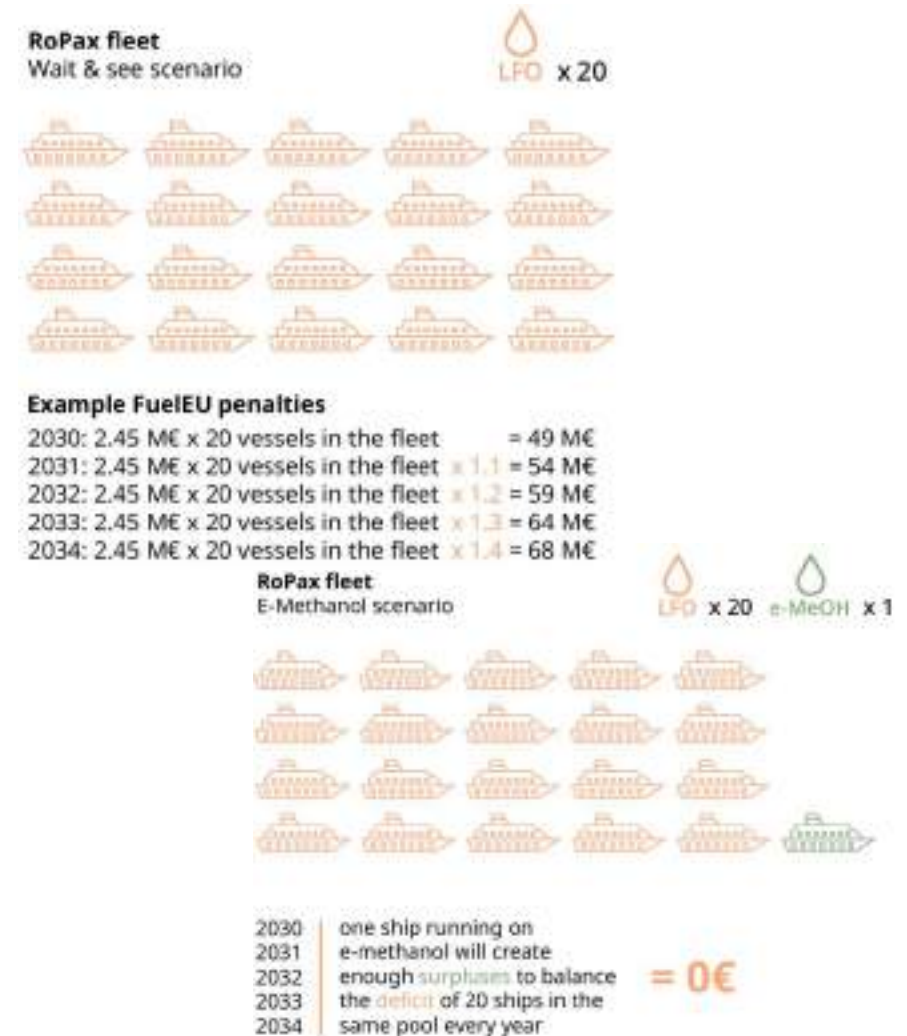
Comparison of fossil fuel and green fuel prices



Regional (EU) regulations



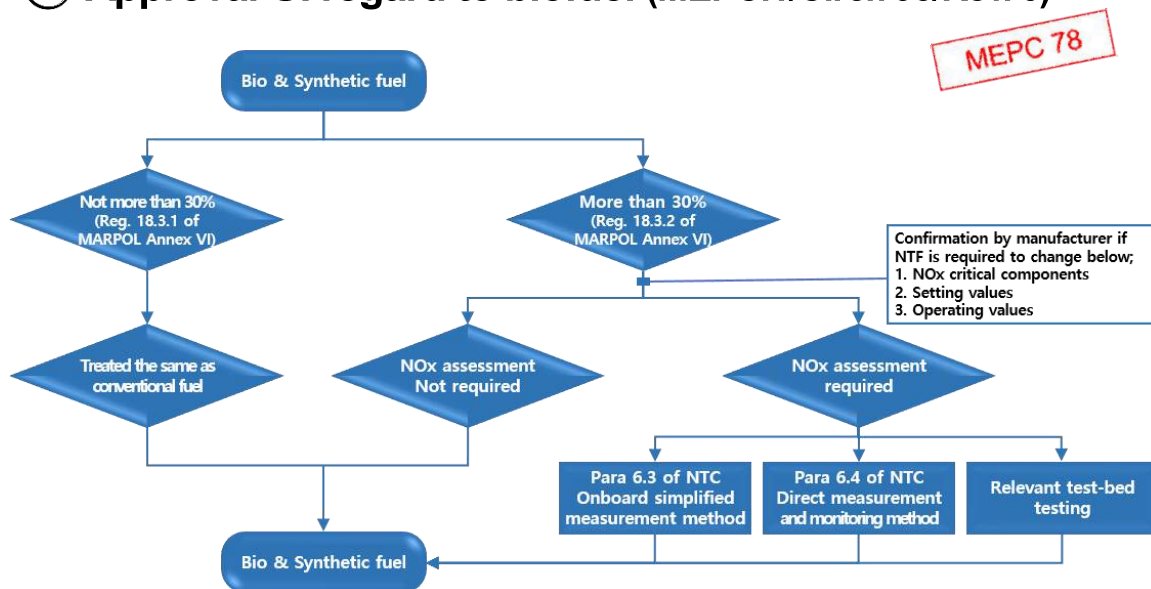
Pooling mechanism (FuelEU maritime)



■ Biofuel – Air pollutants, Sustainability and Bunkering

☑ Approval UI regard to biofuel (MEPC.1/Circ.795/Rev. 6)

☑ Approval of interim guidance on biofuels (MEPC.1/Circ.905)



1. Satisfies the Sustainability Criteria according to the international certification system
2. Reduction of more than 65% compared to 94 gCO_{2eq}/MJ of WTW GHG emissions of MGO fuel
3. CF_{biofuel}: Certified value multiplied by its LCV
4. In any case, CF value of biofuel: >0
(CF_{uncertified biofuel} = CF_{fossil fuel})
5. Interim guidance revoked upon greenhouse gas methodology implementation via LCA guidelines.

☑ Bunkering of B30(to B100) vs. B24

- According to the IBC code, if the biofuel content exceeds 25%, it is designated as a chemical cargo, and conventional bunkering vessels cannot such fuel as cargo.
- Planned for discussion at the PPR Expert Committee and the 30th ESPH Working Group

MEPC 81



International standards and price of marine biofuels

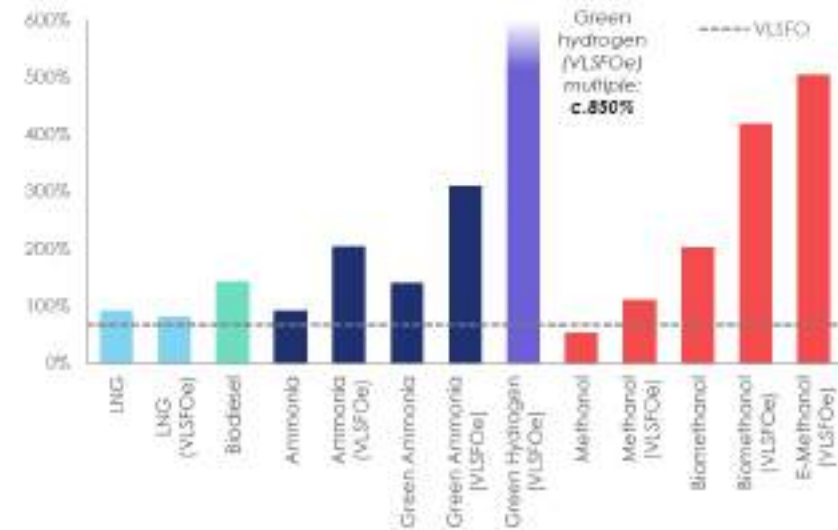
International standards related to biofuels

- ISO 8217: allows up to **only 7.0 v/v % FAME in distillate (DF grades) marine fuel**
- HVO quality **unspecified** in marine fuel standards (EN15940: standard for automotive paraffinic diesel fuels)



Biofuel oil price

- Biofuel price: **Biodiesel(FAME) < HVO < FT-diesel**



Source: Clarksons Research, Spring 2024, Fuelling Transition: Tracking the economic impact of emission reductions and fuel changes.

- Biofuel price will **increase due to competition for biomass with other industries.**

Sectors		2022	2030	2034	2050
Biofuels share by sector	Road	5%	11%	12%	3%
	Shipping	0%	8%	13%	19%
	Aviation	0%	10%	22%	33%

Source: IEA, 2023, Net zero roadmap – A Global Pathway to Keep the 1.5°C Goal in Reach

Ship Using Bio-Methane from Cow Manure Completes Demonstration Trip

The Maritime Executive



Small Japanese coastal tanker vessels, methane fuel derived from cow manure (MOL)
 PUBLISHED JUN 21, 2023 6:42 PM BY THE MARITIME EXECUTIVE
 Japan's Mitsui O.S.K. Lines (MOL) reports that working as part of a group of seven companies they have completed the first-ever test of sailing an ocean-going ship on fuel derived from cow manure. The effort comes as the shipping industry is looking for additional sources and forms of bio-ethane to reduce the overall emissions from operations.

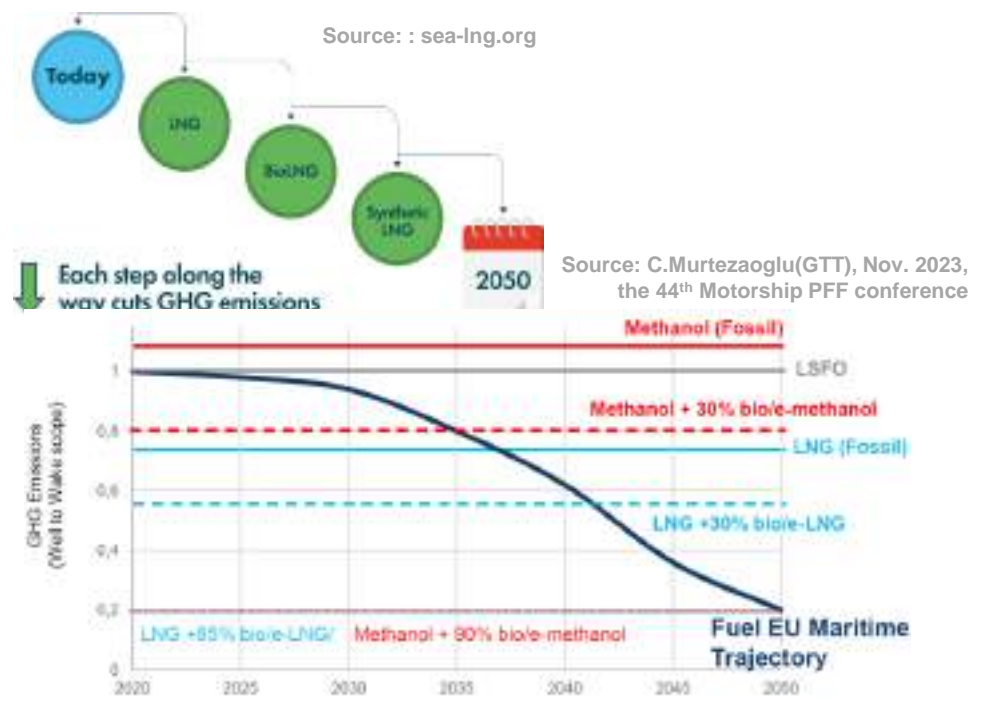
Synthetic LNG trial cuts GHG emissions by 34%

SeatradeMaritime



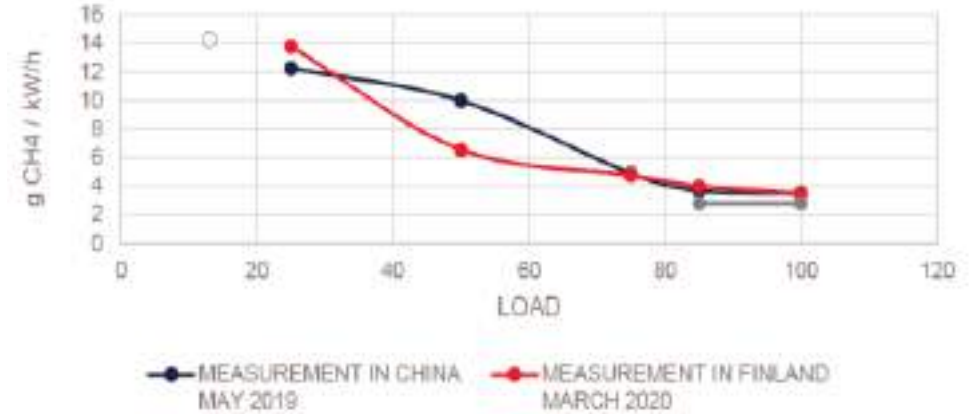
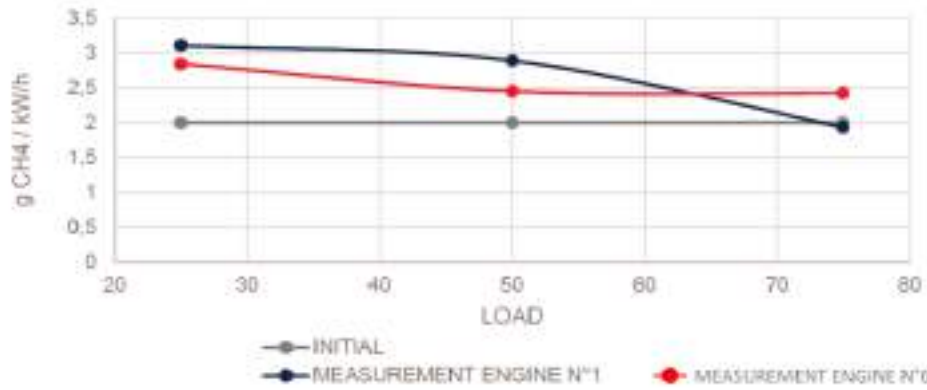
Trial results from the first containership to run on a mix of conventional and synthetic LNG showed emissions reductions of HFO and LNG operation.

Gary Howard | Apr 06, 2022.



■ Methane slip solutions for LNG DF engine

☑ Results of the methane slip measurements (2 stroke & 4 stroke, otto cycle)



Source: Xavier Leclercq, CMA ships – LNG program; Achievements and Challenges, Symp. on. Alternative low-carbon and zero-carbon fuels for shipping, Feb. 9, 2021

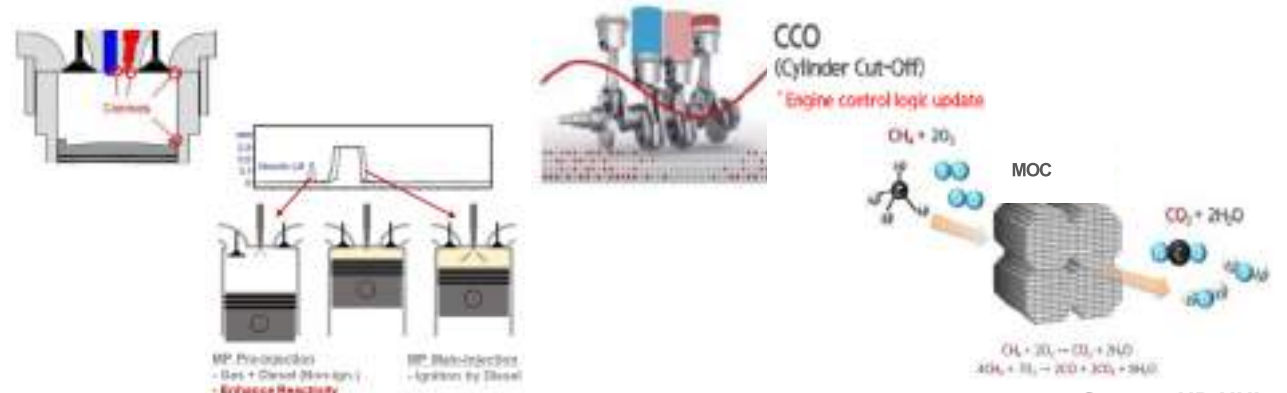
☑ Methane slip reduction potential(2 stroke)

- iCER, X-DF (WinGD)
- MEGA engine(MAN ES)



☑ Methane slip reduction solutions (4 stroke)

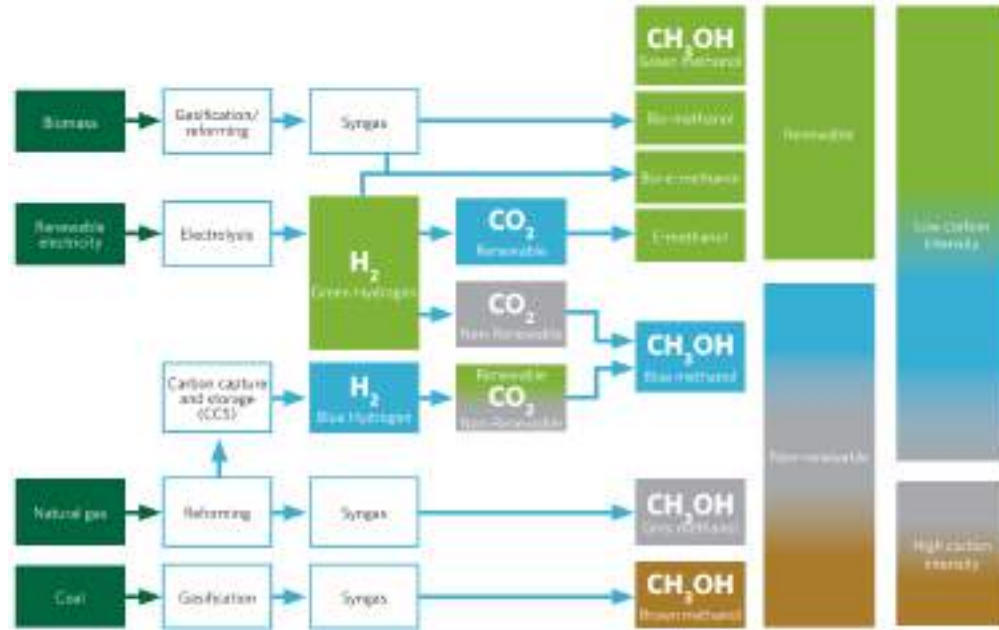
- Combustion strategy & engine design optimization
- After-treatment system



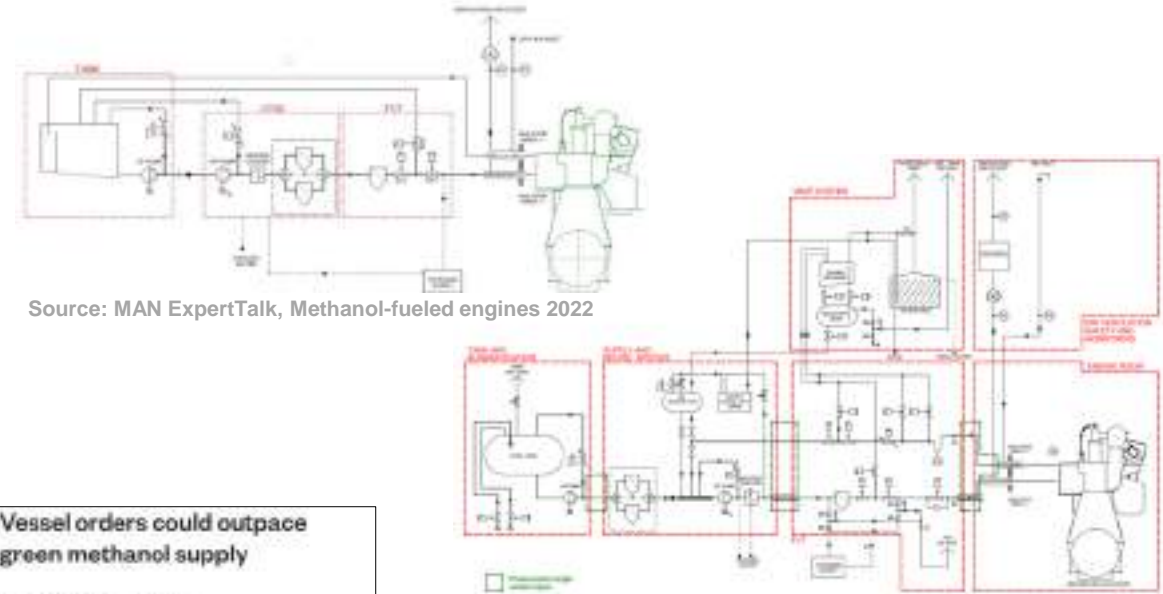
Source: HD HHI

■ Sustainable methanol transition

☑ Fossil methanol → Blue-/Green methanol



Source: Methanol Institute, 2023, Marine Methanol – Future-proof shipping fuel



Source: MAN ExpertTalk, Methanol-fueled engines 2022

Source: Stefan Mayer(MES), Developing the MAN B&W dual fuel ammonia engine, CIMAC congress paper 589, 2023

Vessel orders could outpace green methanol supply

Source: Press release, Nov. 21, 2023, Available at: <https://www.ics-shipping.org/news-item/vessel-orders-could-outpace-green-methanol-supply/>

“Proman executive director corporate finance Andrew Craig noted ‘a significant delta’ between projected green methanol demand and availability, suggesting that the short-term shortfall would need to be filled with low-carbon alternatives, produced from fossil fuels but with emissions captured.”

Maersk’s strategic partner for green methanol supply

9 strategic fuel partnerships in 2023

Reached capacity in 1,000,000 tonnes expected by 2025 after successful pilot phase

Partner	Fuel	Capacity	Geography
Caracal Tank	Green methanol	100,000	North America
CB&I (USOC)	Blue methanol	200,000	USA
DeBe	Blue methanol	200,000	USA
European Energy	Green methanol	200-300,000	NEO, Australia
QTE	Blue methanol	300,000	USA
Q-Cell	Green methanol	300,000	North America
Proton	Blue methanol	100,000	North America
Suez	Green methanol	100,000	North America
WasteFuel	Blue methanol	30,000	South America

■ Sustainable methanol transition

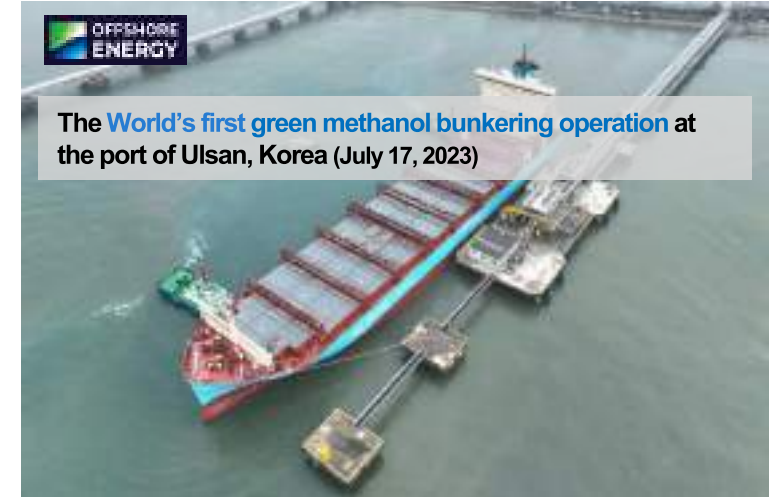
- ☑ Engine development, Methanol fueled Ship building and (green, bio-/E-) methanol bunkering in Korea



HHI EMD unveils **world's largest methanol engine** (Apr.24, 2023)



The **World's first container vessel** (LAURA Maersk) powered by green methanol has arrived in Copenhagen from South Korea (Jan. 29, 2024)



The **World's first green methanol bunkering operation** at the port of Ulsan, Korea (July 17, 2023)



The HiMSEN methanol engine is the **world's first 4 stroke dual fuel methanol engine**, which selectively use methanol and diesel. (Jan. 20, 2023)



The **World's first large methanol-powered boxship** named "ANE Maersk" in HD HHI, South Korea (Jan. 29, 2024)



The **World's first STS green methanol bunkering** to large container ship takes place in Korea, UPA (Feb. 5, 2024)

- Emerging ammonia carrier market

- ☑ Ammonia carrier: Intercontinental transportation of ammonia

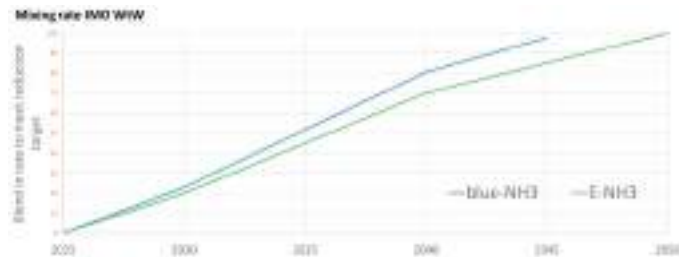
South Korean Shipbuilders Add Orders in Emerging Ammonia Carrier Market

The Maritime Executive



Hyundai created an early rendering of the appearance of the new category of very large ammonia carriers (VLAAC).

PUBLISHED JAN 23, 2024 2:43 PM BY THE MARITIME EXECUTIVE



Source: MAN Energy Solutions, 2024, MAN B&W ammonia engine development

Offshore Energy

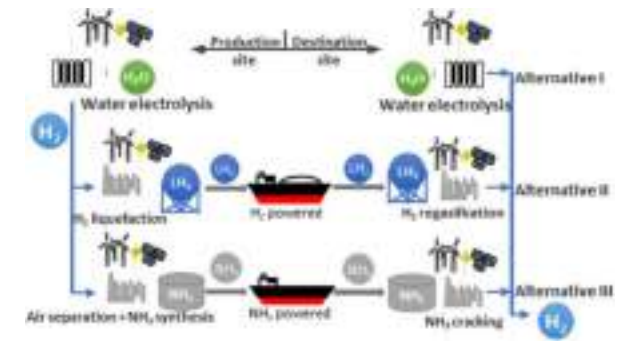
Green Marine Hydrogen Marine Energy Subsea Fossil Energy Africa

HD KSOE kicks off new year with orders for two VLACs and two LPG carriers

Hanwha Ocean bags \$498 million order for world's largest ammonia carriers

Samsung Heavy Industries bags \$235 million gas carrier deal

- Applications of (blue/E) ammonia
 - Hydrogen carrier¹⁾



- (blue/E) Utilized as fuel²⁾

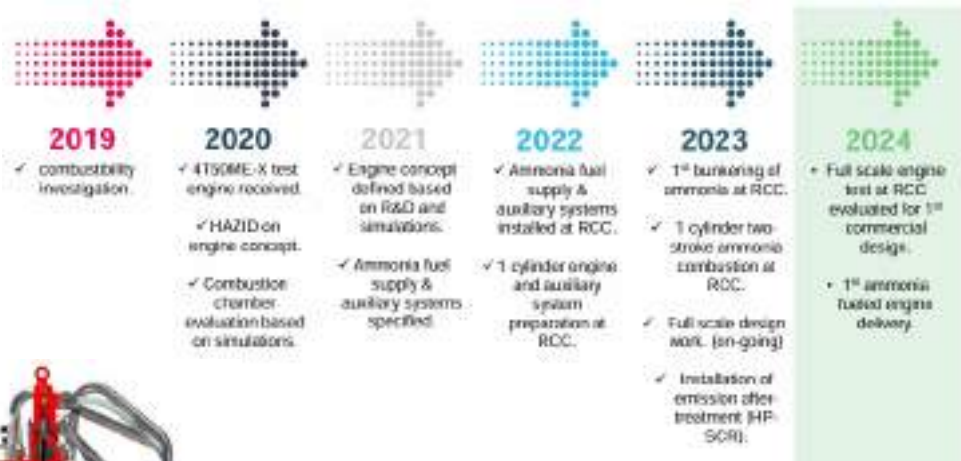


Sources : 1) Antonio Villalba-Herreros et al., Techno-Economic Assessment of Large-Scale Green Hydrogen Logistics Using Ammonia As Hydrogen Carrier: Comparison to Liquefied Hydrogen Distribution and In Situ Production, ACS Sustainable Chem. Eng. 2023, 11, 12, 4716–4726.
2) Mitsubishi's ammonia gas turbine

Ammonia DF engine development (2 stroke)

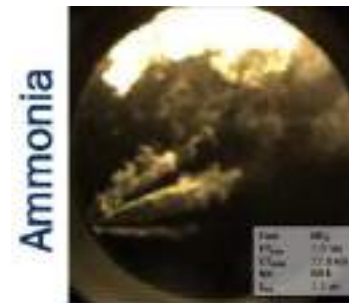
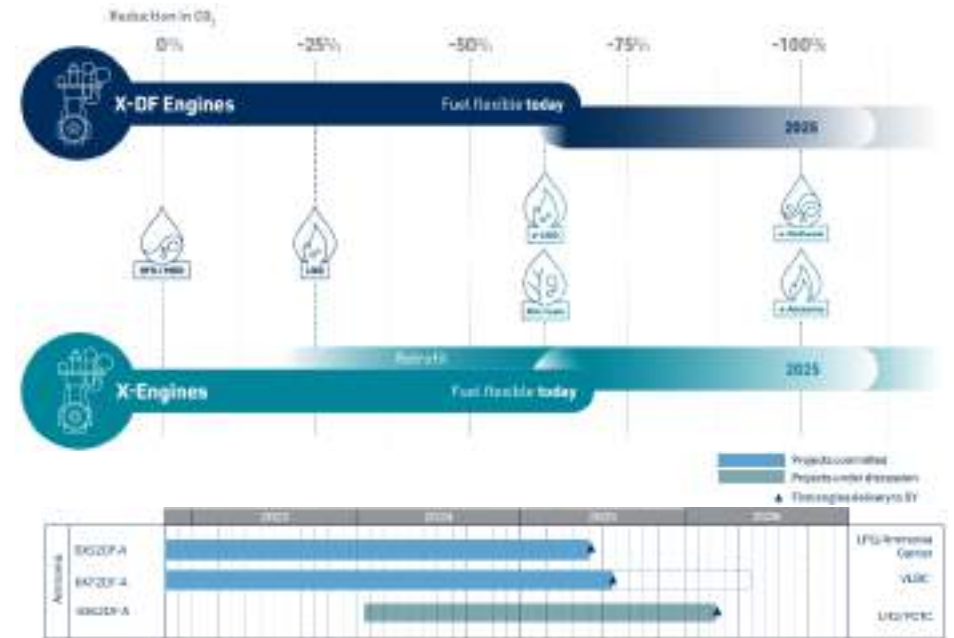
✓ MAN Energy solutions

✓ Win GD



Status on the ammonia engine testing (as of March 5th, 2024)

- 3rd of July 2023: First ammonia combustion
- R&D target(5% pilot oil) is already within reach.
- All cylinder of test engine is operated on ammonia and 100% load is obtained.
- N₂O is handled by engine tuning.
- Very low NOx emissions

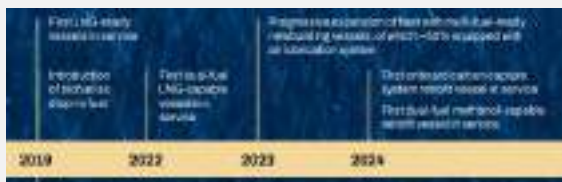


Summary

HMM



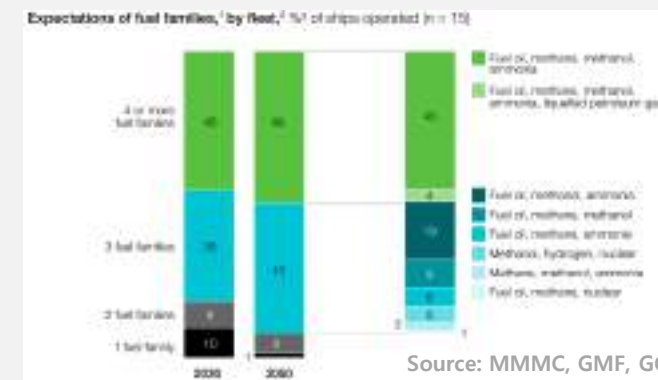
MSC



Maersk



CMA CGM



Source: MMMC, GMF, GCMD, The shipping industry's fuel choices on the path to net zero

Not competitive among alternative fuels and power sources **under various uncertainties**, but **mutually complementary**!

IMO

Goal based fuel standard

GHG Levy

Incentive for first mover
(under discussion)

Demand-pull policies

EU

EU ETS

FuelEU maritime

Pooling

US

US Inflation Reduction Act (IRA)
(production tax credits (PTCs) for green hydrogen & credits for permanent storage of carbon)

Supply-push policies

New signals

Enhancing in TRL of alternative marine fuel
Increasing demand of green fuels
(to be provided) Various regulatory Incentives

Beyond fossil fuels

Appendix

Providing insights as a technological partner



LCO₂ carrier

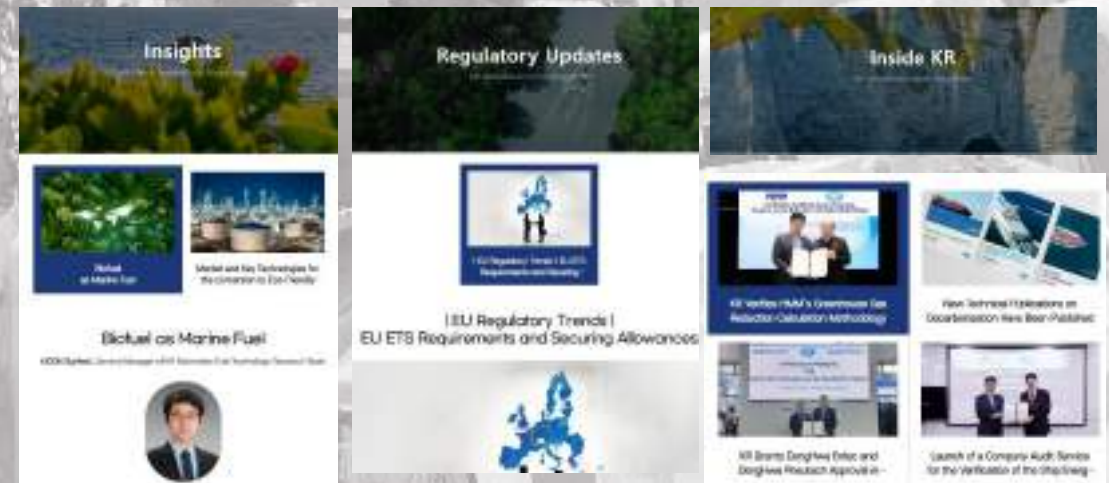
Ammonia

Methanol

Biofuel



<http://kr-decarbonization.co.kr>



Thank you for your attention

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