

Overview on the Green Technologies for Low and Zero-carbon Ships

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Young Jae Sung
Senior Vice President
HD Korea Shipbuilding & Offshore Engineering

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- Market Issue & Status

2. Decarbonized Ships

- Alternative Fueled Ship for Decarbonization

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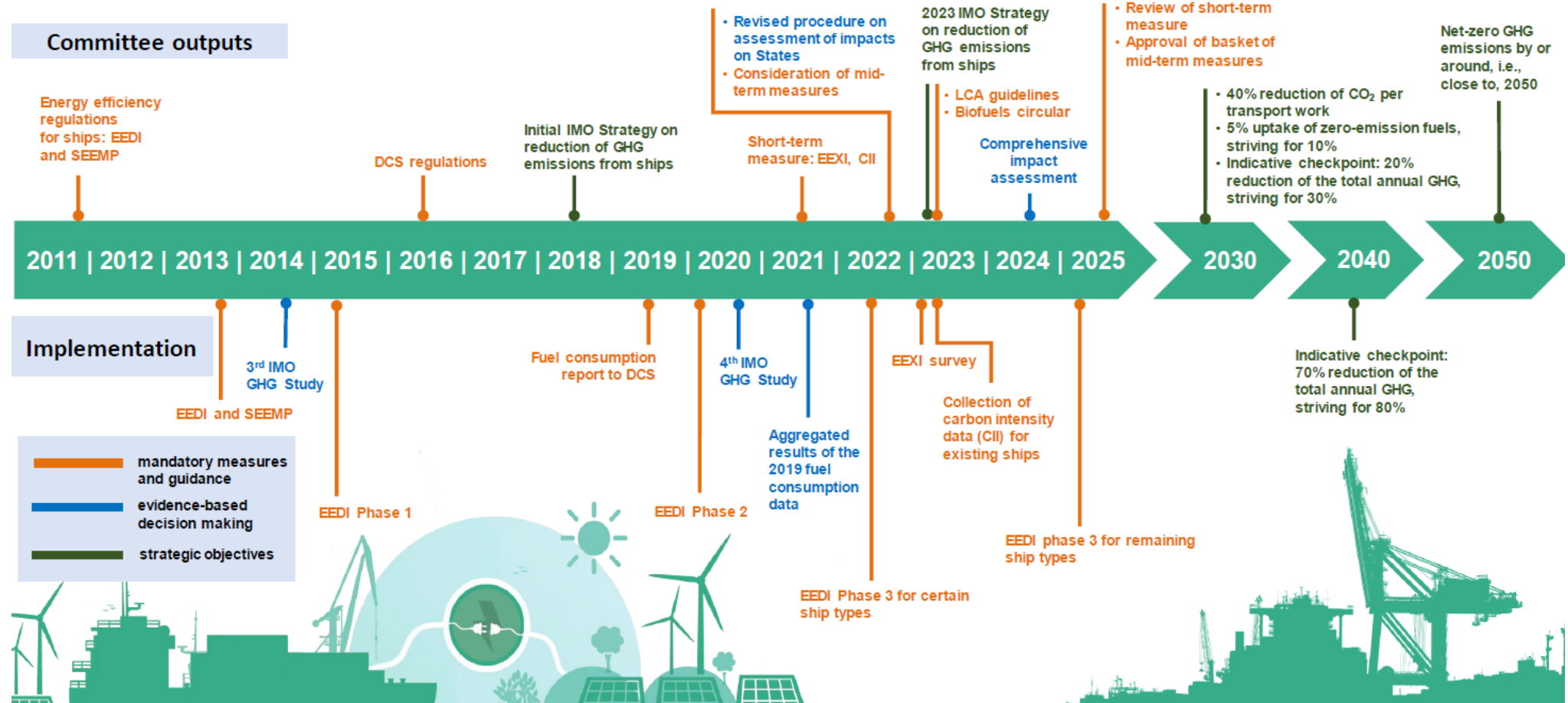
- Energy Saving Devices
- GHG Reduction System

4. Conclusion

GHG Regulations in Maritime Industry

Addressing climate change

Over a decade of regulatory action to cut GHG emissions from shipping



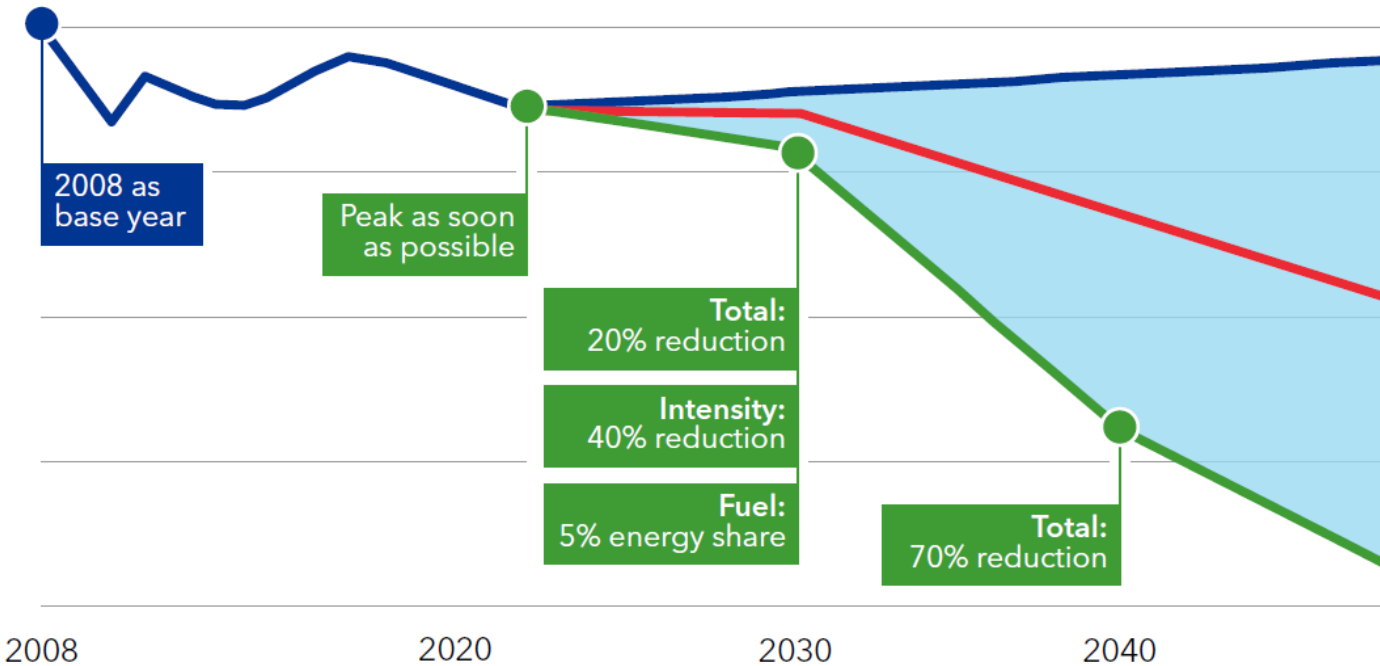
(Source: <https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx>)

1. Change in Shipping Market

GHG Regulations in Maritime Industry

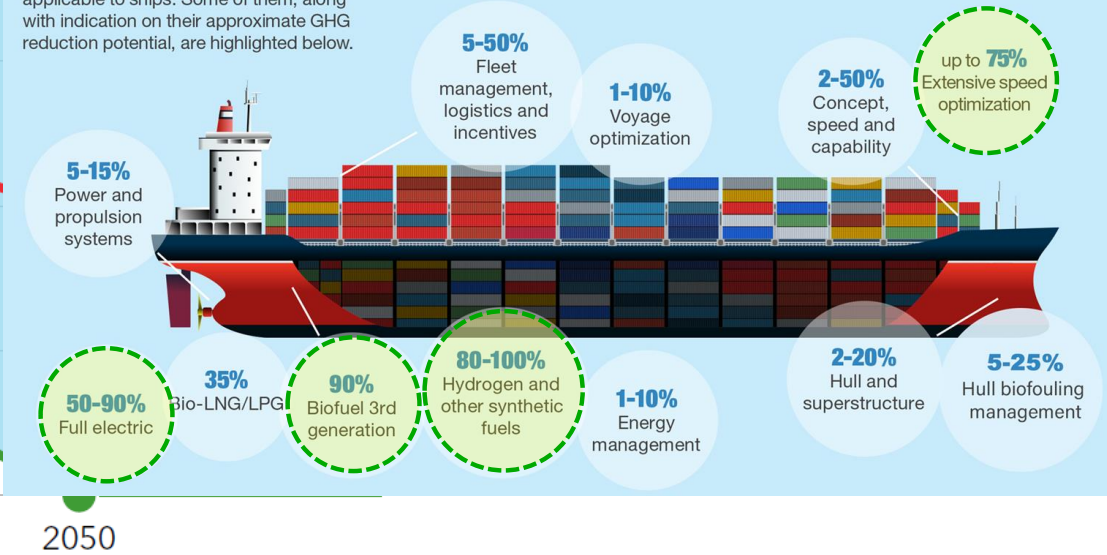
Outline of ambitions and minimum indicative checkpoints in the revised IMO GHG strategy

Units: GHG emissions



A wide variety of design, operational and economic solutions

Achieving the goals of the Initial IMO GHG Strategy will require a mix of technical, operational and innovative solutions applicable to ships. Some of them, along with indication on their approximate GHG reduction potential, are highlighted below.



(Source: <https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx>)

〈Regulation Trend Change〉

- ❖ **Technical & Operational Measures** (EEDI/EEXI/CII)
- ❖ **CO₂ Emission** (EEDI/EEXI/CII)
- ❖ **Tank to Wake Emission** (EEDI/EEXI/CII/ETS)
- ❖ **Individual Vessel**

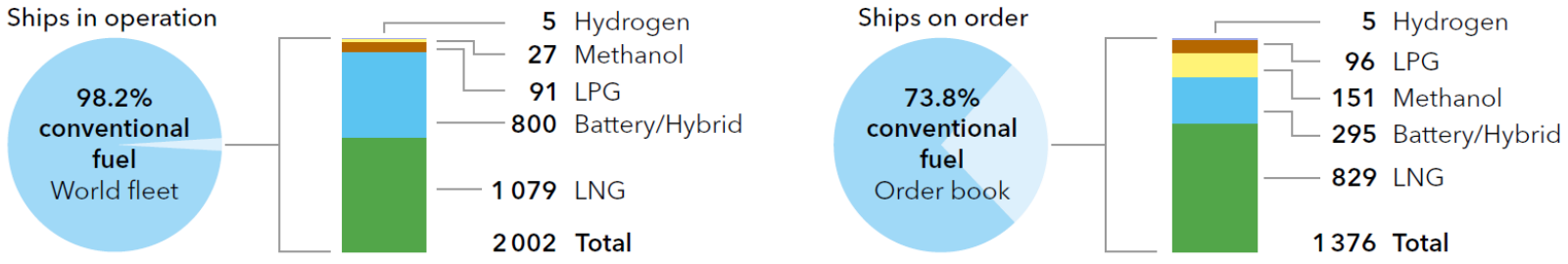
- ➔ **Basket Measures** (Technical & Economical Measures)
- ➔ **GHG (CO₂, CH₄, N₂O) Emission** (GFS, ETS, FuelEU)
- ➔ **Well to Wake Emission** (GFS, FuelEU)
- ➔ **Individual Vessel and Fleet Management**

1. Change in Shipping Market

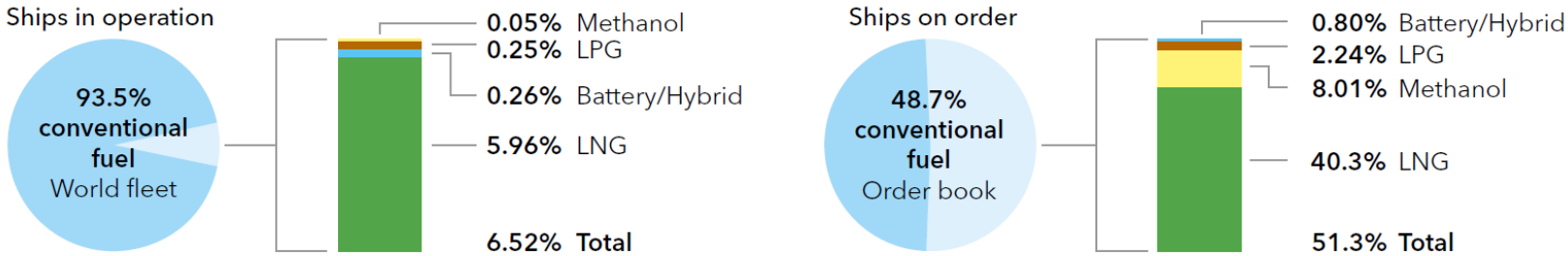
2023 Market Issue & Status

Alternative fuel uptake in the world fleet in number of ships (upper) and gross tonnage (lower), as of July 2023

NUMBER OF SHIPS



GROSS TONNAGE



Sources: IHSMarkit (ihsmarkit.com) and DNV's Alternative Fuels Insights for the shipping industry - AFI platform (afi.dnv.com)



Methanol-fueled Container Carrier ('23.09 delivered, Maersk/HD HHI)

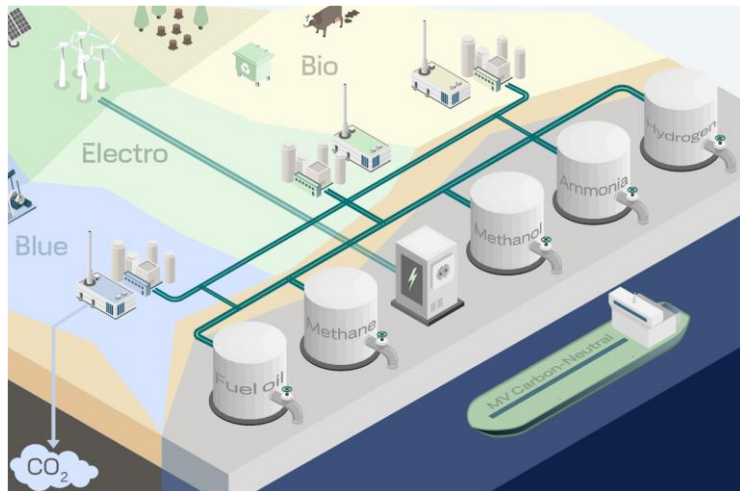
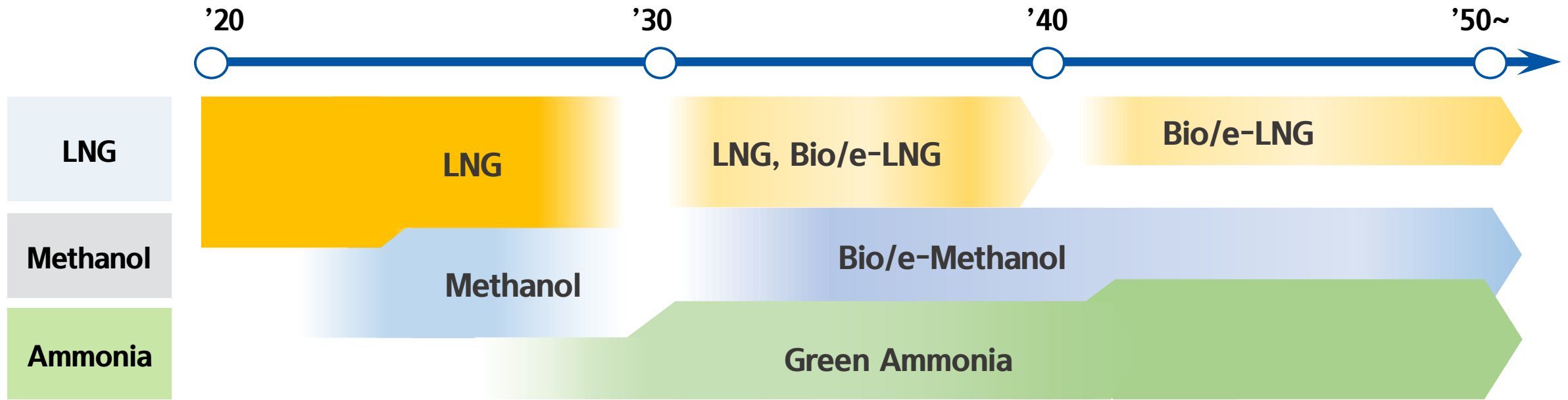
- 6.5% of fleets use alternative fuels
- 51.3% of ordered ship select to use alternative fuel
 - : LNG fuel-powered ships occupies 40.3% of total ship order
- The order of methanol fueled ship increases



1. Change in Shipping Market

6

HD Hyundai Group's prospect



(Source: DNV Maritime Forecast to 2050)

Fuels

- LNG
- LNG + Alternative Fuel
- Methanol
- Ammonia
- Hydrogen



Technologies

- Energy Saving Devices
- GHG Reduction Systems
- Electric Propulsion

LNG Dual Fuelled Vessel

- **Most Feasible** Solution on **Today**
- **Energy Saving Measures** for overcoming Energy density
- **CO₂ / Methane Capture** for Green credentials
- Extension to zero-emission fuels (Bio-LNG, H₂ mix)



Prolonged Use, Possible

Record of HHI Group



World's 1st LNG DF Aframax tanker ('18)



World's 1st LNG DF large Container ('20)



180K LNG DF Bulk Carrier ('20)

Energy Saving Devices



Engine Mounted Generator



Air lubrication system



Wind assisted propulsion

GHG Reduction Systems

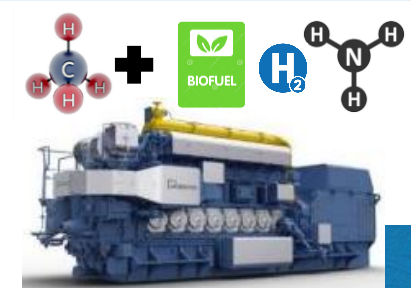


Methane Slip Reduction System



CO₂ Capture/Reduction

Mixed Combustion



Mixed Combustion Engine

Methanol Fuelled Vessel

- **Mature technology** similar to conventional HFO. Need to be scaled-up.
- 11% CO₂ reduction /w methanol (TTW) + additional emission reduction (PM/Smoke, SOx, NOx)
- Extension of **green-fuel supply chain** is the main key factor (Bunkering infrastructure)
- World's 1st methanol fueled container carrier was delivered in Sep. 2023



〈 World's 1st Methanol-fuelled PC 〉
(2016, HMD / Westfal-Larsen)

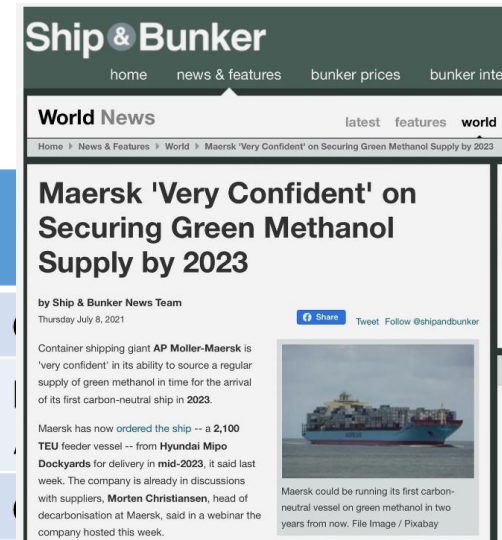


HD 〈 Methanol-fuelled Container 〉
(2023, HHI / Maersk)

〈Maersk's Strategy for Green Methanol Supply 〉

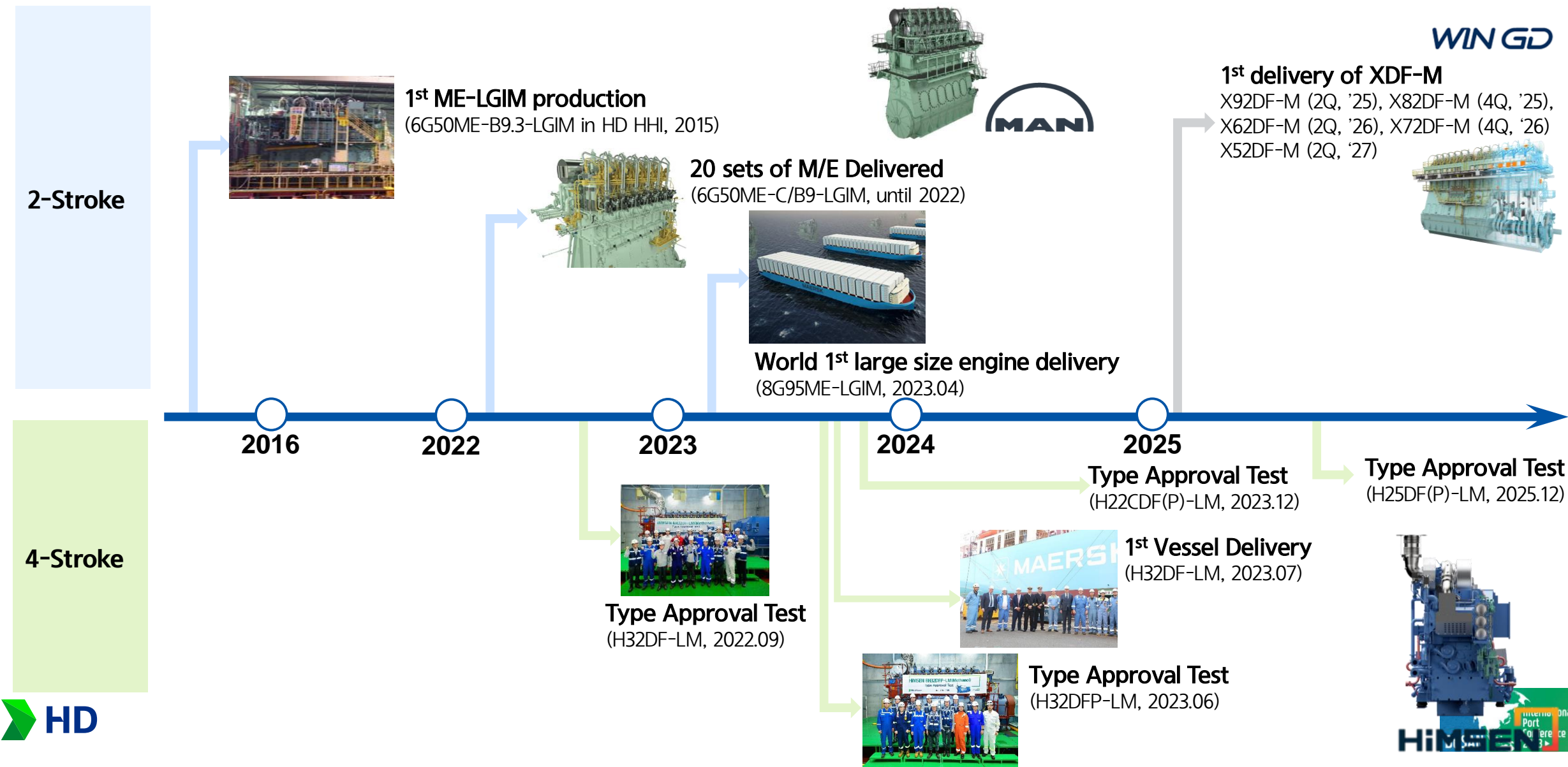
Company	Type	2024~25 (t/year)	After Add (t/year)	
CIMC ENRIC	Bio-	50,000	200,000	
European Energy	E-	2-300,000		
GTB ⁽¹⁾	Bio-	50,000	300,000	
Orsted	E-	300,000		North America
Proman	Bio & E-	100,000		North America
WasteFuel	Bio-	30,000		South America
Total		7~730,000	500,000	

(1) GTB: Green Technology Bank



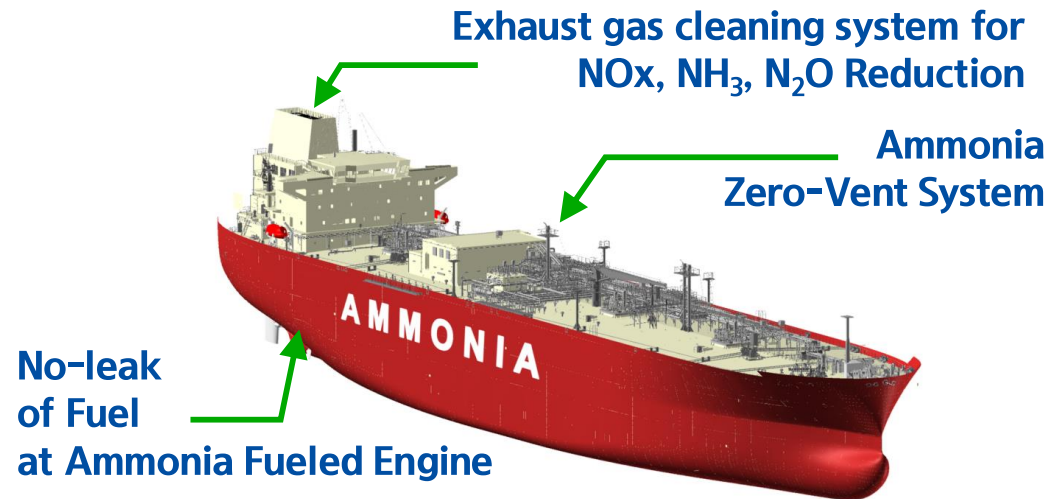
Maersk could be running its first carbon-neutral vessel on green methanol in two years from now. File Image / Pixabay

Methanol Fuelled Engine



Ammonia Fuelled Vessel

- Ship and outfitting (equipment) system considering ammonia's toxic, low viscosity.
- Ammonia is difficult to ignite and, to be solved in engine side.
- Ship yards are preparing LFSS, toxicity control system, and EGCS solutions
- First full-package of ammonia fueled ship will be got ready in 2024
- EPS-HHI signed MOU for Ammonia DF gas tanker delivered as early as 2025.
- World 1st Ammonia fueled LPG Carrier was ordered on Oct. 2023.



〈Zero-Emission and Zero-Venting
Ammonia-fuelled Ship for Safety〉



〈 Ammonia fuelled tanker AIP 〉
(HMD-MAN ES-LR, 2020)



〈 World's 1st Ammonia-fuelled
Ship Order 〉
(Oct. 2023, HMD / ExoStar)



Ammonia Fuelled Ship – Engine

2-Stroke



- [MAN-ES]
- Ammonia Fueled Engine launched in 2024 (ME-LGIA)
 - MOU for Ammonia Fueled Carriers on Jun. 2022 (EPS, MPA, ABS, MAN-ES, HHI)



- [WinGD]
- Ammonia engine MOU on Jun. 2022 (WinGD, HHI-EMD/ 1st Engine delivery in 2025)

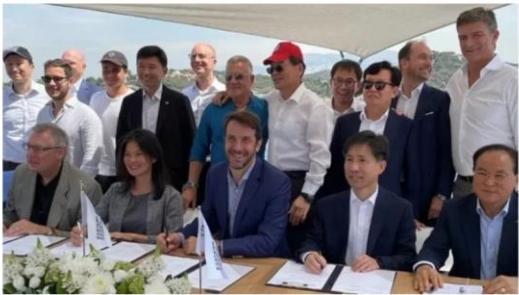
News

EPS signs MoU for new ammonia dual-fuel gas carrier

The use of ammonia as an alternative marine fuel is expected to help cut down carbon dioxide emissions.

June 7, 2022

in



EPS has collaborated with HHI and ABS for the new ammonia-driven vessel. Credit: Eastern Pacific Shipping

News

WinGD and Hyundai to partner on development of ammonia engine

The project will include the development of emissions abatement, fuel supply and relevant safety solutions.

June 15, 2022

in



WinGD and Hyundai signed an MoU to deliver a first engine by 2025. Credit: SarahTz / commons.wikimedia.org

4-Stroke



- [MAN-ES]
- Ammonia Engine launch after 2025



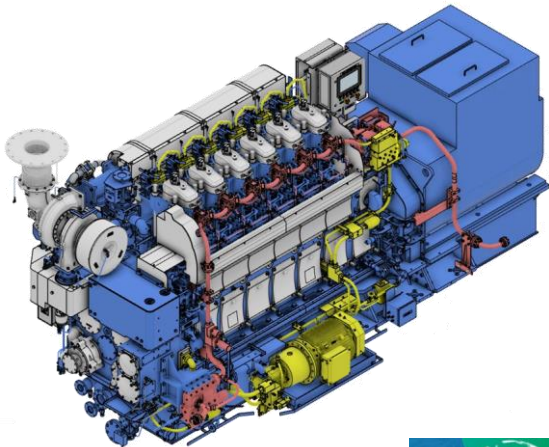
- [Wartsila]
- Tech. ready 2023, Volume ramp-up 2025



- [HHI]
- Test approval test in 2024



〈 Single cylinder test : SCH32 〉



〈 Ammonia HiMSEN concept 〉

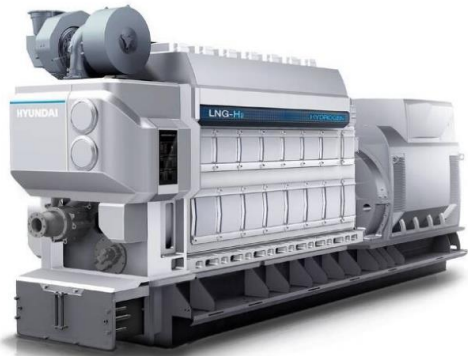


Hydrogen Fuel

- Availability, infrastructure, energy density, technology and price should be improved.
- The performance of LNG-H₂ dual fuel engine was confirmed in May, 2023.
- LNG-H₂ dual fuel engine can be applied to liquefied H₂ carrier by using BOG as fuel.
- H₂ engine will be got ready in 2025.

Hydrogen Engine

Hydrogen Dual-fuel Engine



Hydrogen Engine

Development in
2025
Sales release in
Dec., 2025

LNG-H₂ dual fuel engine demonstration (May, 2023)

Evaluation up to 25 % hydrogen (2023)

Evaluation 30 % and over hydrogen (~2024)



LH₂ Carrier



Development of liquefied H₂ carrier

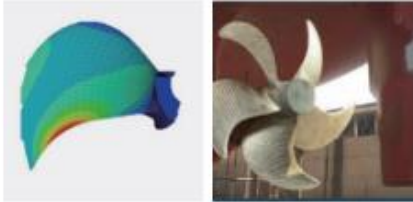
Hydrogen Fuel

Hydrogen Vision of HD HYUNDAI



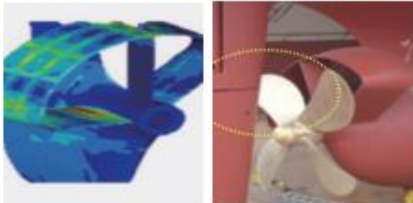
Energy Saving Devices

Propeller Re-design



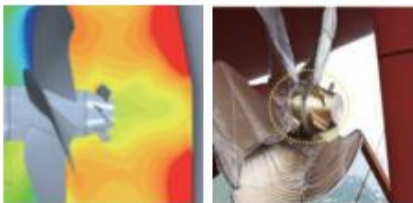
- Abt. 2~3% FOC saving
- Recommend for slow steaming vessel

Hi-PSD (Pre Swirl Duct)



- Abt. 2~6% FOC saving
- Most effective

Hi-Fin (PBCF)



- Abt. 0.5~1.5% FOC saving
- Easy Installation

Bulbous Bow Retrofit



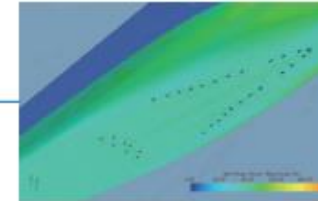
- Abt. 2~3% FOC saving
- Recommend for slow steaming vessel

Hi-Rudder Bulb

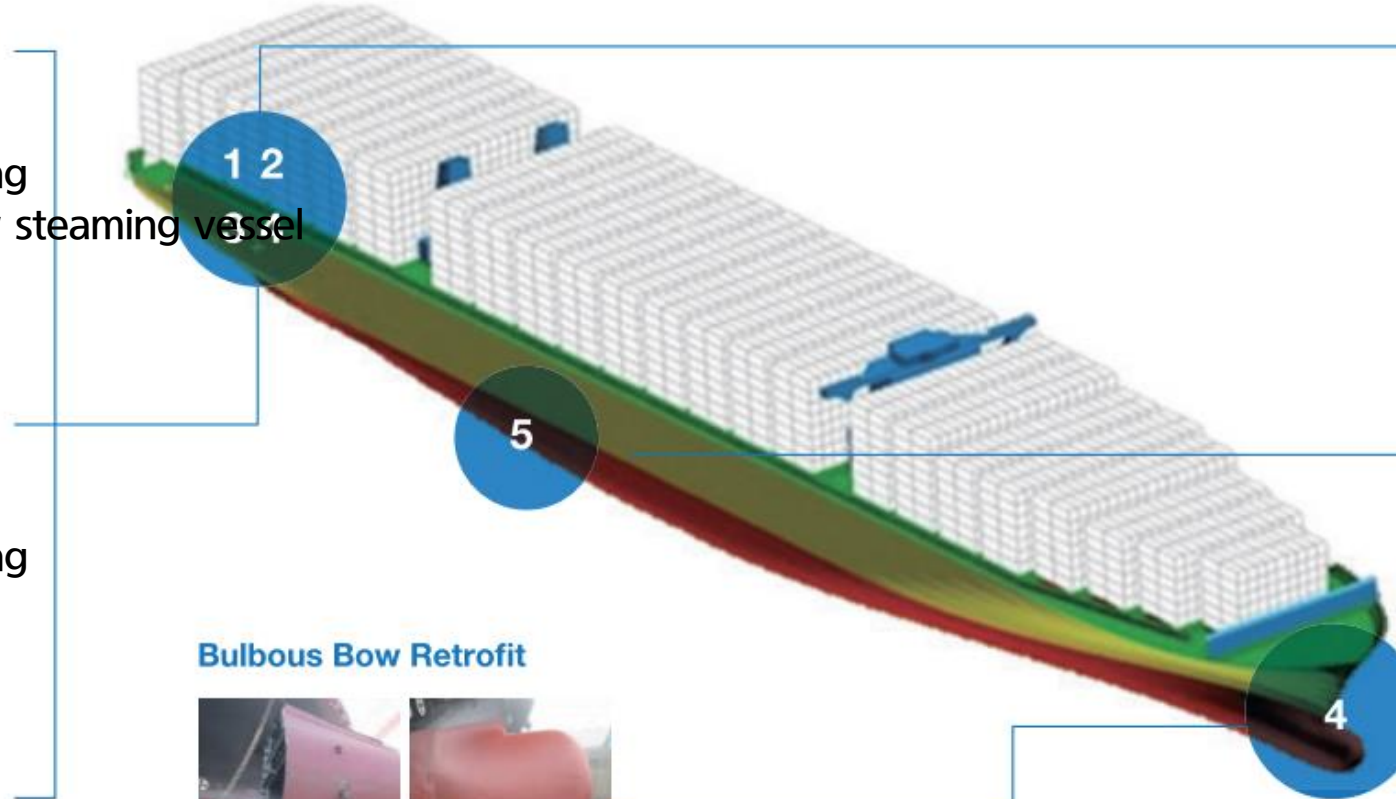


- Abt. 1~2% FOC saving
- Eliminate the hub vortex

Hi-ALS



- Abt. 5~8% FOC saving
- Reduce the frictional res.



Energy Saving Devices

Energy Saving Device (ESD)

Hi-ALS / Hi-PSD / Hi-Fin / Hi-Rudder with Bulb

GHG Reduction System

On-board CCS

- Requires high-efficiency solvent and energy recovery technology
- Under development for Compact and Minimized Design



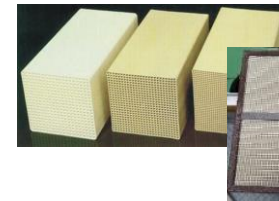
〈 0.7MW Pilot Scale Test,
1Q 2023 〉



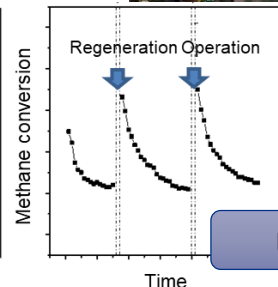
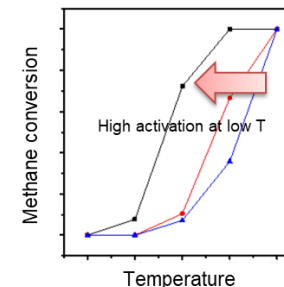
〈 Onboard Carbon Capture
Storage System 〉

Methane oxidation catalyst system

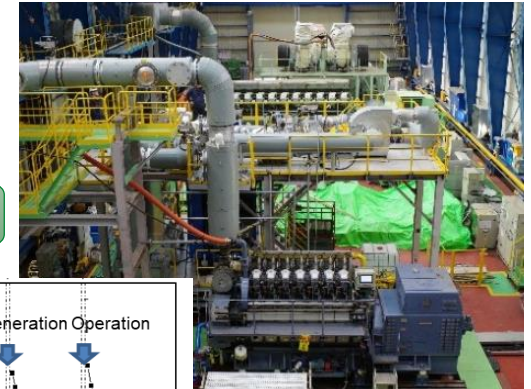
- High-activated oxidation catalyst at low temperature
- High durable catalyst based on engine integrated regeneration system against to H_2O and SO_x poisoning



High activation catalyst



Reasonable regeneration



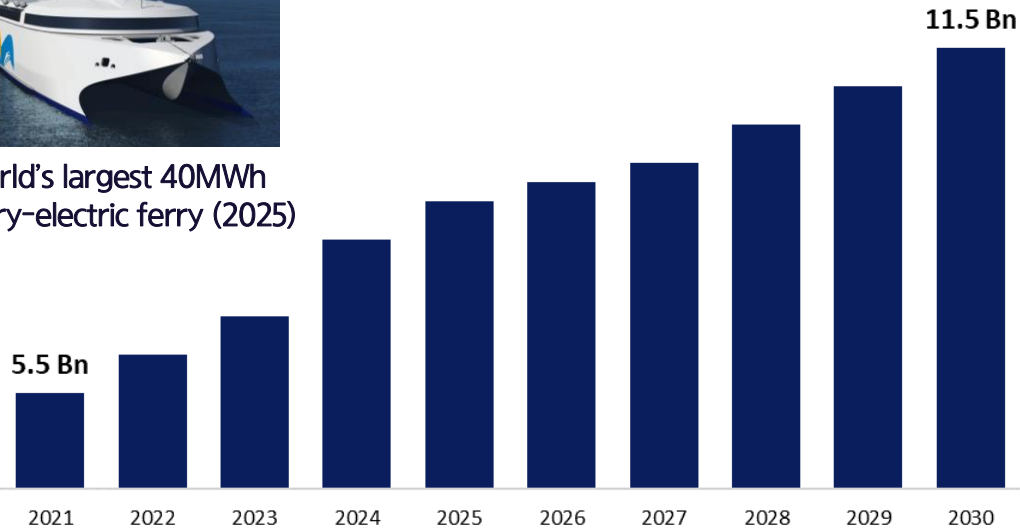
〈MOCS test facility with HiMSEN engine〉

Fuel Cell and Electric Propulsion



World's largest 40MWh battery-electric ferry (2025)

Global Electric Ships Market



(Source: <https://www.sphericalinsights.com/reports/electric-ships-market>)

Europe



- Amogy Ammonia Power Solution's Tug Boat (2023 Sea-trial)
- Ammonia, 600kW PEMFC, 400kWh Battery
- World's First DNV AiP

China



- CSIC's Electric Propulsion Liner (2022)
: World's Largest 7.5MWh LFP Battery (CATL)
- Application of Chinese Battery and Converter

Japan



- KHI's Electric Propulsion Product Carrier (2022)
: 3,480 kWh Lithium-ion Battery
- PowerX plan to build a power carrier (2025)

'17

'18

'19

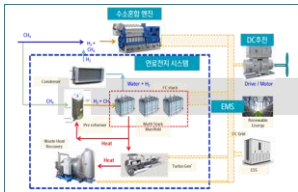
'20

'21

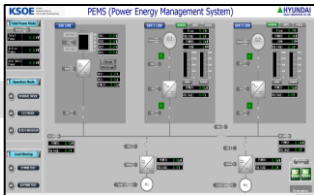
'22

'23

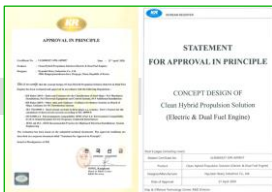
TRL 1~3 : Basic Tech. Research



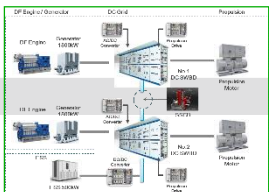
Multi-Fuel Electric Propulsion System
DNV AIP (2017)



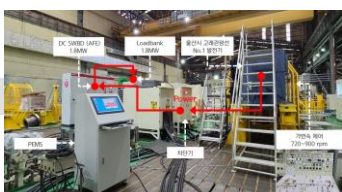
Integrated Control System
Pilot Product (2018)



HiMSEN (LNG DF) Engine Electric Propulsion System
KR AIP (2020)



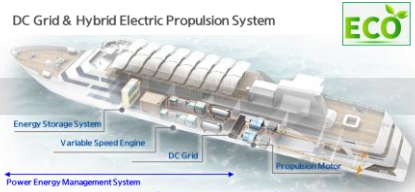
4MW DC Electric Propulsion System
KR Approval (2021)



Korea First 1.8MW High Efficiency VFD Generation System (2021)

TRL 7~8 : Onland

TRL 9 : Actual System



Ulsan Taehwaho (2,800DWT) Actual system proven trial (Jun.~Nov. 2022)



Electric Propulsion System for VLCC LR AIP (2023)

Rapidly Changing Market and Action Needed

Regulations

Evolve faster
and stricter

- ✓ Technology for decarbonization should speed up
- ✓ Operational measure to be provided
- ✓ Uncertainty of regulation to be minimized

Fuels

Various fuel path
after 2040

- ✓ Flexible technology for fuel mix to be prepared
- ✓ High efficiency ship for increased fuel cost
- ✓ Cross industry collaboration for supply chain

Thank you for your attention