[Shipbuilding]
“Green Technology for Decarbonization, Life Cycle Management and Green Shipping Corridor”

[조선] “탈 탄소 대응기술과 디지털전환에 따른 미래 조선 기술” Preliminary

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Senior Vice President, AVL List GmbH

25 October 2023

Overview

Preliminary

Context

Decarbonization vs GHG

- Maritime Transportation
- Fuels versus Emission in Maritime Industry
- Maritime Emission Regulations

What

Facts

- Decarbonization versus GHG
- Current Status of Technology Development
- Reality Check

What to do/How

Revolution or Evolution

- New Technologies and its the State-of-Art
- Complexity and Flexibility
- Cooperation & Collaboration: Green Shipping Corridor

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Note: Author reserve corrections and modification.

50% of power for all world trade covered by our engines

3%

of worldwide CO_2 emissions are caused by shipping (~ 1.2 bn tons of CO2)

90%

of the goods traded around the world are transported via maritime shipping

50%

IMO: Reduction of annual shipping emissions by 2050 (compared to 2008)

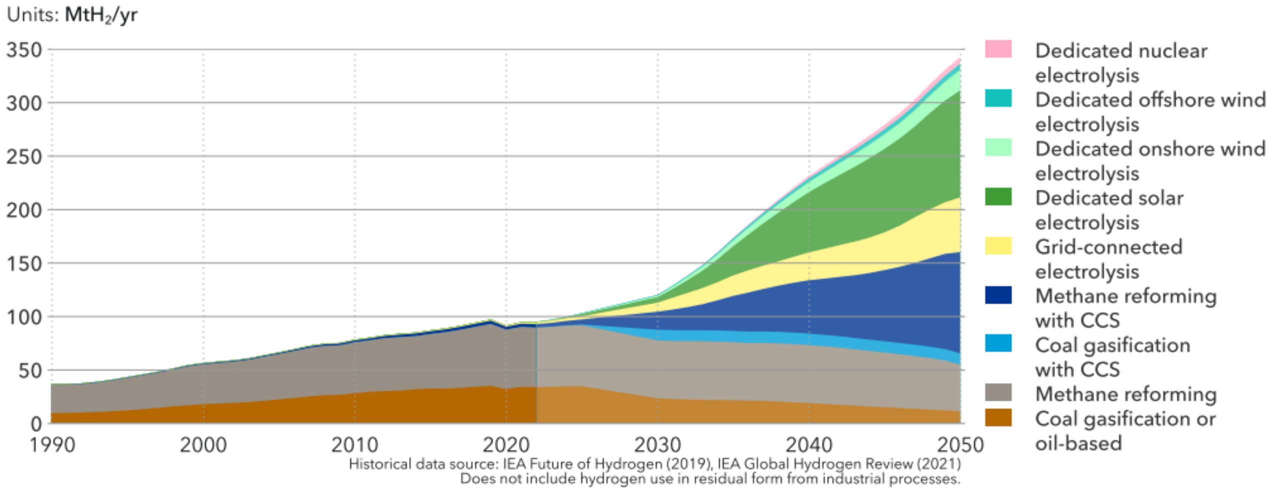
Only with alternative green fuels

the CO_2 reduction targets can be reached

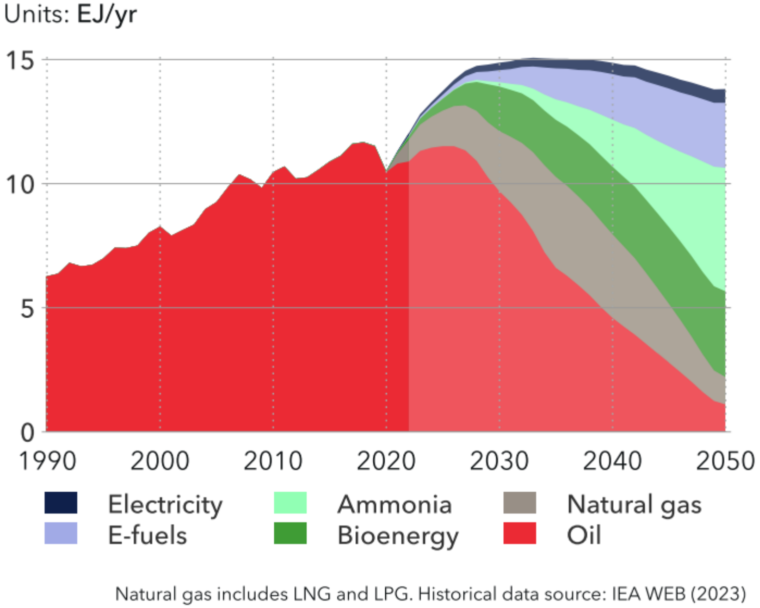
Forecast

Fuels versus CO_2 Emission

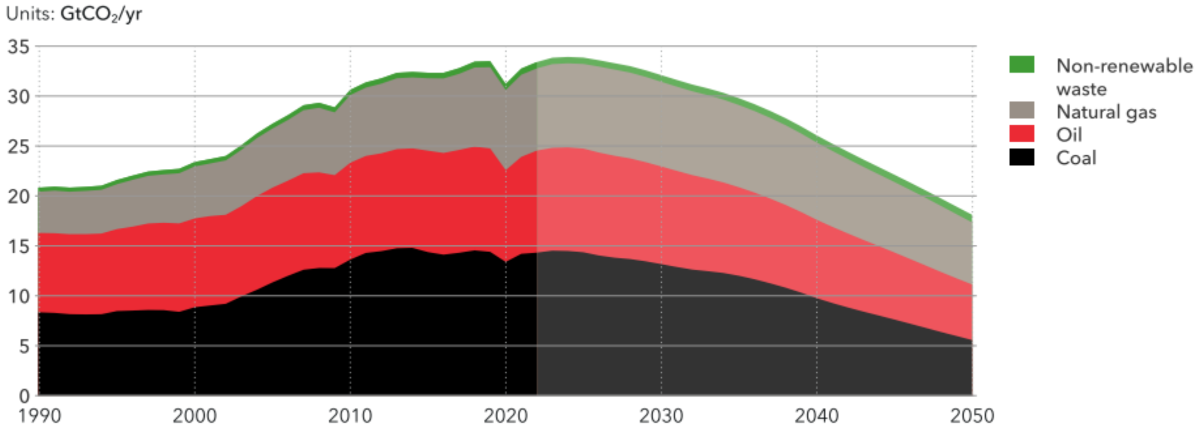
World hydrogen production by production route



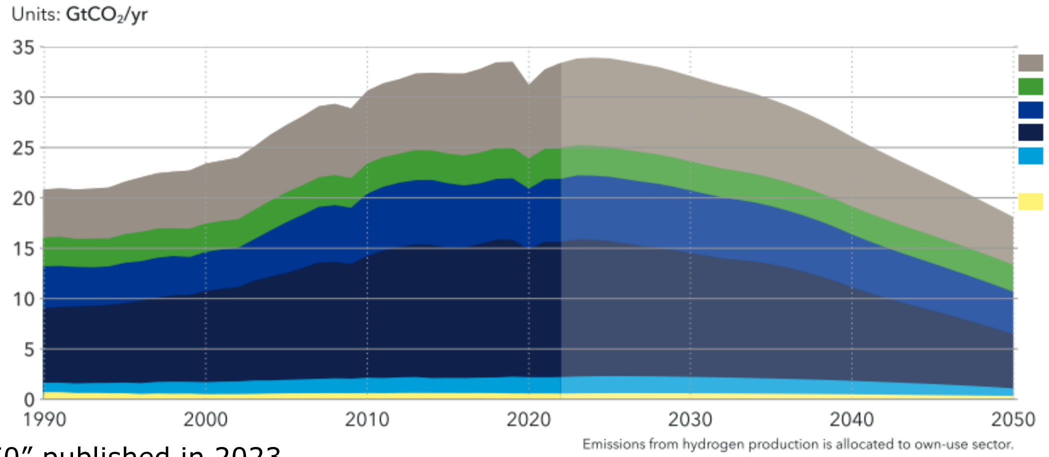
World maritime subsector energy demand by carrier



World energy-related CO_2 emissions by fuel source

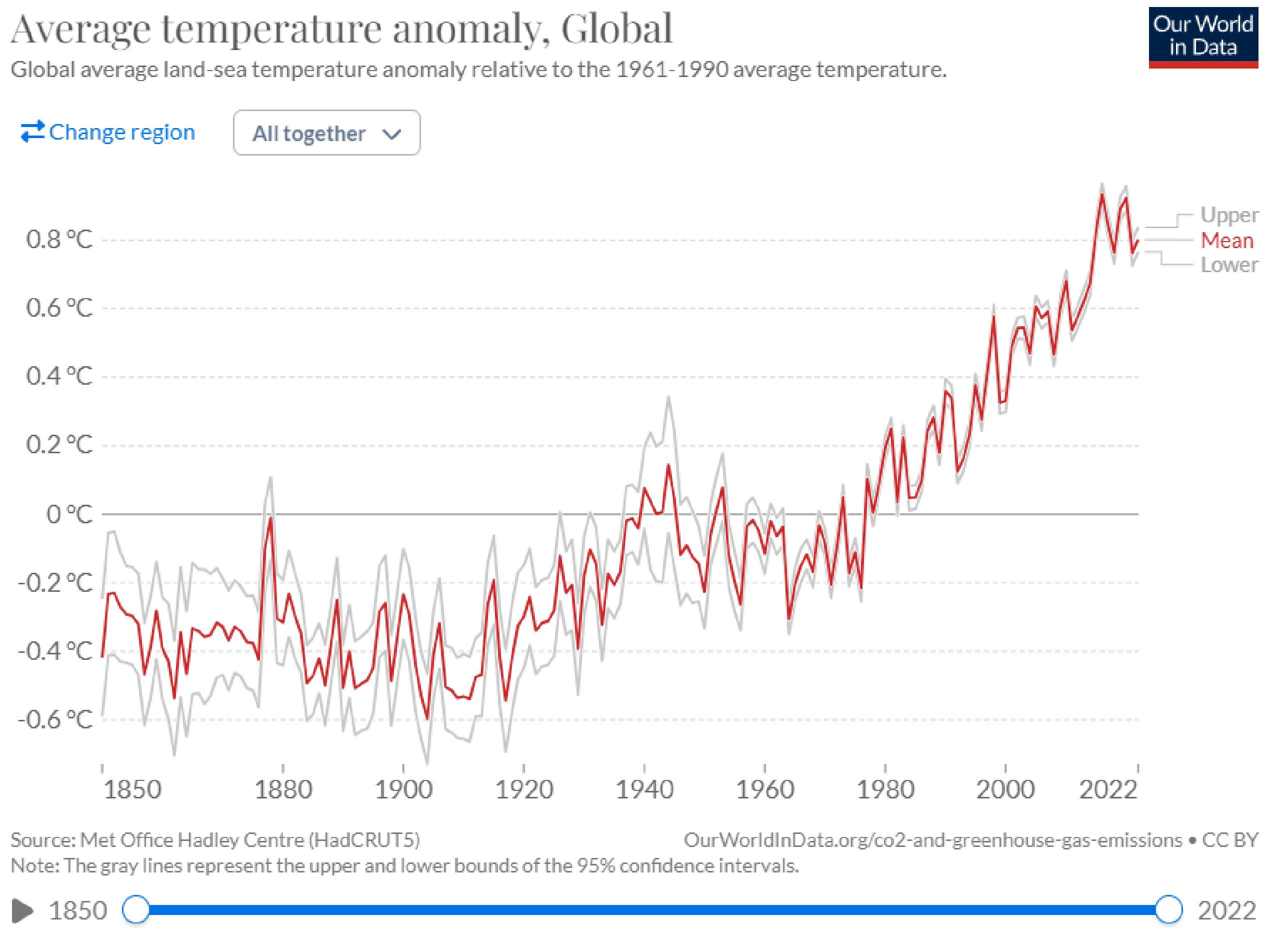


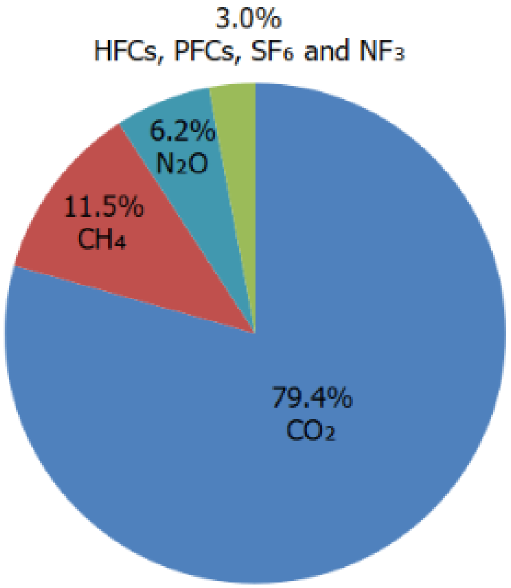
World energy-related CO_2 emissions by sector



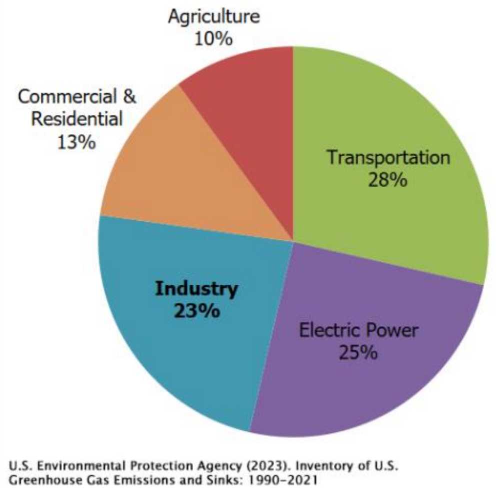
Source: DNV "Maritime Transition Outlook 2050" published in 2023

Green House Gas – CO_2, CH_4, N_2O, Fluorinated Gas, PM, etc





Total U.S. Emissions in 2021 = 6,340 Million Metric Tons of CO_2 equivalent (excludes land sector). Percentages may not add up to 100% due to independent rounding. Land Use, Land-Use Change, and Forestry in the United States is a net sink and offsets 12% of these greenhouse gas emissions. This net sink is not shown in the above diagram. All emission estimates from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021*.

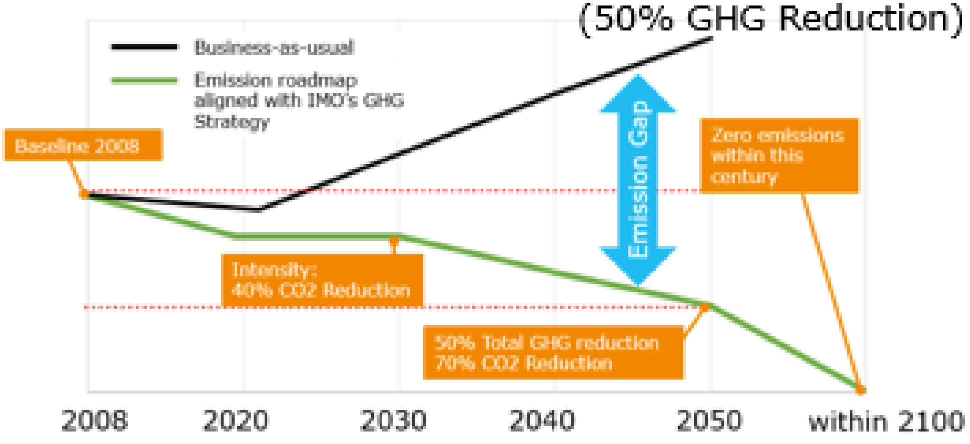


Source:https://ourworldindata.org/co2-and-greenhouse-gas-emission, https://www.epa.gov/ghgemissions/overview-greenhouse-gases
https://www.google.com/search?q=biggest+contributor+to+greenhouse+gas+emissions+globally&rlz=1C1GCEA_enAT1013AT1013&ei=dfqbZJbLFJTo7_UPxtOz6As&oq=contributor+to+greenhouse+gas+emissions&gs_lp=Egxnd3Mtd2l6LXNlcnAiJ2NvbnRyaWJ1dG9yIHRvIGdyZWVuaG91c2UgZ2FzIGVtaXNzaW9ucyoCCAAyBhAAGAUYHjIGEAAYBRgeMggQABgFGAcYHjIGEAAYBRgeMgYQABgFGB4yCBAAGAUYBxgeMggQABgFGAcYHjIGEAAYBRgeMgYQABgFGB4yCBAAGAUYBxgeSPNAUABYjh5wAHgBkAEAmAFloAHQCaoBBDE0LjG4AQHIAQD4AQHCAgcQABgNGIAEwgIGEAAYBxgewgIIEAAYBxgeGA_CAggQABgHGB4YE8ICChAAGAcYHhgPGBPCAgkQABgNGBMYgATCAgoQABgFGAcYHhgT4gMEGAAgQYgGAQ&sclient=gws-wiz-serp#imgrc=UPNzTtjozI422M

Market Drivers
Emission regulations world-wide

GHG 2050
Referenced to 2008 values
- 40% CO2 reduction by 2030
- 70% CO2 reduction by 2050

(50% GHG Reduction)



Short-term 2018 – 2023
- Tighter EEDI & SEEMP
- Speed Reduction
- Energy efficiency indicators
- National Action Plans

Mid-term 2023 – 2030
- Energy efficiency measures (new and existing ships)
- Carbon pricing
- Plan for low carbon fuels

Long-term 2030
- Development of (net) zero carbon fuels
- New and innovative emission reduction mechanisms

Based on DNVGL Maritime Transition Outlook 2050

→ **Zero Carbon !**

EU Parliament (16.09.2020)
- in favor of 40% CO2 reduction by 2030
- Maritime transport to be included in EU Emissions Trading System (ETS)

China plans to become Carbon-Neutral by 2060

Korea aim to reduce CO_2 over 35% reduction by 2030

European Green Deal Making the EU Climate Neutral by 2050

FuelEU Maritime
- Calculation of the fleet average GHG intentsity in 2020 and based on this reference, emission levels (-75% reduction from 1 January 2050)
- Maritime transport to be included in EU Emissions Trading System (ETS)
- Zero emissions requirements by 2030 (ships at berth)
- Scope proposed to be 50% of emissions from inbound and outbound EU voyages and 100% of emissions form intra-EU voyages and when in EU ports

Biden pledges to slash greenhouse gas emissions in half by 2030

CNBC

Market Observation on Transition Methanol on Spotlight

Maiden voyage and arrival at Copenhagen for namegiving of Laura Maersk, the world's first methanol fuel-enabled container ship. Image, courtesy A.P. Møller - Mærsk A/S.

MAN Energy Solutions developed the ME-LGIM dual-fuel engine for operation on methanol, as well as conventional fuel (source: MAN ES)

total nearly 20 vessels.

MAN wins Maersk methanol engines contract
18 Oct 2022by Jamey Bergman
MAN Energy Solutions will supply the engines for Maersk's latest six methanol-ready, dual-fuel newbuilding box ships
Hyundai Heavy Industry's (HHI) shipbuilding division has ordered six MAN B&W G95ME-C10.5-LGIM dual-fuel main engines in connection with a recent ship order from container shipping giant Maersk.
In early October 2022, Maersk announced a six-vessel order for 17,000-TEU container vessels with HHI.

DFDS
Copenhagen-headquartered freight and passenger ferry operator DFDS is evaluating a system that injects methanol and hydrogen as a solution for its conventional four-stroke engines.

Source: DNV "Maritime Transition Outlook 2050" published in 2023 and press release by HD KSOE and public media

MAN wins retrofit contract on 22 June 2023 2 min read
11 container ships to be outfitted with engines capable of using methanol.
Maersk Line recently signed a Letter of Intent (LOI) with China's Yangzijiang Shipbuilding Ltd. for the construction of eight 8,000 TEU methanol-powered container ships. (22 June 2023)

METHANOL ENGINE, FUEL CELLS, HYBRID SYSTEMS - ROLLS-ROYCE PRESENTS NEW MTU PROPULSION SOLUTIONS FOR SHIPS AT SMM
Posted on September 06, 2022

- Launch from 2026: Methanol engines based on mtu Series 4000
- Launch from 2028: mtu fuel cell systems
- Available from 2023: mtu Hybrid PropulsionPack for mtu Series 2000 and 4000

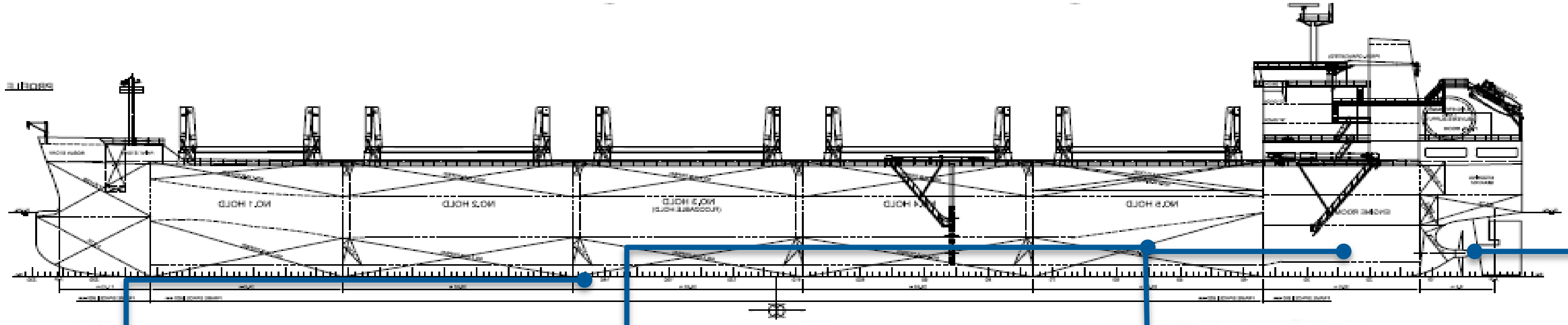
Rolls-Royce will be showcasing new sustainable mtu marine solutions for propulsion, automation and service at SMM, the international maritime industry trade fair, in Hamburg, Germany, from 6 – 9 September 2022, under the slogan 'Pioneering the journey to Net Zero'. At booth 307 in Hall 3A, Rolls-Royce will present methanol engines, fuel cell concepts, hybrid systems, diesel engines with exhaust aftertreatment and for use with sustainable fuels, as well as mtu NautIQ marine automation products.
Market launch from 2026: Methanol engines based on the mtu Series 4000

COSCO splashes $2.87 bln on twelve methanol-powered 24,000 TEU mammoths
October 31, 2022, by Jasmina Ovcina Mandra

Hong Kong-listed shipping major COSCO Shipping Holdings has placed an order for the construction of twelve 24,000 TEU methanol dual-fuel containerships worth $2.87 billion.
The construction contract was signed by the company's subsidiaries Orient Overseas Container Line (OOCL) and Cosco Shipping Lines with Nantong Cosco Khi Ship Engineering (NACKS) and Dalian COSCO KHI Ship Engineering Co. (DACKS).
Under the contract, NACKS, a joint venture between Kawasaki Shipbuilding Corporation and COSCO Shipping, will be encharged with building seven units from the batch, while DACKS shipyard, another JV between COSCO Shipping and Kawasaki Shipbuilding, will be entrusted with the construction of the remaining five ships.

Wavelength secures methanol fuel supply deal in China
October 17, 2022, by Fatima Bahtić
Portugal-based energy and tech company Wavelength Technology Center has secured a contract for a methanol marine fuel supply system.

The-state-of-art - Methodology
Progression of Complexity



	Bunker Fuel	Power Generation	Prime Mover	Propulsion System
Today	▪ HFO (dominantly) ▪ MDO/MGO	▪ Aux. Diesel Gensets ▪ DF Gensets	▪ 2-St, 4-St Diesel (HFO) ▪ DF Engines	▪ Mechanical Propulsion ▪ Electric Propulsion
2030-2050	▪ Hydrogen ▪ Ammonia ▪ Methanol ▪ LNG ▪ SNG (Syn. Methane) ▪ LPG ▪ Biofuel, HVO, etc.	▪ LNG, H2, Gensets ▪ Hybrid Power System ▪ Fuel Cell System ▪ Alternate Marine Power (AMP) – „Cold Ironing“	▪ DF Engines ▪ Multi Fuel Capability ▪ SCR, EGR, Scrubber ▪ ORC – WHR Systems ▪ Hybrid PTI/PTO	▪ Electric propulsion ▪ Hybrid Propulsion Syst. (w/shaft generator) – PTO (Transit, parallel, shore connection mode) – PTI (Diesel electric, fully electric, boost mode)

Hybrid & Integration Technologies: CCUS, Electrolyzer, Wind Power etc.

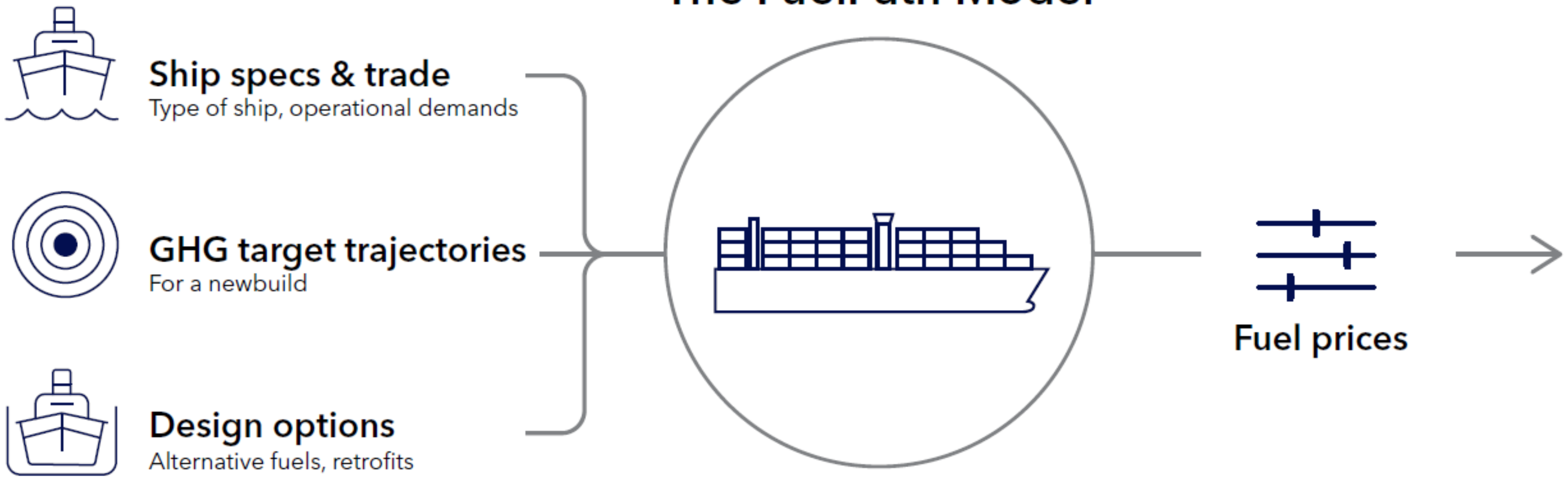
Maritime Transportation and Shipbuilding

Pathway to Future of Propulsion System → Strategy towards GHG

- ✓ 70% of CO2reduction in 2050 and net zero emission
- ✓ TTW to WTW, GWP100 vs GWP100
- ✓ EEDI(New shipbuilding), EEXI/CII(Existing vessels)
- ✓ Strategy Move: Decarbonization CO_2, NOx, SOx
  → GHG Gases; CO_2, CH_4, N_2O, PM(BC)
- ✓ CCUS, PtX
- ✓ **Crew Traininig & Logistics of Sourcing new components**

Estimated total cost of ownership

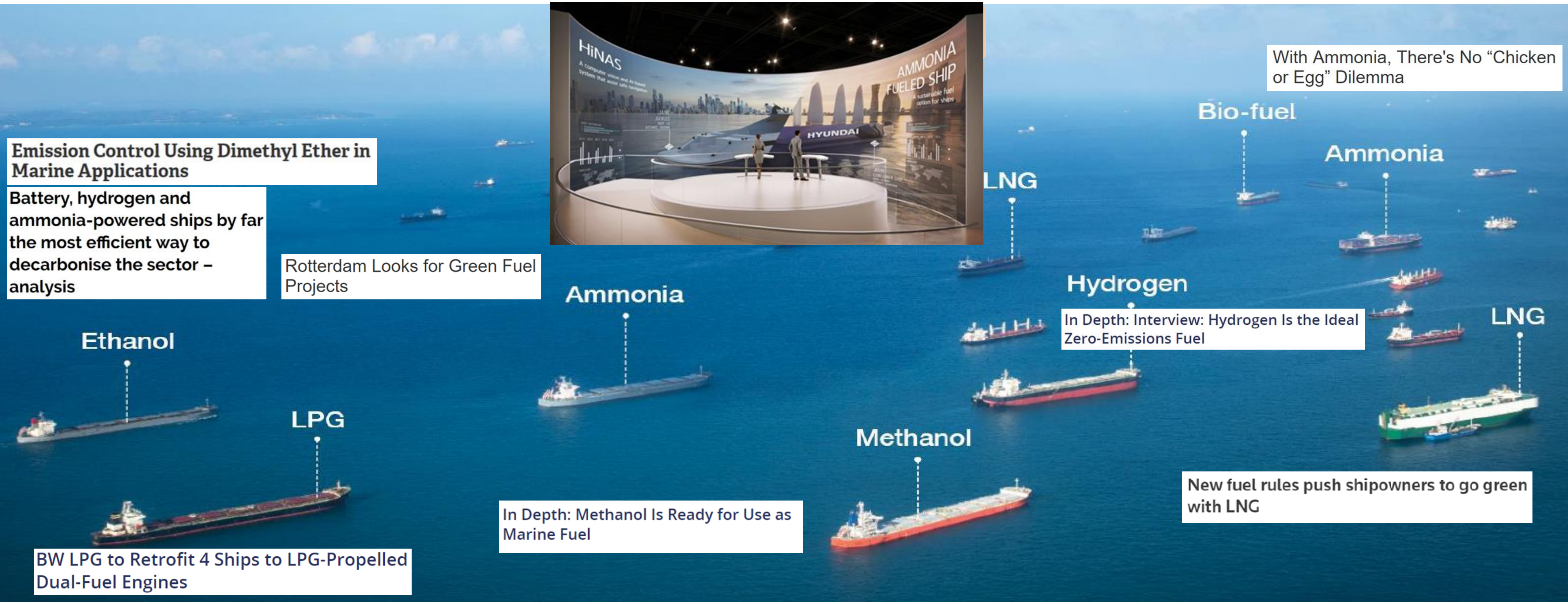
The FuelPath Model



Key considerations
Maturity & availability of technology
Specific energy (weight) & density (volume)
Safety considerations (flammability, toxicity)
Regulatory framework
Global availability of fuel (terminal network)
Availability of bunkering facilities
Sustainability (ESG/CSR aspects)
Cost (CAPEX, OPEX)
Incentivation (regulation, financing)
Flexibility for future adaptation

Source: Edited based on BV Verifuel, Large Engine Competence Center@LEC GmbH

A Future Scenario for Fuels on Shipping
Complexity and Flexibility



Source: HD KSOE, Presentation by Mr. Kjeld Aabo/MAN E.S. at The Maritime Hydrogen Conference at NorShipping 2022, Oslo| G. Stiesch – Decarbonization – Large Engine TechDays – ©2021

Thank you

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