Ship Fuel Transition and Future Changes in the Maritime Logistics Industry

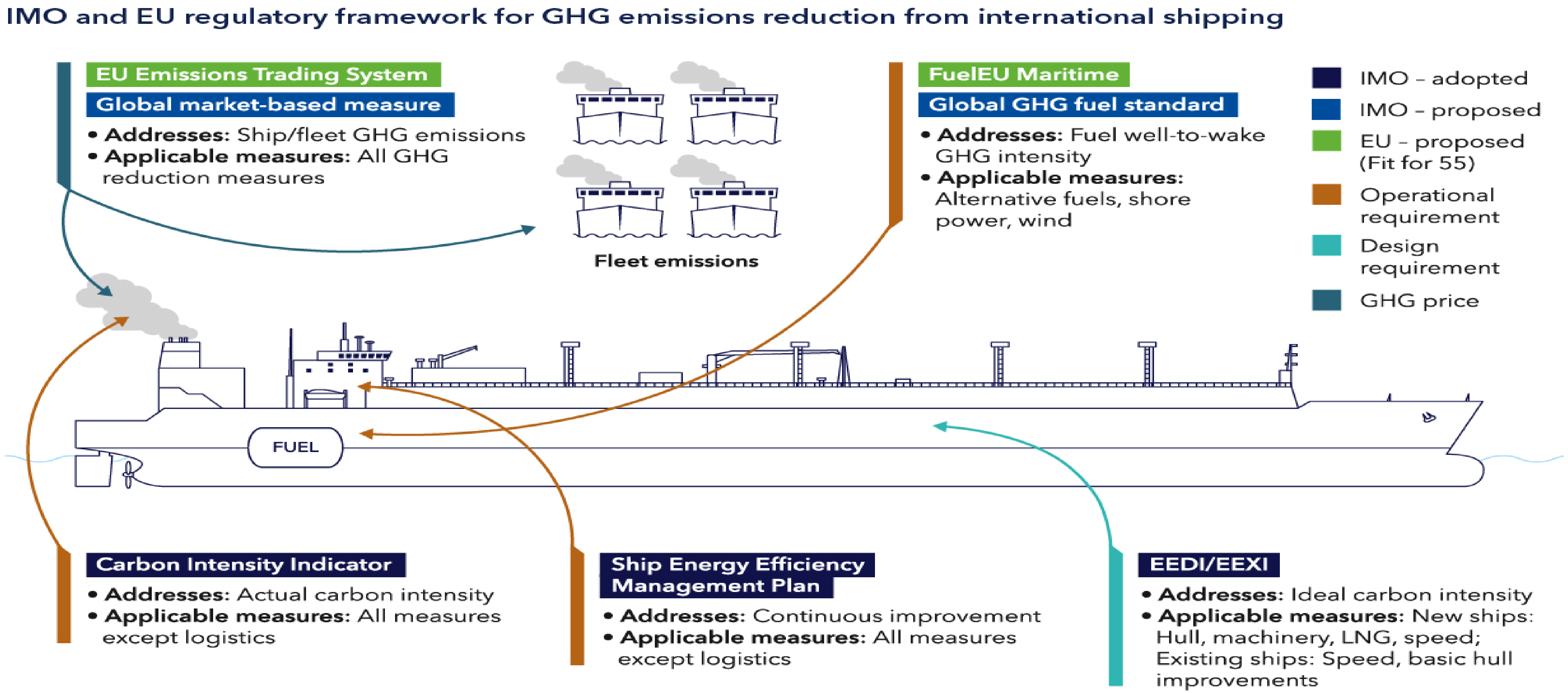
Eon-Kyung Lee
Deputy President of Logistics and Maritime Industry Research Department
Korea Maritime Institute

October 24, 2023

Contents

Three Key Direction for Reduction on GHG Emissions from Ships by IMO and EU

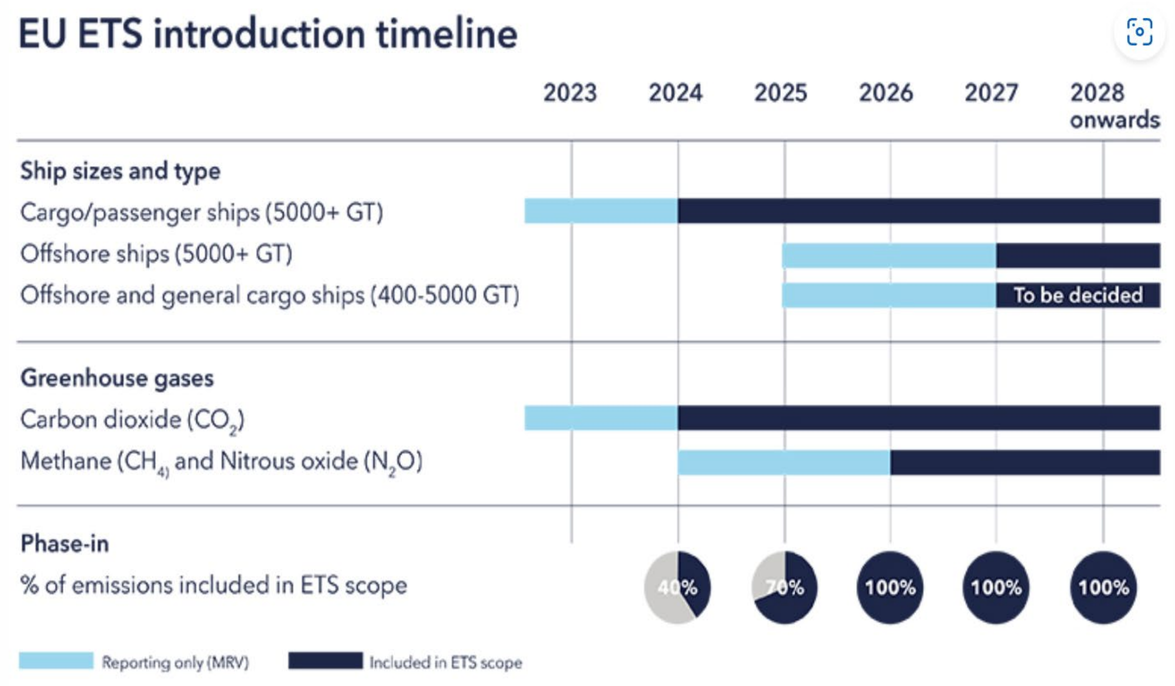
- Technical Measures(EEDI/EEXI), Operational Measures(SEEMP, CII), Economic Measures(MBM-ECTS, Levy)



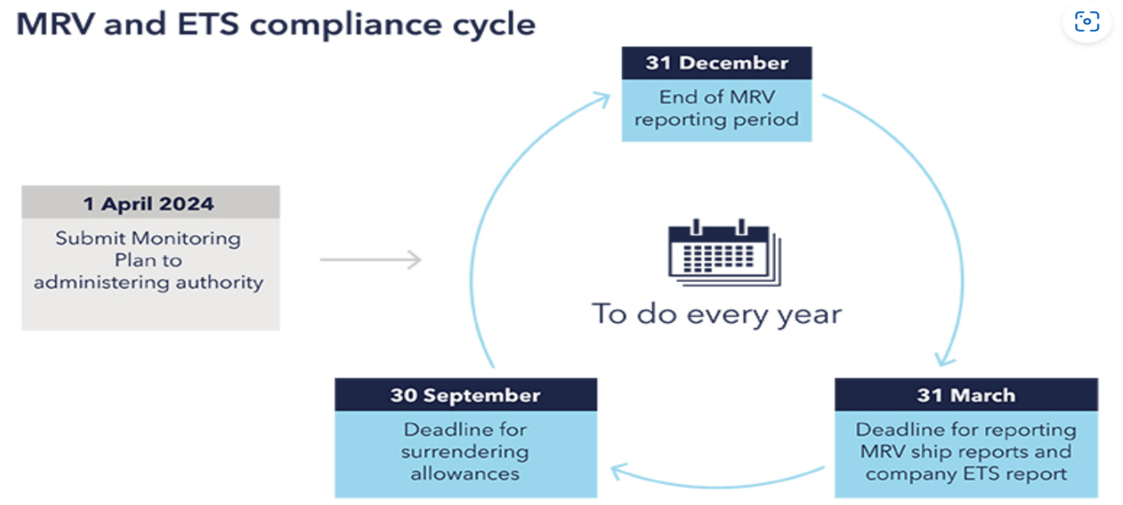
Source: DNV Maritime Forecast to 2050-Energy Transition Outlook 2022

GHG Reduction Mechanism in the EU(1/2)

- EU-ETS and MRV(Measurement, Reporting, and Verification) Mechanism



Shipping companies with ships operating to or from ports in the EU or EEA will be required to hold sufficient EUAs for the GHG emissions from ships under their control and surrender these allowances to the authorities each year. These companies are required to monitor, report and verify the GHG emissions on an annual basis under the EU MRV regulation and this information is used to determine the allowances they need to surrender.



Starting in 2025, the shipping company must submit a verified company emissions report to the administering authority by 31 March each year based on MRV ship emissions reports for the previous year, in line with a revised MRV monitoring plan required from 1 January 2024. This in practice means the ship emissions report needs to be verified and submitted a month earlier than under the current MRV system.

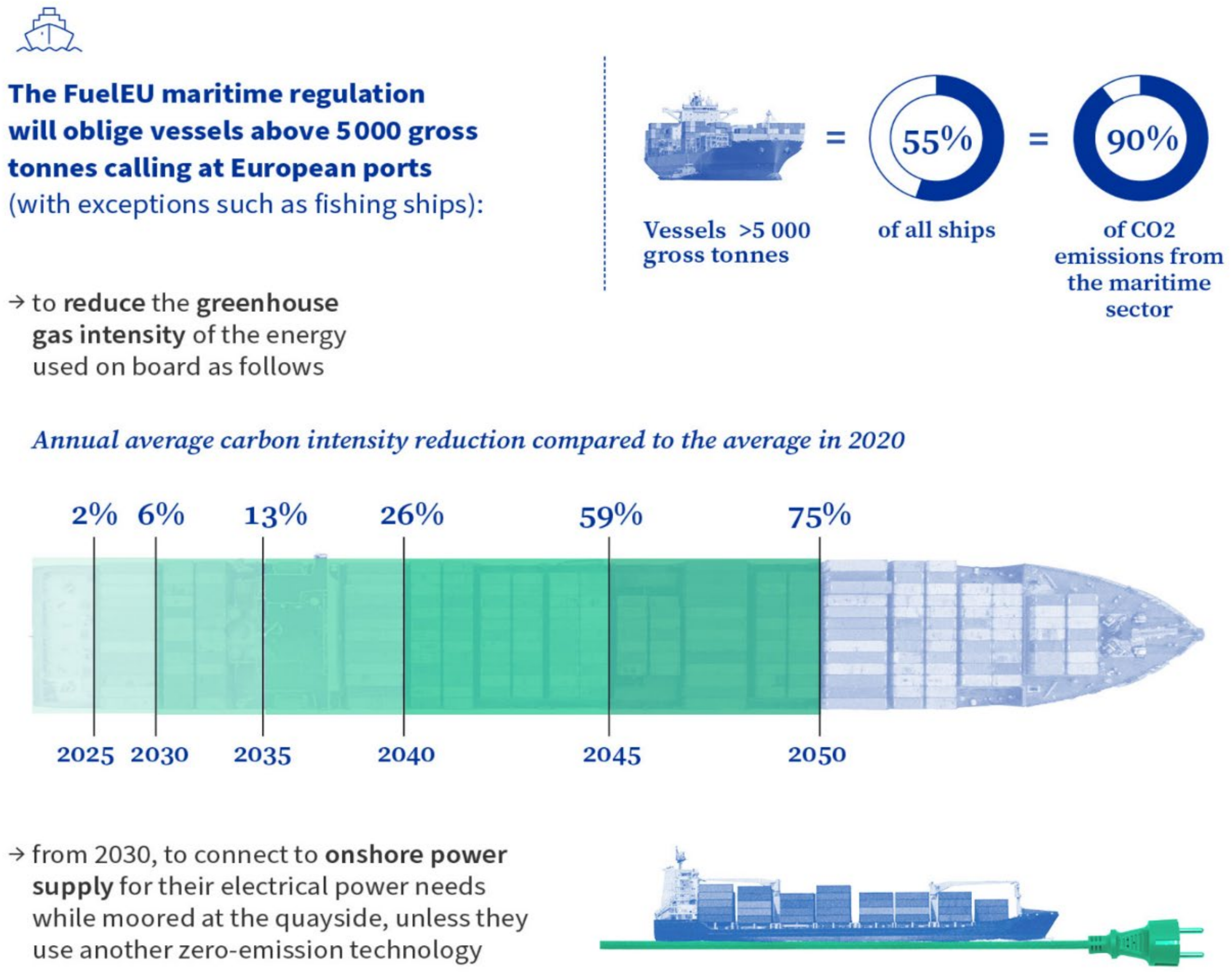
The necessary emission allowances are required to be surrendered to the administering authority by 30 September each year. Failure to surrender allowances within the deadline for a single ship can affect compliance for an entire fleet.

Companies that fail to surrender allowances are liable to an excess emissions penalty of 100 Euros per tonne of CO2, and are still liable for surrender of the required allowances. Failure to comply for two or more consecutive periods may result in the ships of the company being banned from trading in the EU.

Source: DNV

GHG Reduction Mechanism in the EU(2/2)

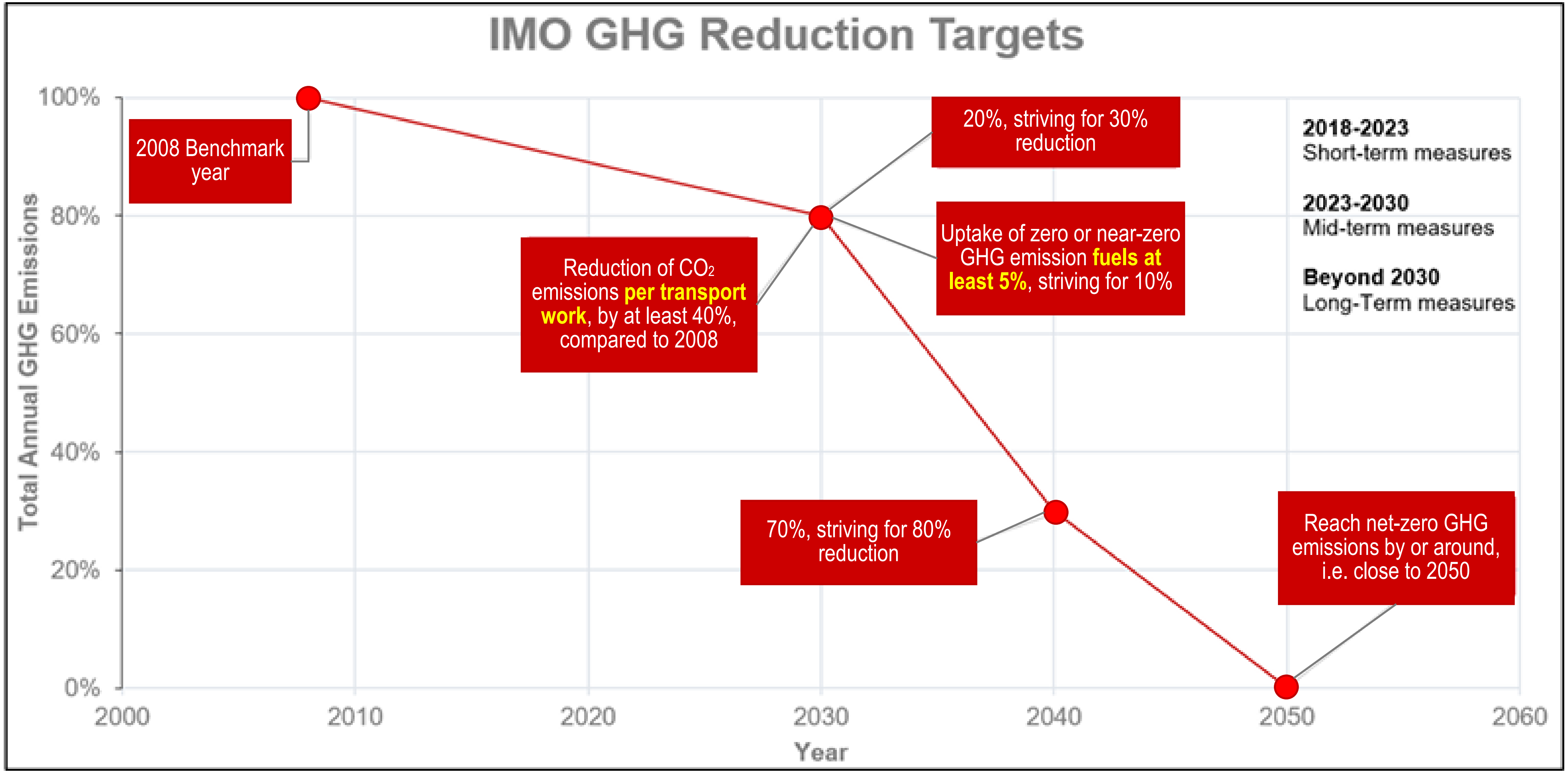
- EU, Fit for 55 – Target of reducing greenhouse gas emission by at least 55% across all sectors by the year 2030



Source: DNV

MEPC 80th Session(July 3 to 7, 2023) : IMO GHG Reduction Targets

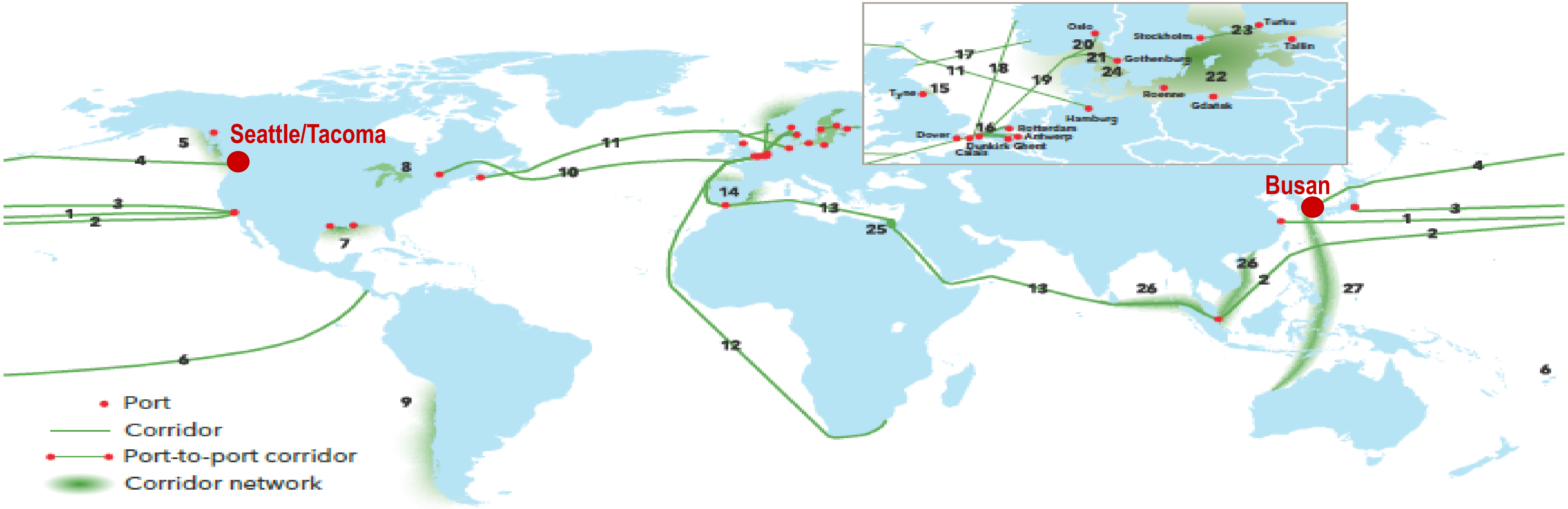
- GHG emissions from international shipping to reach net-zero by around 2050



Source: ABS, NEWS BRIEF MEPC 80

Green Shipping Corridors: Zero-emission maritime routes between two(or more) ports

- Thirty green shipping corridor initiatives announced as of June 202

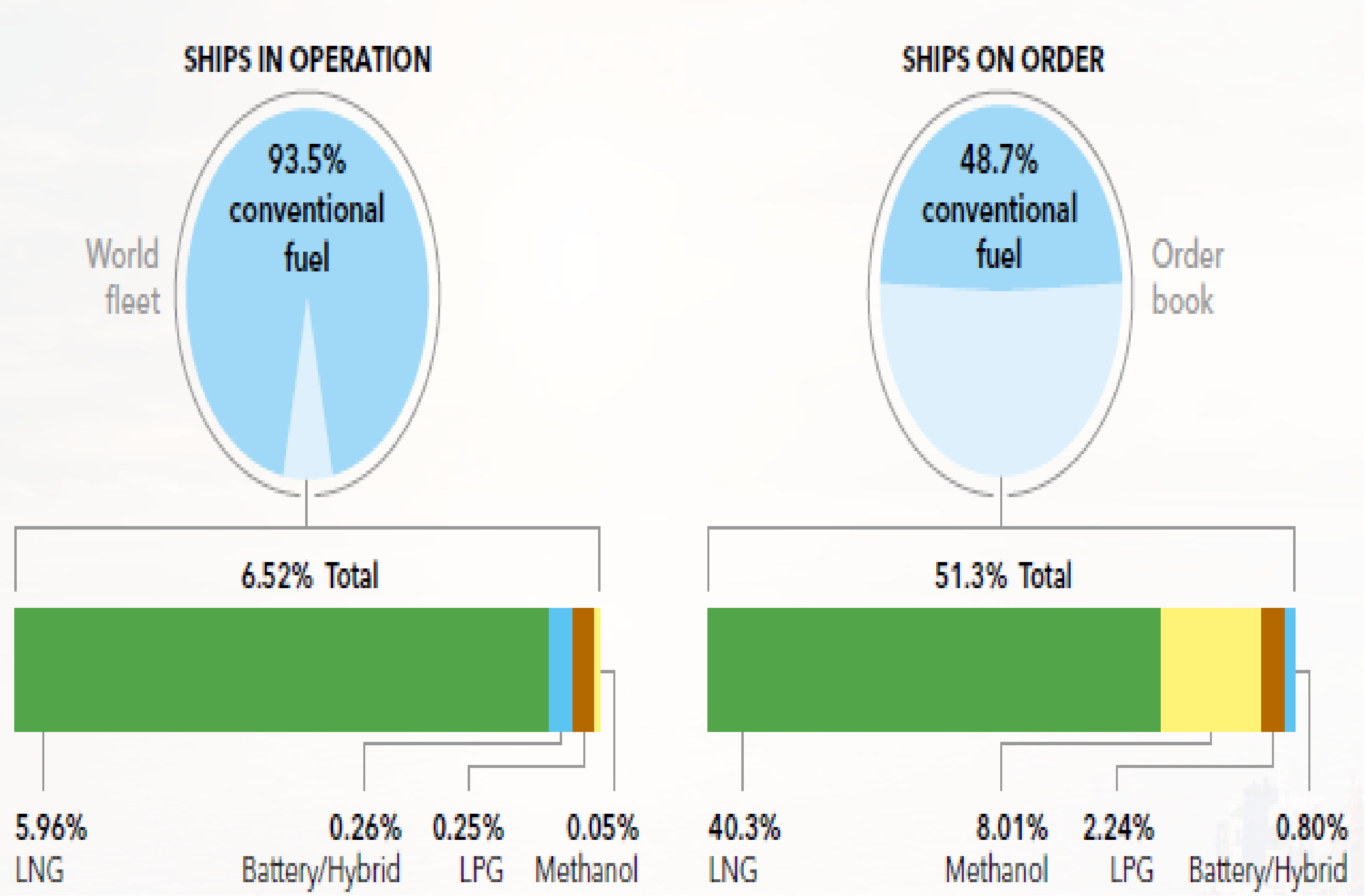


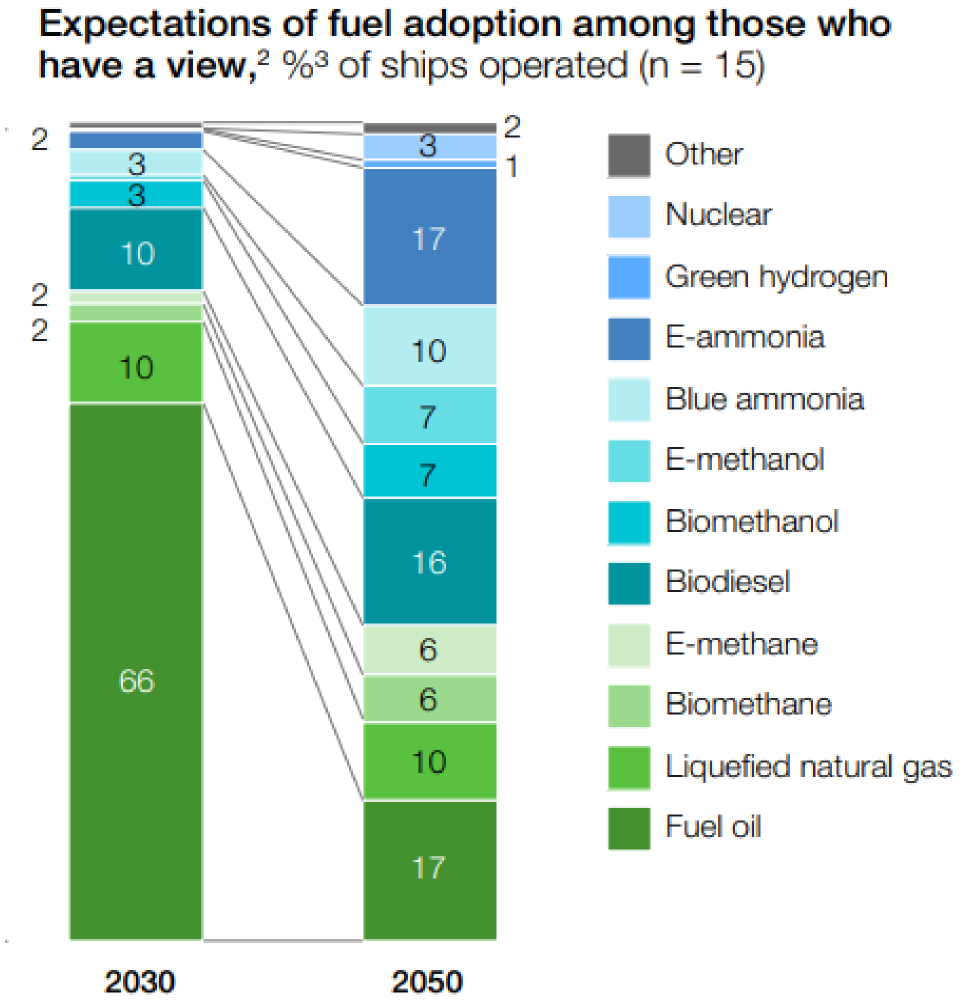
1 Shanghai – Los Angeles (LA)
2 LA-Long Beach – Singapore
3 LA – Tokyo –Yokohama
4 Busan – Seattle/Tacoma
5 Pacific Northwest – Alaska
6 US – Fiji – Panama
7 Gulf of Mexico
8 Great Lakes – St. Lawrence
9 Chilean Green Corridor Network
10 Antwerp – Montreal
11 Halifax – Hamburg
12 South Africa – Europe Iron Ore Corridor
13 Singapore – Rotterdam
14 Green Corridors Spain
15 Clean Tyne Corridor
16 Dover – Calais and Dover – Dunkirk
17 H_2 powered North Sea Crossing
18 Rotterdam – West-Coast Norway
19 Gothenburg – North Sea Port
20 Oslo Fjord – Rotterdam
21 Gothenburg – Rotterdam
22 European Green Corridor Network
23 Turku – Stockholm (Decatrip)
24 Nordic Regional Corridors
25 Suez Canal
26 SILK Alliance
27 Australia – East Asia Iron Ore
28 Rotterdam – Algeciras*
29 QUAD Shipping Taskforce*
30 G7 Corridors*

Source: DNV(2023)

Ship Propulsion Fuel Transition

- LNG → Methanol → Hybrid(E-ammonia, Hydrogen, etc.)

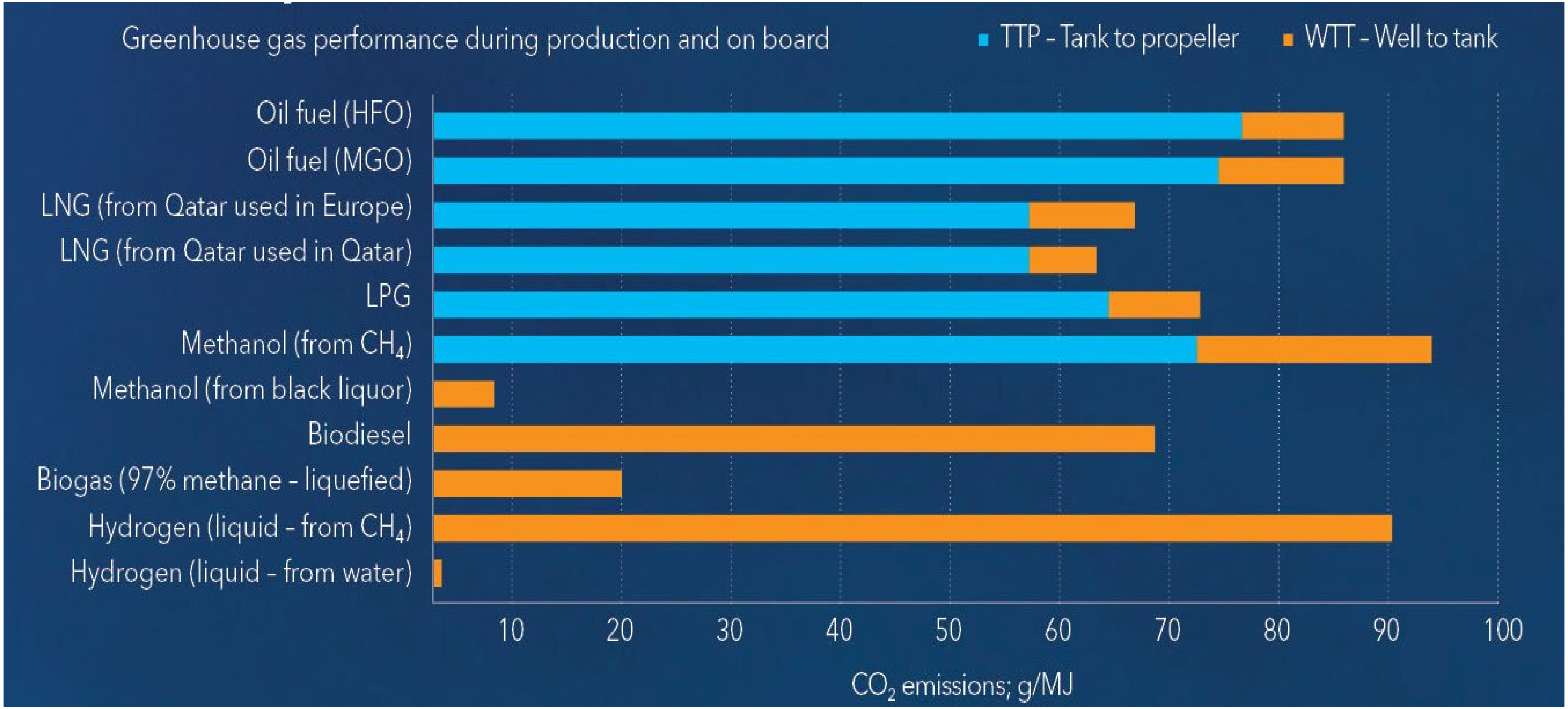




Source: DNV(2023), Mckinsey(2023.4)

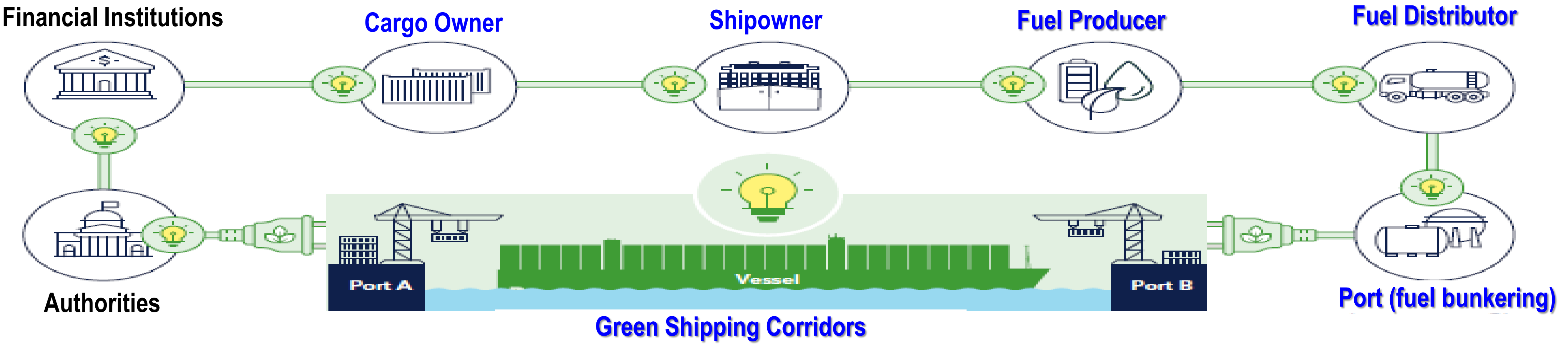
CO_2 Emissions of Fuel Alternatives in Shipping

- GHG performance during Well-to-Tank and Tank-to-Wake(=Tank-to-Propeller)



Source: V. Efecan, E. Gurgen, Investigation of the usability of renewable energy in maritime transportation, Mersin University Journal of Maritime Faculty, December 2019

Changes in Production-Storage-Shipping Logistics due to Ship Fuel Transition



Fuel Type	Production Technology	Port Facilities	Maritime Transportation(Ship)
Oil	Drilling, Refining	HFO, MDO Bunkering Facilities	Diesel Engine, Steam Turbine
LNG	Gas Production Facilities	Liquefaction Facilities LNG Bunkering Facilities LNG Handling Facilities	Cargo Containment System(-163^{o}C) Fuel Gas Supply System Dual Fuel Engine
NH3 (Ammonia)	Green Ammonia Production Facilities Required	Storage, Bunkering, Handling Facilities Required	Conversion of LPG Transport Ships to Ammonia Transport Ships, -33°C
LH2 (Liquid Hydrogen)	Green Hydrogen Production Required	Liquefaction, Bunkering, Handling Facilities (**Currently Nonexistent**)	CCS, FGSS, Engine **Development** Required (-252°C)

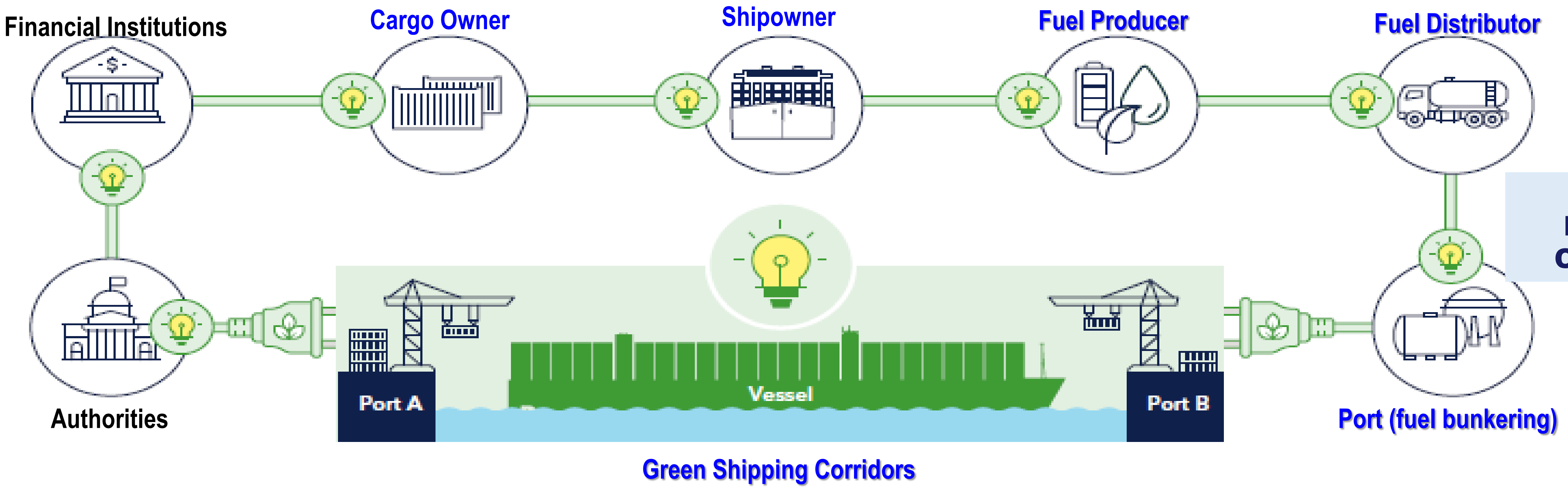
Source: DNV(2023), Written by Eon-Kyung Lee(KMI) and Prof. Sewon Kim(University of Sejong)

Seven Logistics Challenges to Address Due to Ship Fuel Transition

① Carbon-Neutral Fuel Supply and Demand Outlook

② Ship Engine and Technology Changes

③ Transport Containers Development



④ Port Facility Changes

⑦ Carbon Reduction Monitoring

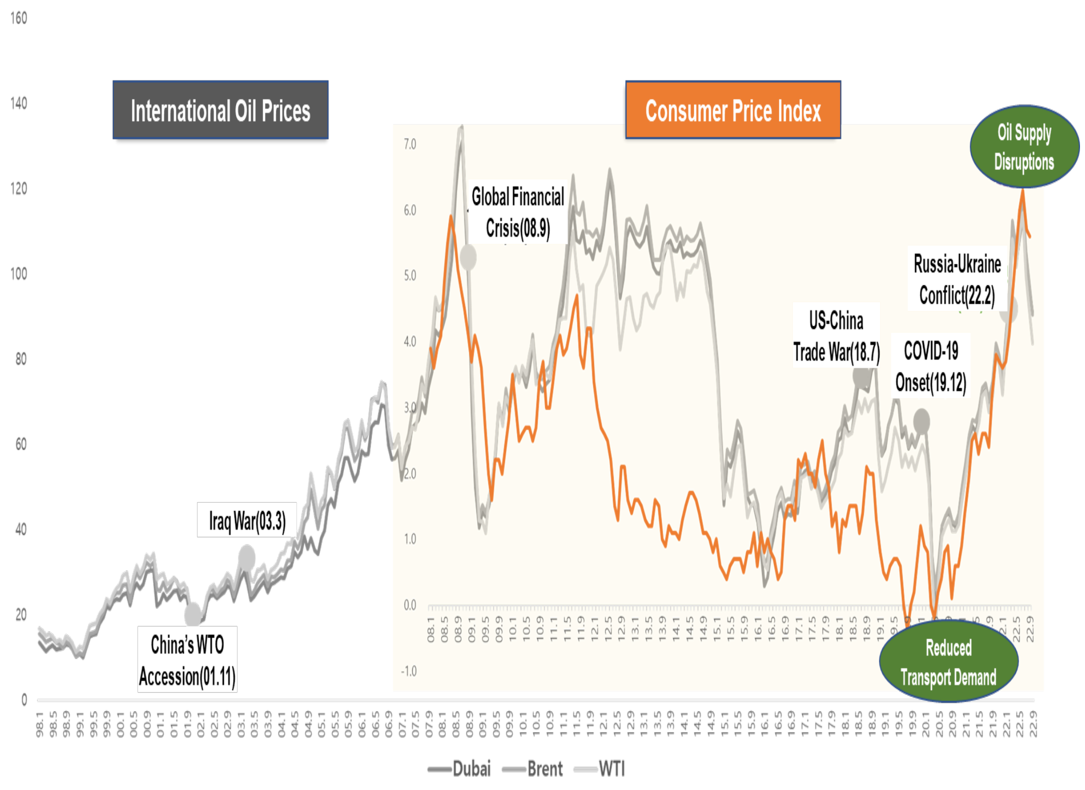
⑥ Risk Monitoring of the Entire Supply Chain

⑤ Maritime Transport Routes Changes

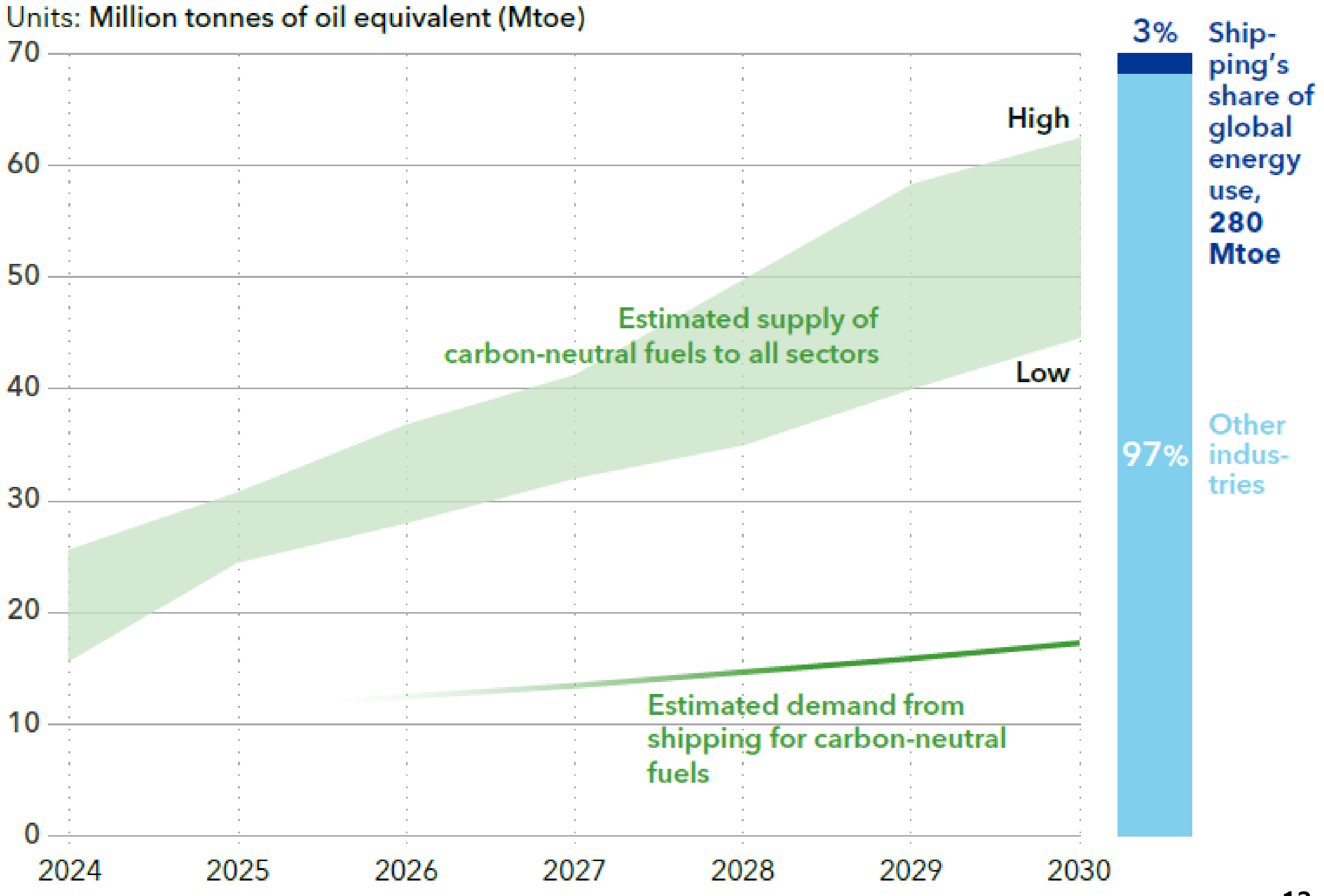
Source: DNV(2023), Written by Eon-Kyung Lee(KMI) and Prof. Sewon Kim(University of Sejong)

① Outlook on Carbon-Neutral Fuel Production and Demand

- Exploration of variables impacting prices, supply & demand for shipping carbon-neutral fuels
- Estimated supply and demand of carbon-neutral fuels, and price prediction



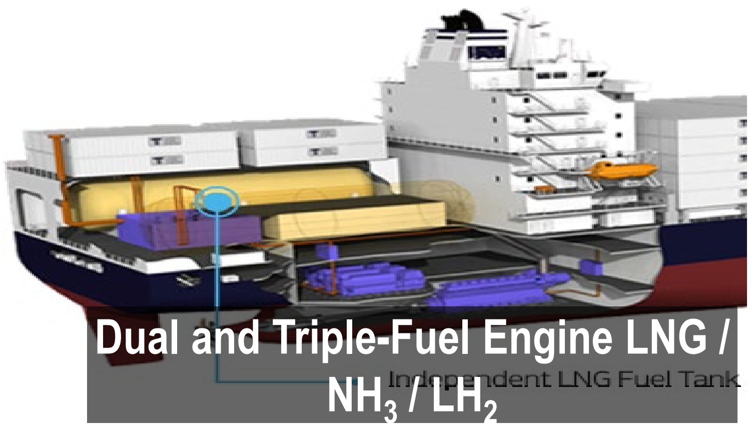
Cross-sector supply of carbon-neutral fuels vs. total shipping demand



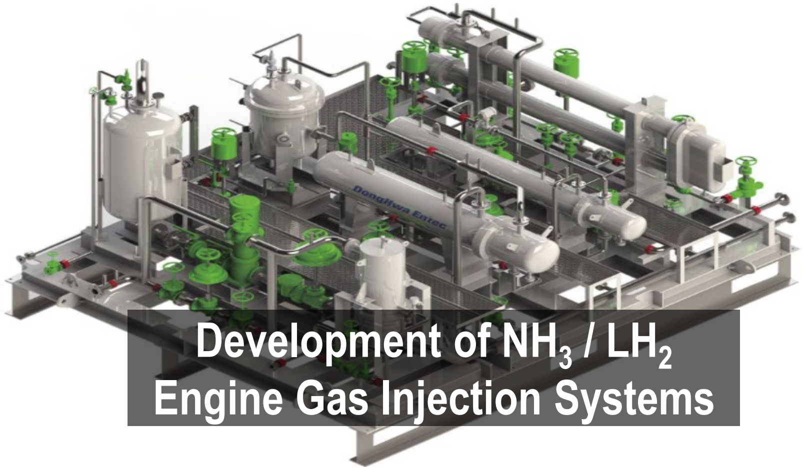
Source: DNV(2023), Eon-Kyung Lee Revised based on "Logistics Trend 2023"

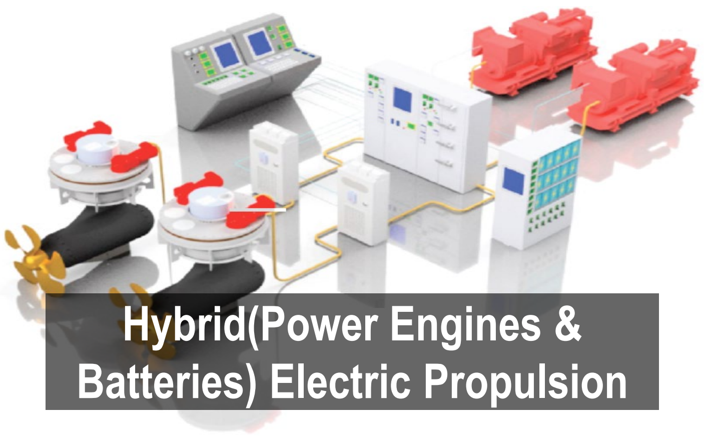
② Ship Engine and Technology Changes

- Development of large ship engines and propulsion systems for eco-friendly fuels such as LNG, ammonia, and liquid hydrogen
- Development of maritime transport tanks, bunkering, and loading/unloading systems for ammonia and liquid hydrogen
- Introduction of New Propulsion Methods Such as Electric and Nuclear Propulsion



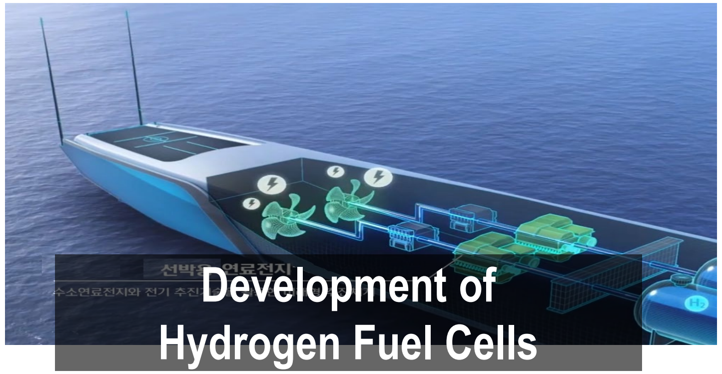
Dual and Triple-Fuel Engine LNG / NH_3 / LH_2


Development of NH_3 / LH_2 Engine Gas Injection Systems


Hybrid(Power Engines & Batteries) Electric Propulsion

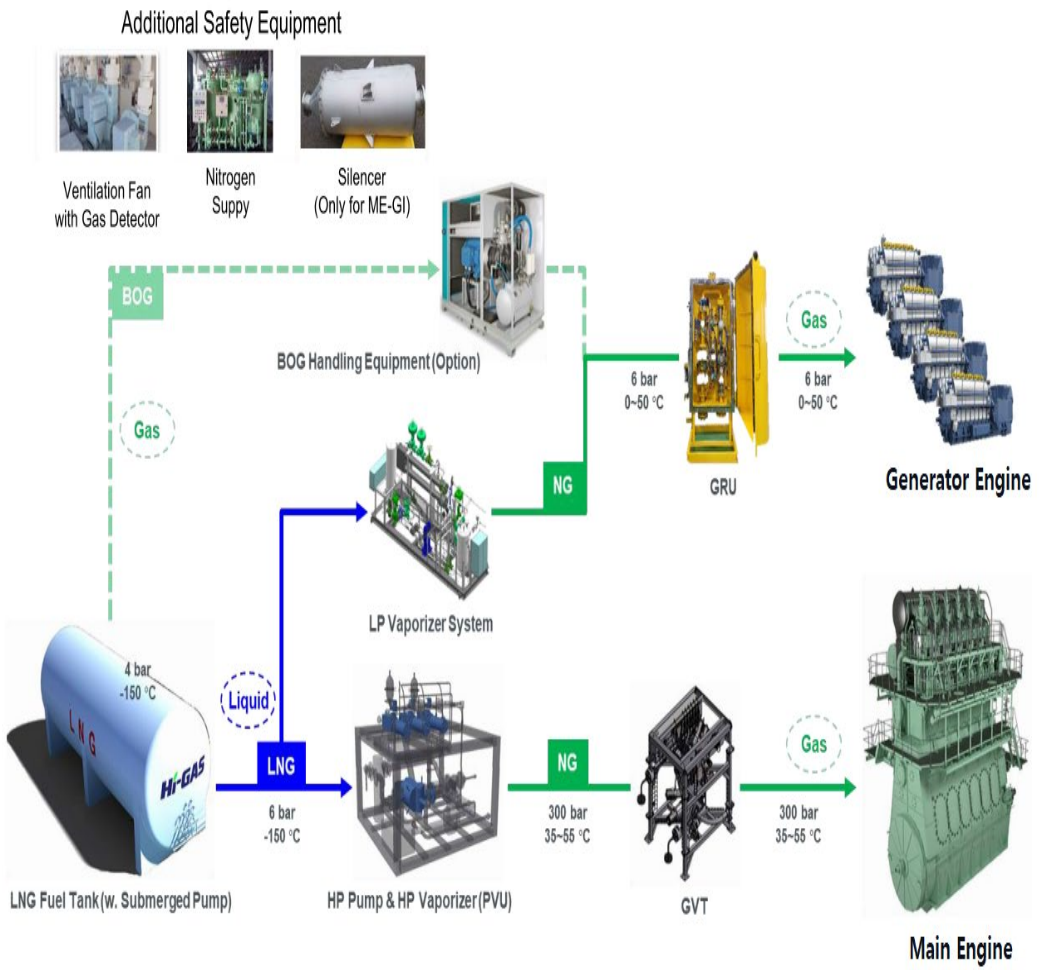

Carbon-Neutral Small Nuclear Reactor Propulsion


Development of NH_3 / LH_2 Transport Tanks

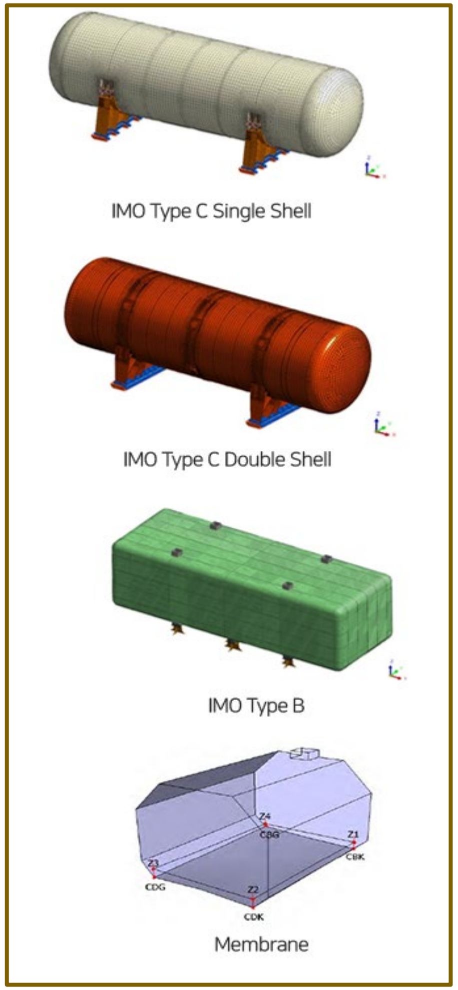

Development of Hydrogen Fuel Cells

Source: Eon-Kyung Lee Revised based on "HD Hyundai Homepage"

③ Development of Transport Containers



LNG, LH_2 **FGSS** **Engine**



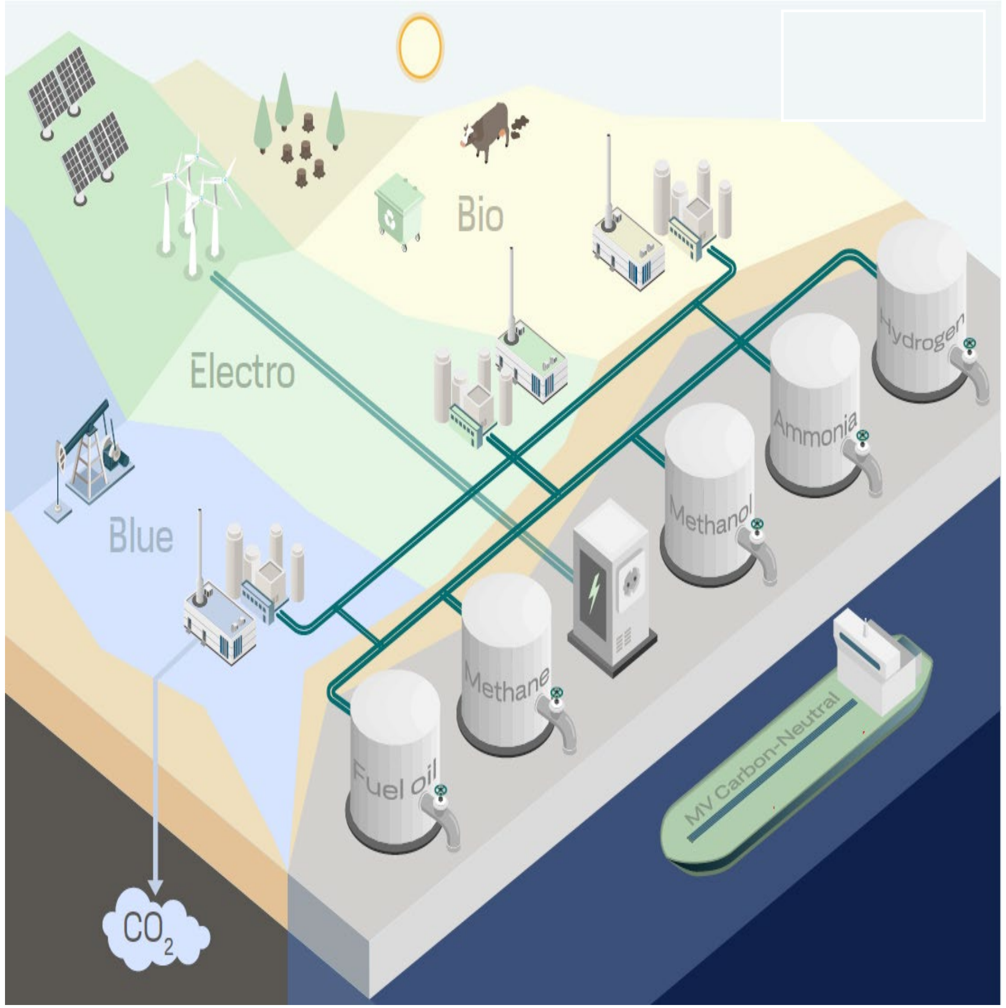
CCS

- **<u>Cooling ISO Tank</u>**: Transporting Food Products (Milk, Beer, etc.) and Secondary Battery Electrolytes
- **<u>Cryogenic ISO Tank</u>**: Transporting Gases such as Hydrogen and Helium

Source: Eon-Kyung Lee Revised based on "HD Hyundai, and cncryotank Homepage"

④ Port Facility Changes

- Implementation of Infrastructure Projects for Storage, Distribution, and Bunkering Based on Alternative Fuel Types

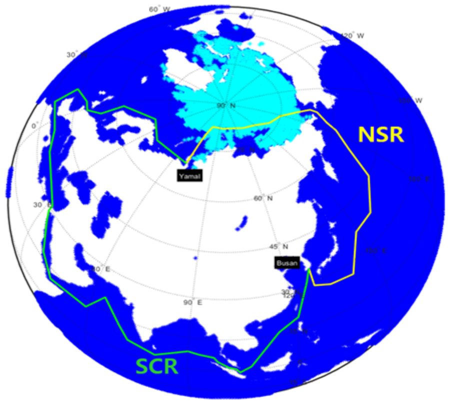


Fuel types	Distribution and storage	Bunkering infrastructure
Fuel oils (e-diesel, bio-diesel)	Can use existing distribution and storage facilities for conventional fuel	Can use existing bunkering infrastructure
Gaseous fuels (e-methane, bio-methane)	Can use existing distribution and storage facilities for LNG	Can use existing LNG infrastructure
Methanol (e-methanol, bio-methanol)	Existing storage and distribution infrastructure: methanol terminals, already traded by ships	Successful demonstration bunkering operations, ship-to-ship bunkering possible. Partially developed bunkering infrastructure.
Ammonia (e-ammonia, blue ammonia)	Existing storage and distribution infrastructure: ammonia terminals, already traded by ships	No bunkering infrastructure today, and no bunkering operations demonstrated. Barriers remaining to be solved.
Hydrogen (e-hydrogen, blue hydrogen)	No existing distribution infrastructure	No existing bunkering infrastructure Local bunkering demonstrated. Barriers remaining to be solved.

Source: DNV(2023), IMO FFT(2023)

⑤ Changes in Maritime Transport Routes for Carbon-Neutral Fuel Propulsion Ship

- Comparison Simulation of Liquid Hydrogen Transport from Russia to South Korea: NSR vs. SCR
- Liquid hydrogen has a higher boil-off rate (BOR) compared to LNG and operates at lower temperatures, favoring NSR.
- Transportation costs on NSR are at least $3 million lower in winter and up to $5 million lower in summer compared to SCR



	SCR	NCR
Distance(Nautical Mile)	13,700	4,900
Voyage Period(at 15 knot)	38day	14day
Summer Average Temperature	35°C	0°C
Winter Average Temperature	35°C	-40°C

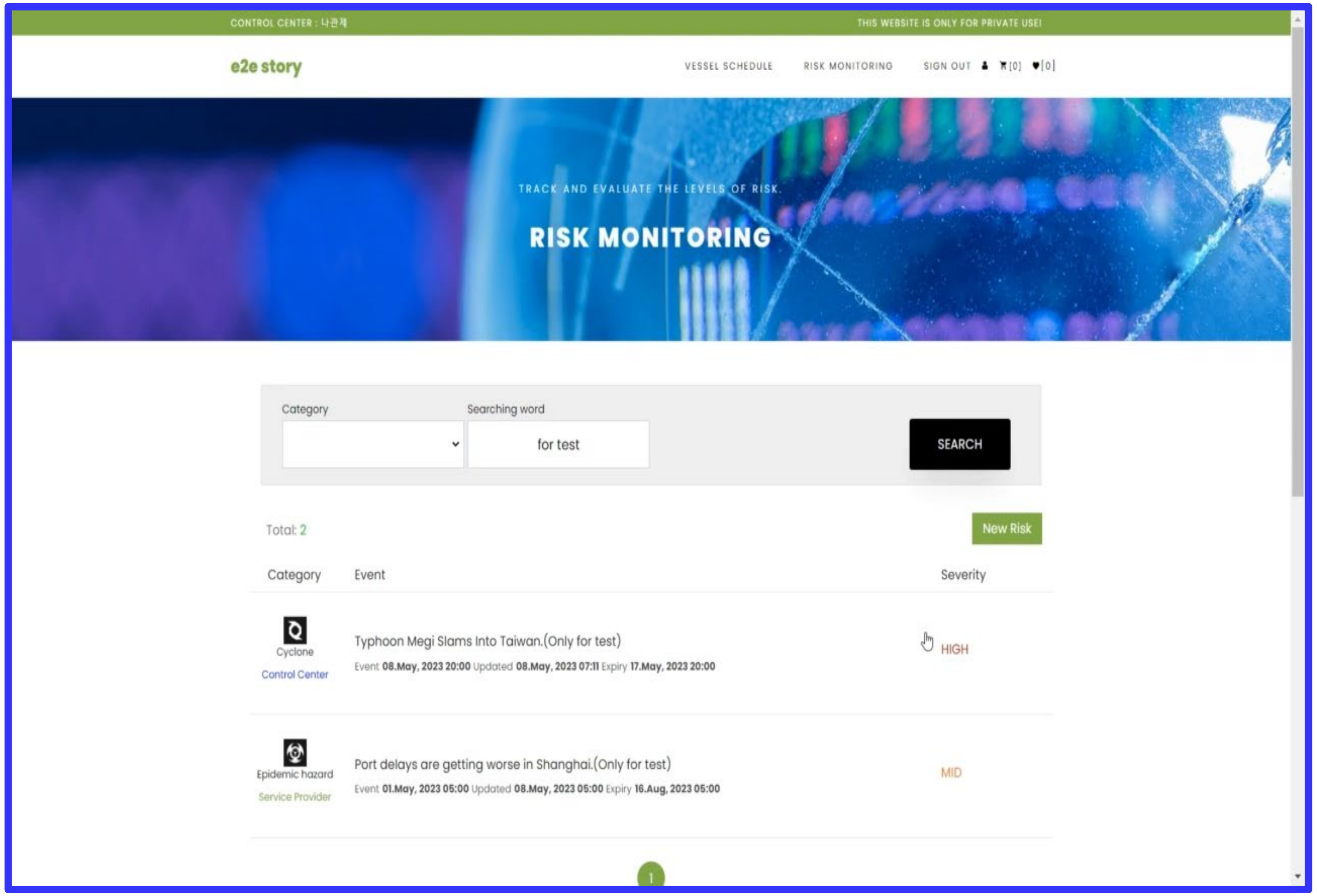
Speed (knot) \ $Million	Suez Canal Route	North Sea Route(Winter)		North Sea Route(Summer)	
	Voyage Expense	Voyage Expense	Save	Voyage Expense	Save
15	7.03	2.21	4.82	1.85	**5.18**
16	6.59	2.07	4.52	1.74	4.85
17	6.2	1.95	4.25	1.64	4.56
18	5.86	1.84	4.02	1.54	4.32
19	5.55	1.74	**3.81**	1.46	4.09

Source: Sewon Kim, Jisung Jo, et. al. (2021), Autonomous Vessel Voyage Planning Modeling in Northern Sea Route with Liquid Hydrogen Transportation and Propulsion, LOGMS 2021. revised by Eon-Kyung Lee)

⑥ Risk Monitoring of the Entire Supply Chain

- One killed as ship carrying 3,000 cars catches fire off Dutch coast (July 26, 2023)

- Monitoring and mitigation measures for safety incidents, including explosions, during maritime shipping



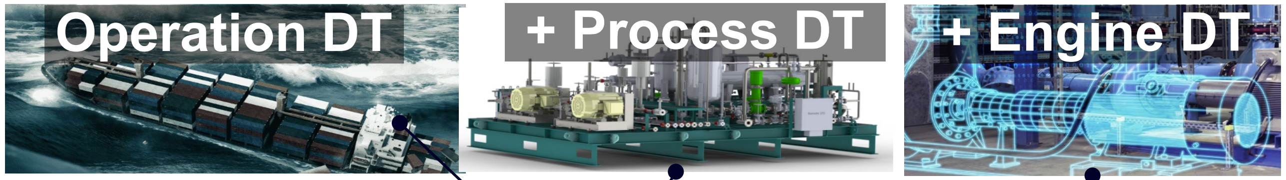
Source: Jisung Jo,Eon-Kyung Lee, and Heyri Park, "Advancement of Smart Console Center Platform - Establishment of Disaster and Emergency Monitoring System", KMI, 2023 Ongoing Research Report; https://www.theguardian.com/world/2023/jul/26/cargo-ship-fire-off-dutch-coast

⑦ Carbon Reduction Monitoring for Alternative Fuel Propulsion Ship

- Monitoring CO_2 emissions for Carbon-Neutral Fuel Propulsion vessels based on ship operations digital twin

Fuel Consumption = ∑

CO_2 Emissions ∝ Fuel Consumption



Carbon Intensity Indicator

$$CII=\frac{100-Z}{100}\left(\frac{Fuel\ Consumption \times Carbon\ Factor}{Capacity \times Distance}\right)$$

Z: IMO Yearly Reduction Index, ***Fuel Consumption***: Operational Fuel Consumption
Carbon Factor: Fuel Carbon Content, ***Capacity***: Deadweight, ***Distance***: Operational Distance

Source: Written by Eon-Kyung Lee(KMI) and Prof. Sewon Kim(University of Sejong)

Thank You

eklee@kmi.re.kr