2022 KOREAN-HELLENIC MARITIME COOPERATION FORUM

How to respond to IMO GHG Regulation

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Korean Register

01.

IMO GHG Regulations

IMO Initial GHG Strategy

VISION ▸▸▸ **Decarbonization** — Phase GHG emissions of ships out ASAP in this century

TARGET ▸▸▸

1. **Carbon Intensity to decline**
   - **Further Phases of EEDI for New Ships**

2. **Carbon Intensity to decline**
   - (**tCO2/ton·mile**) **40% by 2030** and **70% by 2050** compared to 2008

3. **GHG emissions to peak and decline**
   - **Peak** GHG emissions as soon as possible
   - (**Total annual emissions**) **50% by 2050** compared to 2008

2018-2023 Short-term measures

- Improvement of **EEDI and SEEMP**
- Develop **technical and operational energy efficiency** measures for both new and existing ships with **three-step approach**
- Existing **Fleet Improvement** Programme
- **Speed** optimization and reduction
- Measures for **methane** and **VOCs**
- **National** Action Plans, **Technical** cooperation and capacity-building, **Port** development (AMP etc), **R&D** activities, **Incentives** for first movers, Lifecycle **guidelines** for fuels, **GHG study**

2023-2030 Mid-term measures

- Programme for **alternative fuels**
- **Operational energy efficiency measures** for both new and existing ships
- **Emission Reduction Mechanism (MBM)**
- **Technical** cooperation and capacity-building, **Feedback** mechanism

Beyond 2030 Long-term measures

- **Zero-carbon or fossil-free fuels**
- **Emission Reduction Mechanism**

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After Cop26, carbon neutral of shipping

2100 => 2050

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- **Zero-carbon or fossil-free fuels**
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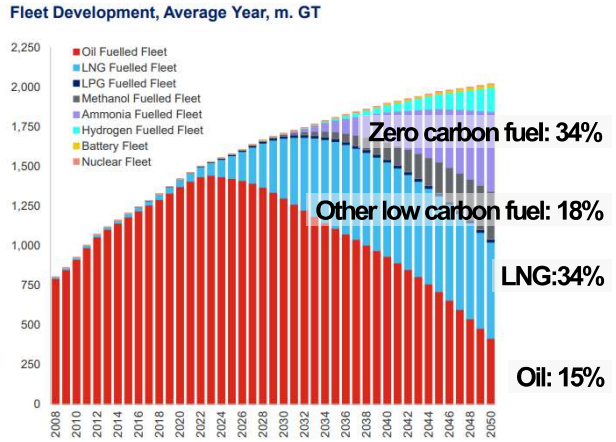
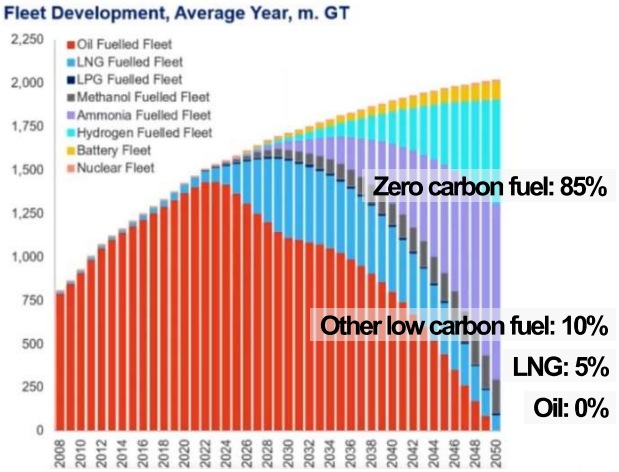
Decarbonization Scenario

* IMO Initial Strategy (50% by 2050)



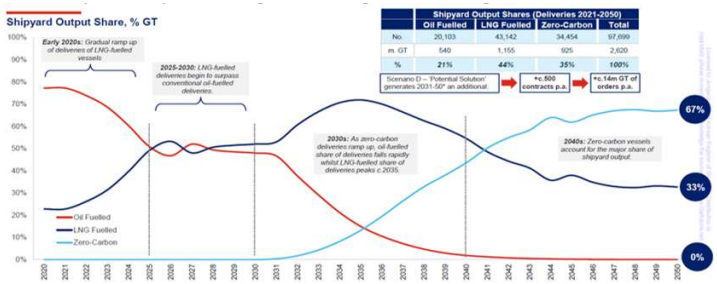
* Net-zero target(100% by 2050)



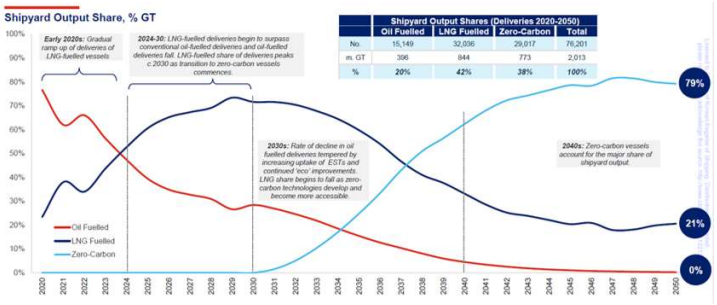
Source: Clarksons Research, Fuelling Transition: Tracking the Economic Impact of Emission Reductions & Fuel Changes, September 2021 webinar

Source: Trevor Crowe, The shipping sector to 2030, Clarksons research, 2019 & 2020

Oct. 2019 report (order based)

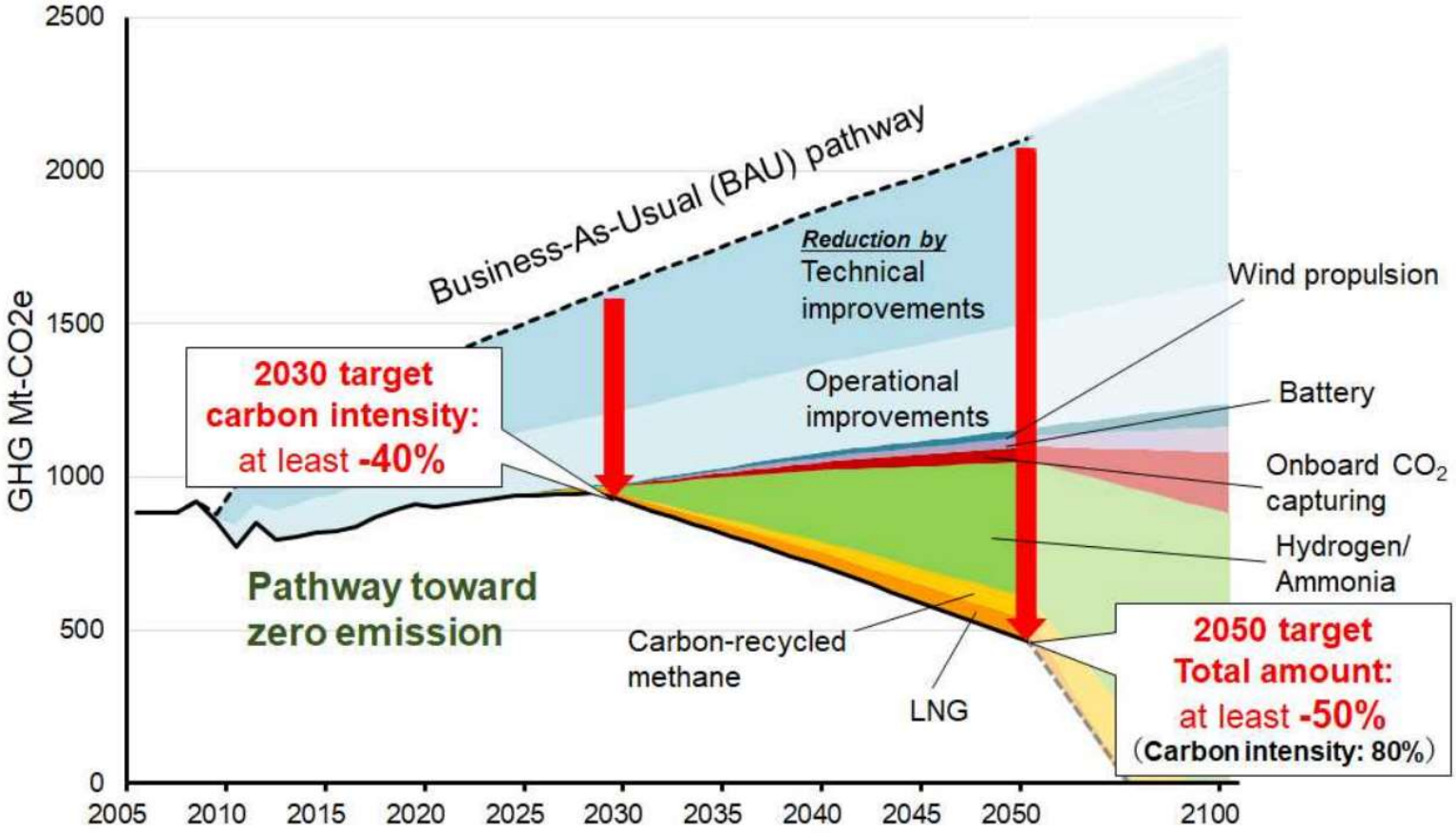


Mar. 2020 report(order based)



? after decarbonation target year changed to 2050

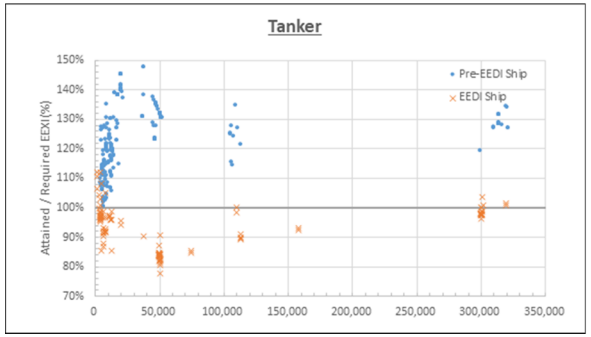
Decarbonization Regulation/Measures



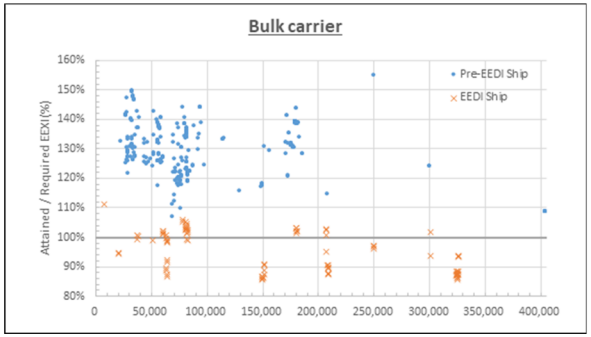
Source from JSTRA

EEXI calculation data

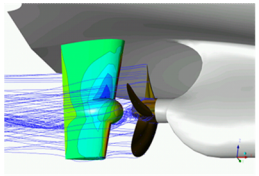
적용선박	총합	만족	불만족	불합격률
PRE-EEDI 선박	333	9	324	97%
EEDI 선박	107	79	7	7%
합계	440	88	331	75%

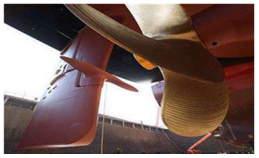


적용선박	총합	만족	불만족	불합격률
PRE-EEDI 선박	366	0	366	100%
EEDI 선박	45	58	31	34%
합계	456	58	397	87%

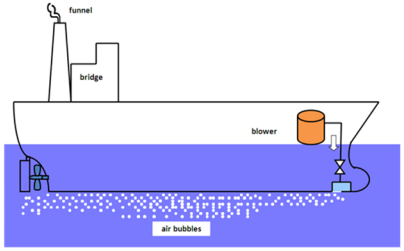


Category A

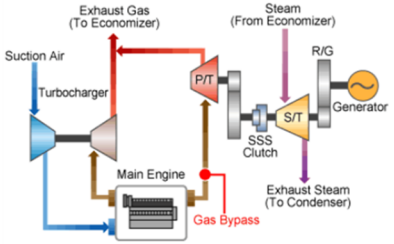




Category B



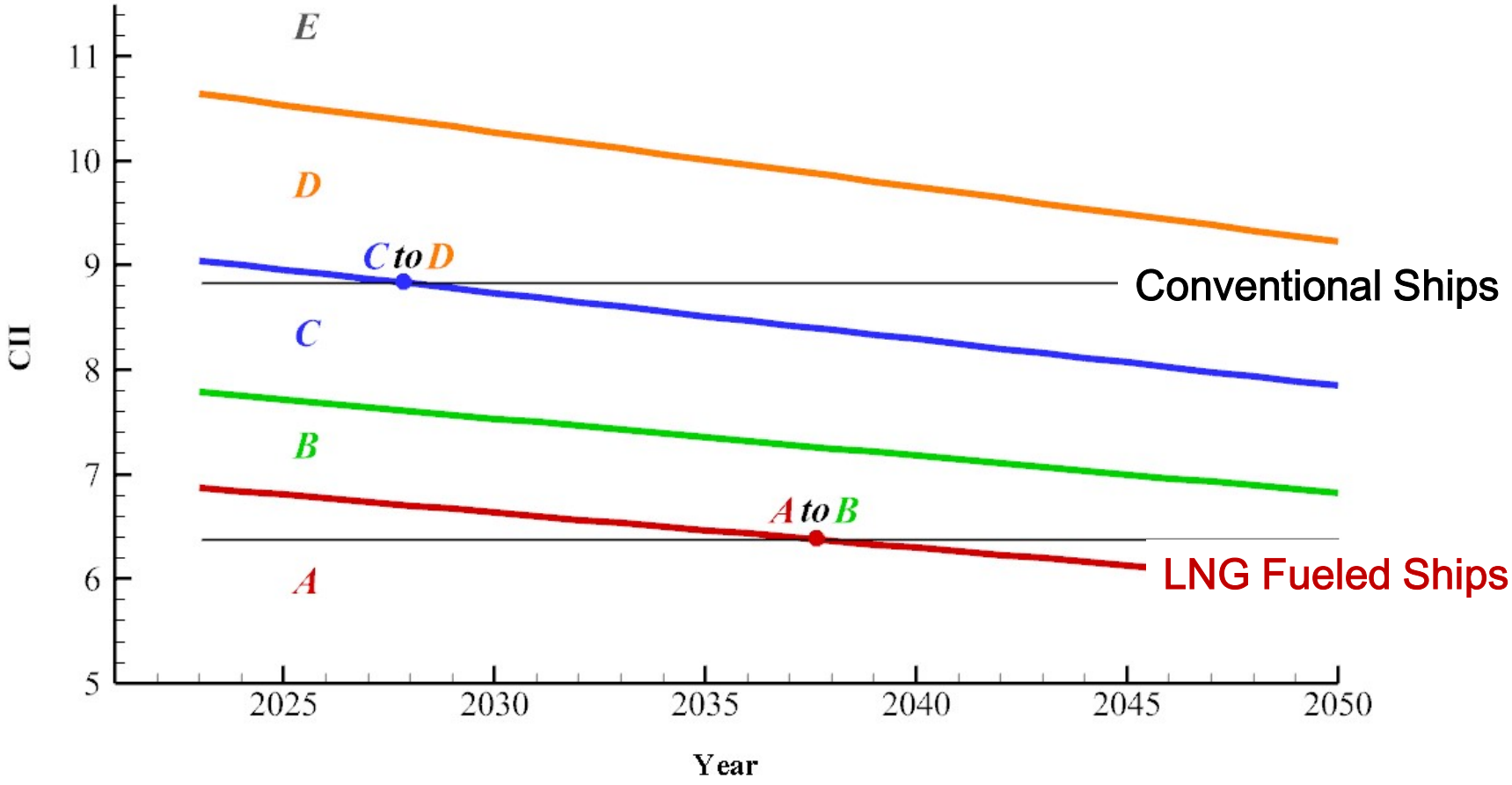
Category C



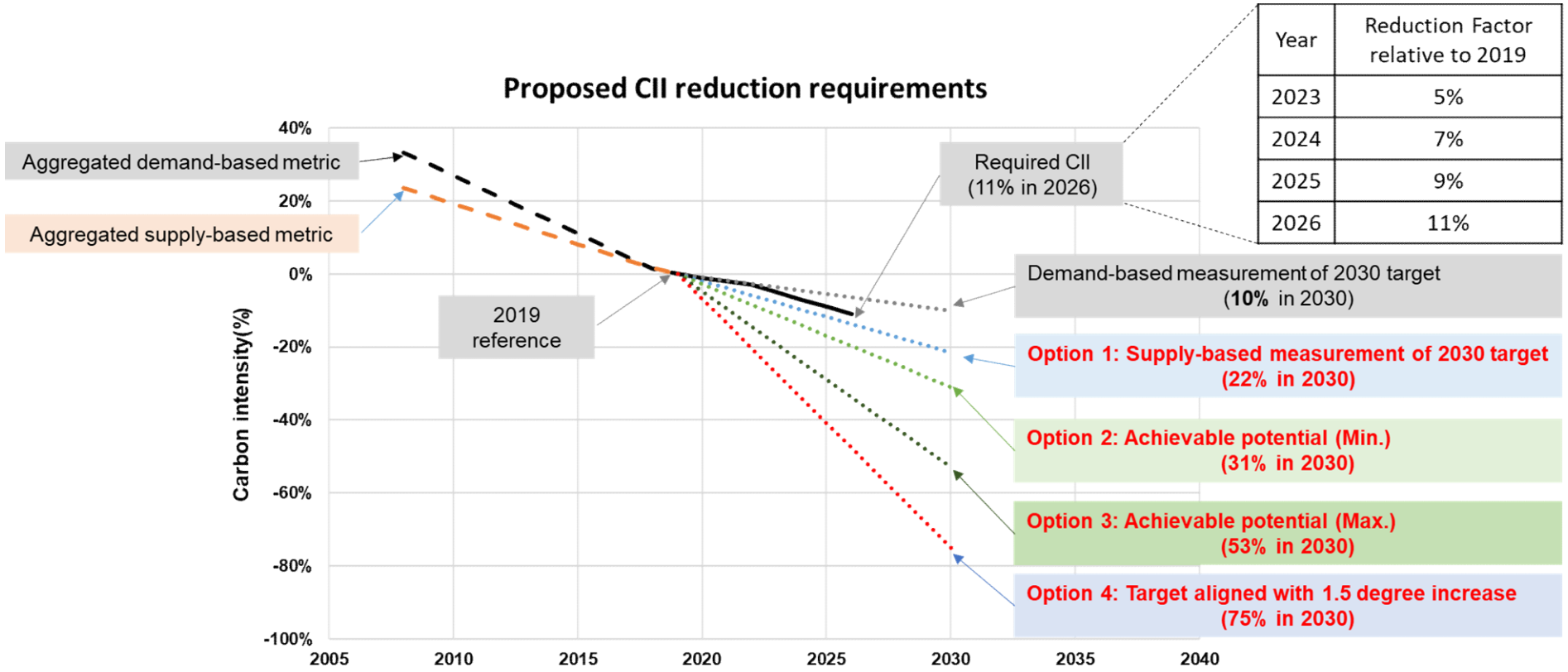
CII(Carbon Intensity Indicator Rating)

✓ Corrective actions & SEEMP revision

- Rated as D for 3 consecutive years
- Rated as E for one time



CII reduction factor options under IMO discussion



Year	Reduction Factor relative to 2019
2023	5%
2024	7%
2025	9%
2026	11%

- 2019 ~ 2026: CII Reduction factor was decided. (11% in 2026)
- 2027 ~ 2030: Decided later after reviewing the effectiveness of CII in IMO

CII simulation

SHIP TYPE	SHIP NAME	DWT	DISTANCE [nm]		CO2 EMISSION [ton]		ATTAINED CII		REQUIRED CII (2020)	CII RATING											
			2020 DCS	EPL IMPACT	2020 DCS	EPL IMPACT	2020 DCS	EPL IMPACT		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
					40,577	37,177	7.27	6.74	7.53	C	C	C	B	C	C	C	D	E	E	E
					44,650	40,182	7.57	7.09	7.53	C	C	C	C	C	C	C	D	E	E	E
					29,335	29,155	7.36	7.33	7.53	C	C	C	C	C	C	D	D	E	E	E
					21,899	20,715	6.82	6.60	7.53	B	B	B	B	B	C	C	D	E	E	E
					35,078	33,637	7.04	6.80	7.53	B	B	C	B	C	C	C	D	E	E	E
					28,307	27,563	6.48	6.35	7.53	B	B	B	B	B	B	B	D	D	E	E
					35,616	29,326	8.12	7.71	7.97	C	C	C	C	C	C	D	D	E	E	E
					27,095	22,743	8.46	7.55	7.97	D	D	D	C	C	C	C	D	E	E	E
					22,599	22,416	9.09	9.02	11.37	A	A	A	A	A	B	B	C	D	E	E
					22,569	22,381	8.59	8.53	11.38	A	A	A	A	A	A	A	B	D	E	E
					20,629	18,376	11.43	10.73	11.97	C	C	C	B	C	C	C	D	E	E	E
					5,948	-	5.72	-	7.07	A	A	B	B	B	B	B	C	D	E	E
					8,050	-	18.83	-	20.65	B	B	C	C	C	C	C	D	E	E	E

02.

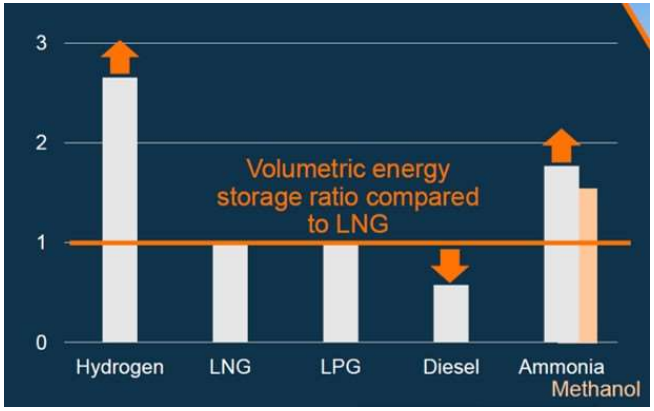
Zero Carbon Fuels

(Ammonia, Hydrogen)

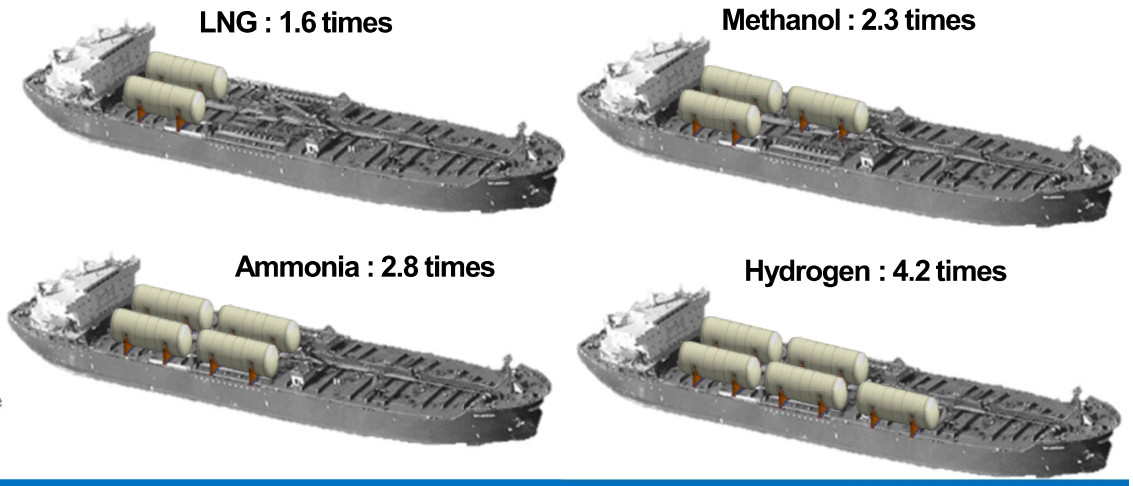
Comparison of alternative marine fuels

Energy storage type	Supply energy (MJ/kg)	Energy density (MJ/L)	Required tank volume (m^3)	Supply pressure (bar)	Injection pressure (bar)	Emission reduction compared to HFO Tier II (%)			
						SOx	NOx	CO_2	PM
HFO	40.5	35	1,000	7-8	950				
Liquefied natural gas (LNG, -162°C)	50	22	1,590	300 methane	300 methane	90-99	20-30	24	90
				380 ethane	380 ethane	90-97	30-50	15	90
LPG(including Propane/Butane)	42	26	1,346	50	600-700	90-100	10-15	13-18	90
Methanol	19.9	15	2,333	10	500	90-95	30-50	5	90
Ethanol	26	21	1,750	10	500				
Ammonia(liquid -33°C)	18.6	12.7	2,755	70	600-700	90-95	-	95	90
Hydrogen(liquid -253°C)	120	8.5	4,117						

Source: MAN energy solutions, Engineering the future two-stroke green-ammonia engine, 2019

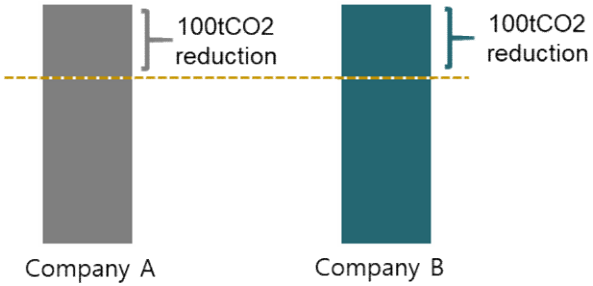


Source: Sebastiaan Bleuanus, Enabling green H2 usage in current and future maritime power generation, Wartsila, Motorship conference 2019



IMO MBM, EU ETS

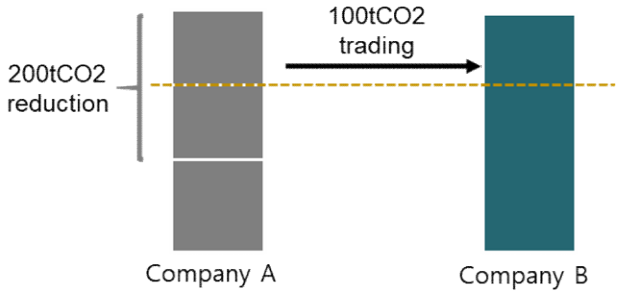
As-is



	Company A	Company B
Reduction Target	100tCO2	100tCO2
Marginal Abatement Cost	$10/tCO2	$30/tCO2
Direct Reduction	100tCO2	100tCO2
Reduction Cost	$1,000	$3,000

Total Reduction Cost : $4,000

To-be



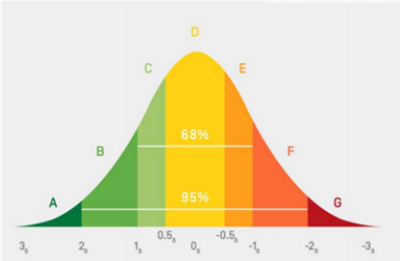
	Company A	Company B
Reduction Target	100tCO2	100tCO2
Marginal Abatement Cost	$10/tCO2	$30/tCO2
Direct Reduction	200tCO2	-
Allowance Price	$20/tCO2	
Reduction Cost	-	$2,000

Total Reduction Cost : $2,000

Provision of EU ETS impact assessment

Carbon Neutral Drive of Industry

RIGHTSHIP



"Shell now needs to go further with our own ambitions, which is why we aim to be a net-zero emissions energy business by 2050 or sooner. Society, and our customers, expect nothing less."

bp BP sets ambition for net zero by 2050, fundamentally changing organisation to deliver

12 February 2020

MAERSK

To accelerate the transition to carbon-neutral shipping, Maersk has set a new and ambitious target in 2018 of having net-zero CO2 emissions from operations by 2050.

RE 100

CMA CGM

The CMA CGM Group heads towards carbon neutrality by 2050

0 ZERO CO_2 emissions (2050 goal)

HMM

Towards Carbon Neutral Shipping

50% CO_2 emissions (2030 goal)

*Compared to 2008 / Based on total emissions

Source: Homepages of Each Corporate

SEA CARGO CHARTER

clean CARGO Sustainable Transportation

POSEIDON PRINCIPLES

Conventional Fuels VS Zero Carbon Fuels

FO
LNG

Ammonia, Hydrogen, Carbon neutral

Conventional Fuels VS Zero Carbon Fuels

FO
LNG

Ammonia, Hydrogen, Carbon neutral

Incentives from IMO, EU

Conventional Fuels VS Zero Carbon Fuels

FO
LNG

Ammonia, Hydrogen, Carbon neutral

- Incentives from IMO, EU
- Incentives from Financial circles

Conventional Fuels VS Zero Carbon Fuels

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LNG

Ammonia, Hydrogen, Carbon neutral

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- Incentives from Financial circles
- Incentives from Cargo owners, Chatterers

Conventional Fuels VS Zero Carbon Fuels

FO

LNG

Bio fuel, Synthetic LNG, CCS

Ammonia, Hydrogen, Carbon neutral

Incentives from IMO, EU

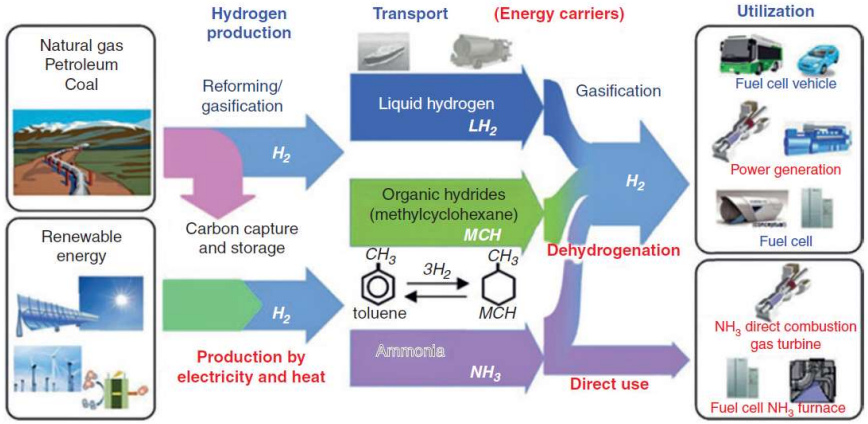
Incentives from Financial circles

Incentives from Cargo owners, Chatterers

Fuel price (Ammonia)

Developing overseas CO_2 free hydrogen supply chain

- Feasibility Study of Overseas Hydrogen Supply Chain
  - Overseas Hydrogen Production
  - Transportation by Ship (LH2, LOHC, NH3)
  - Domestic Utilization



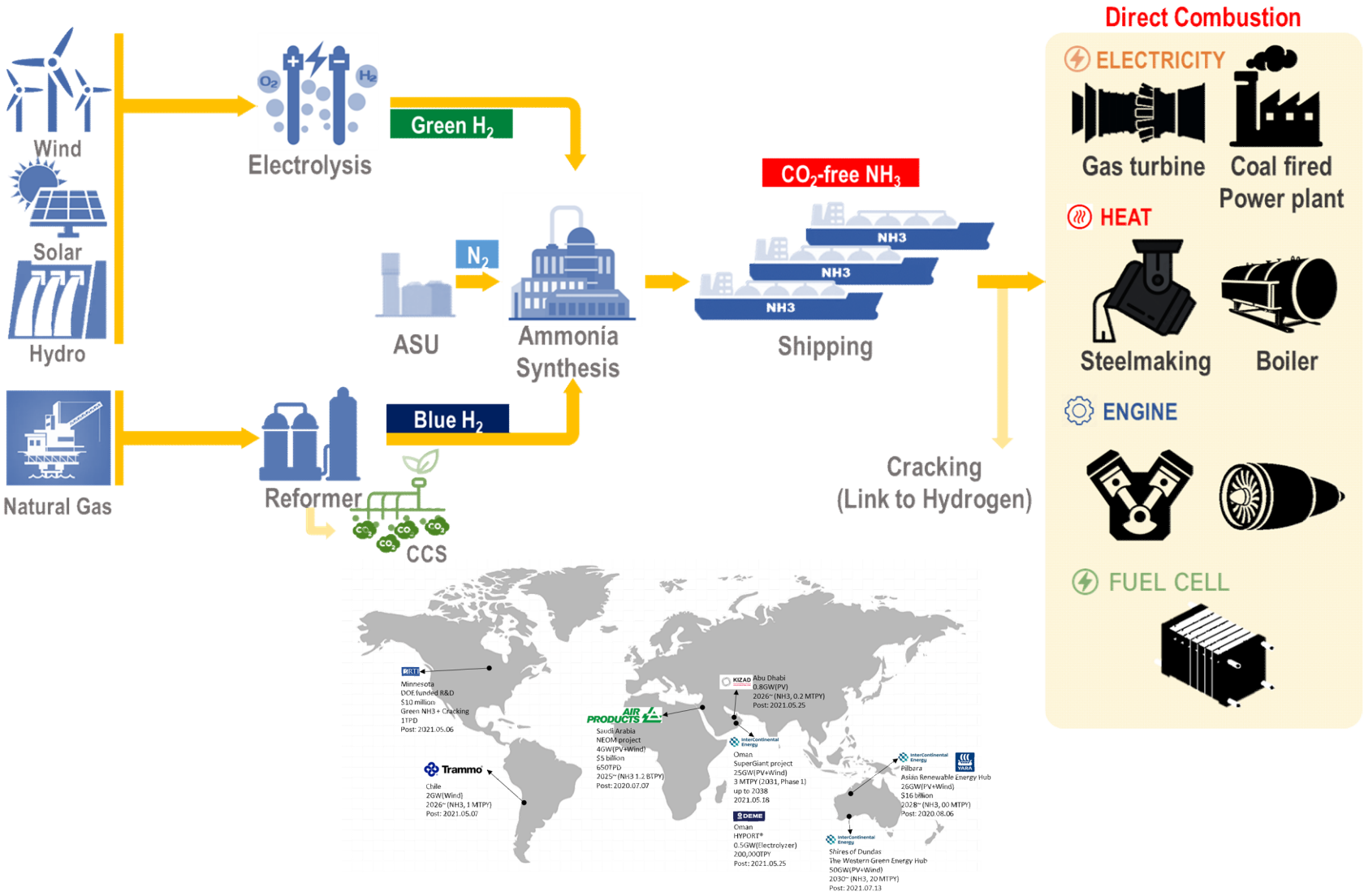
Source: Clean Energy, 2018

Participating Green Hydrogen Overseas Business Group

- Goal : Importing clean hydrogen from overseas before 2030
- MOU between 30 Companies and MOTIE
- Operated by Production, Storage/Transport*, Utilization parts

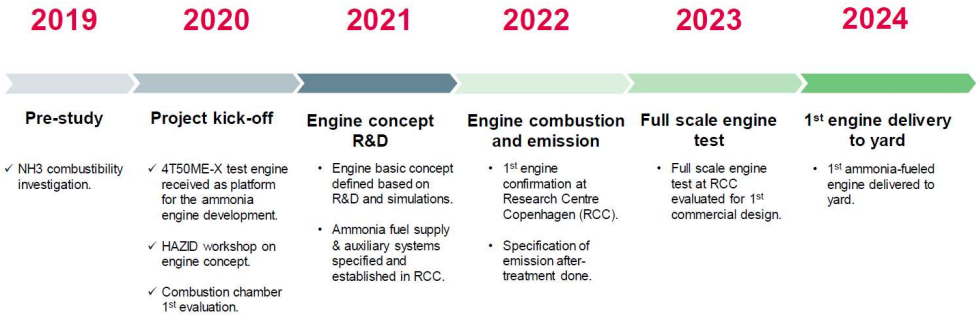
  * KR leads Storage/Transportation part

Green/Blue Ammonia Price

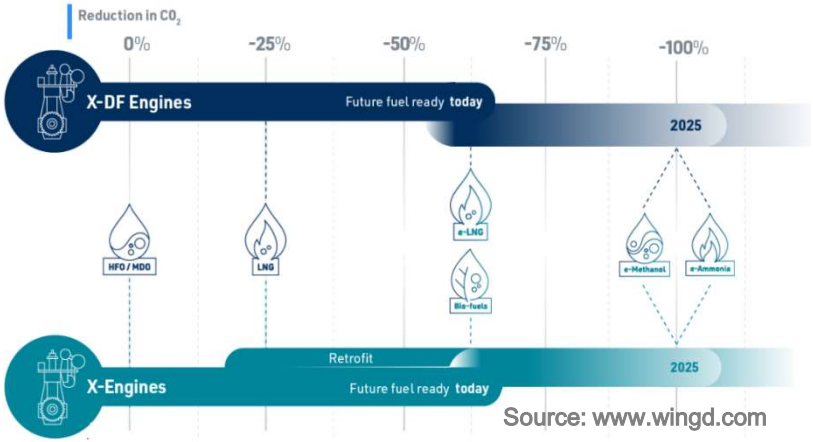


Ammonia engine development

Trends of R&D of ammonia fueled engines by engine manufacturers (2 stroke)



Source: Peter H. Kirkeby, MAN ES engines for alternative fuels, Motorship PFF conference, Nov. 2021



Source: www.wingd.com

Trends of R&D of ammonia fueled engines by engine manufacturers (2 stroke)

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

MAN Energy Solutions

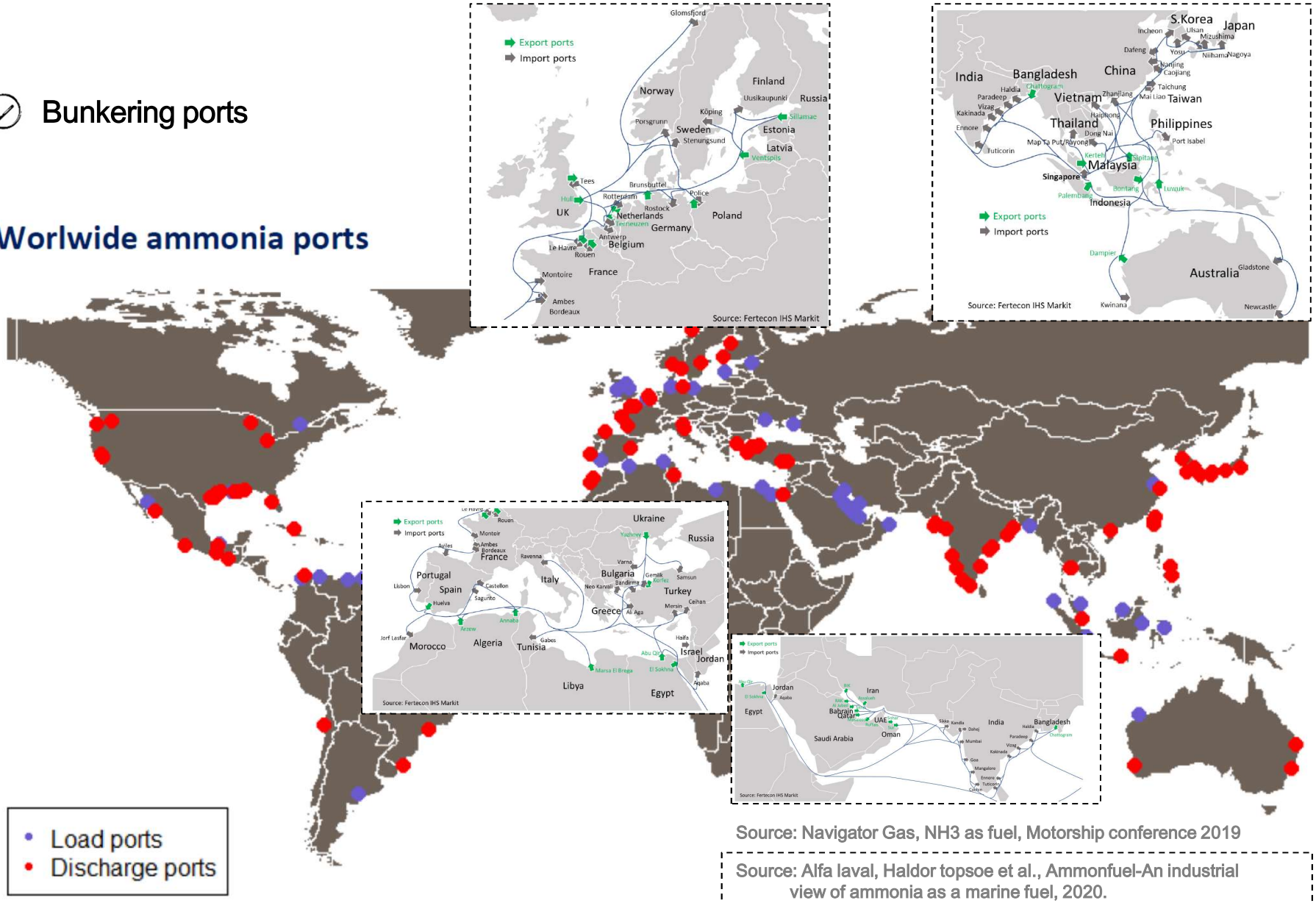
* AmmoniaMot project(~Dec. 2023)

WÄRTSILÄ

* Indicative: 2020
Verified: 2022

Bunkering Infra

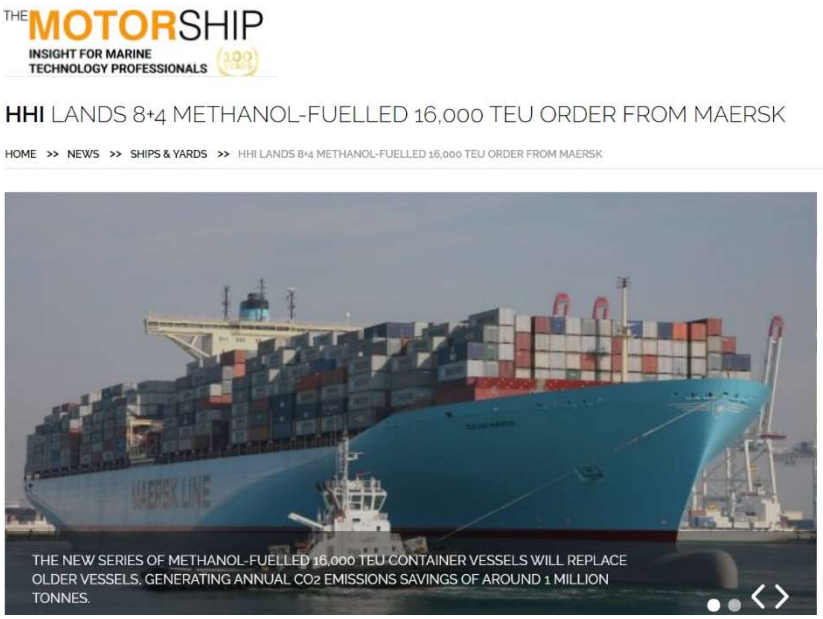
- Bunkering ports



Source: Navigator Gas, NH3 as fuel, Motorship conference 2019

Source: Alfa laval, Haldor topsoe et al., Ammonfuel-An industrial view of ammonia as a marine fuel, 2020.

Carbon Neutral Fuel (e/bio Methanol)



Source: www.motroship.com, 24 Aug. 2021

A.P. Moller-Maersk has placed an order with Hyundai Heavy industries for 12 x 16,000 teu container vessel newbuildings. The order for the dual-fuel methanol-fuelled newbuildings, which will be operated on carbon neutral methanol, includes an option for a further 4 vessels.

MAERSK's 2020 sustainability report

Biodiesel	**Drop in fuel** **But availability and other sectors need it**
Methanol (bio-methanol and e-methanol)	**Already in operation and liquid at normal conditions** **But, scalability and green production questions**
Lignin fuels A new biofuel based on biomass residue (lignin) and alcohols (methanol or ethanol)	**Price-competitive** **But, In development stage, scalability and infrastructure for supply questions**
Ammonia (green ammonia)	**Fully zero emissions fuel and can be produced at scale** **Bu,t Safety, toxicity and infrastructure challenges.** **Dependent of cost/maturity of electrolyser technology**

Source: Simon C. Bergulf, Decarbonization of shipping: New fuels, new regulatory framework, new reality around the corner. IMO symposium on alternative low-carbon and zero-carbon fuels, 2020.

03.

GHG Strategy

Uncertainty

- ✓ IMO regulation
  - GHG Strategy
  - CII
  - IMO ETS, Carbon Tax
- ✓ Technology development
  - LNG(Methane Slip), Ammonia(Engine, Safety, N2O, Ammonia slip), Hydrogen(Large capacity FC, Insulation)
  - CCS(Energy, Volume, Value chain of Harbor), ESD(Payback)
- ✓ Fuel Infra
  - Fuel price, Mass production, Bunkering infra

Owner's Option

- **IMO(global) & EU(local) GHG regulations (2030, 2050, ETS)**
- **Alternative fuels(incl. alternative power sources)**
  - FO + Biofuel
  - LNG + CCS + Synthetic LNG
  - LNG + (ammonia, hydrogen, etc.)
  - Methanol
  - Ammonia, hydrogen
  - Fuel cell, batteries, Hybrid
- **Energy Saving Device**
- **Bunkering Infra, Fuel price**

Consideration of various technical measures

Need overall approaches

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Cost Effective Solution

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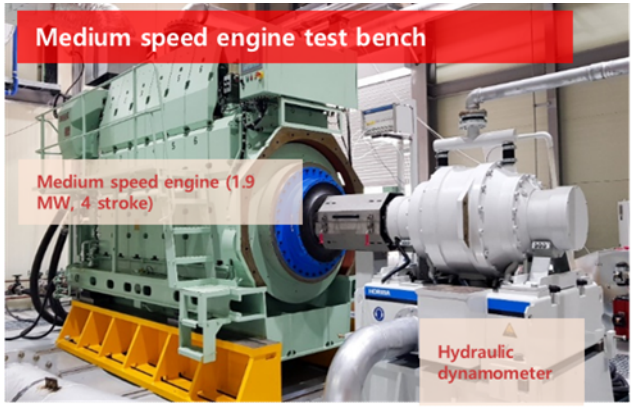
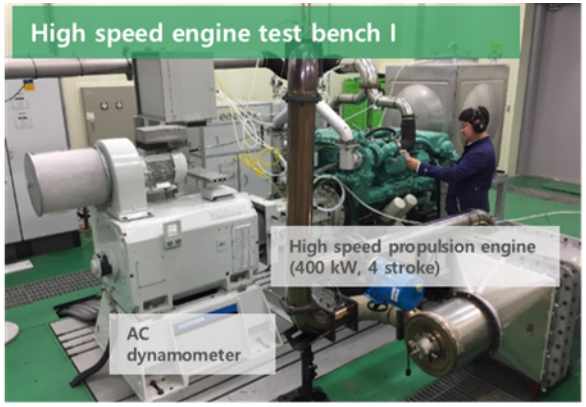
Cost Effective Solution

Flexibility

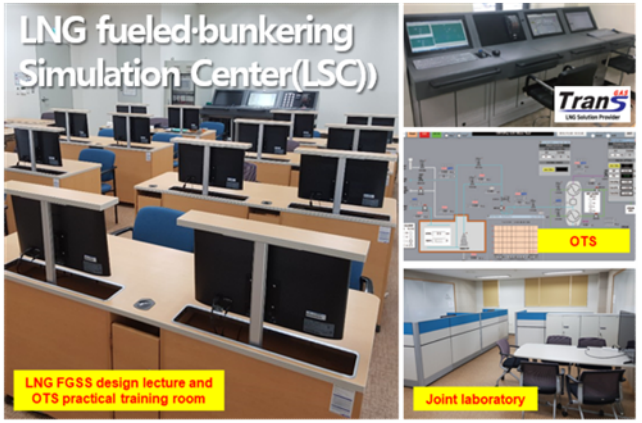
KR Activity (R&D Infra)





Greenship TCC : Internal Combustion Engine

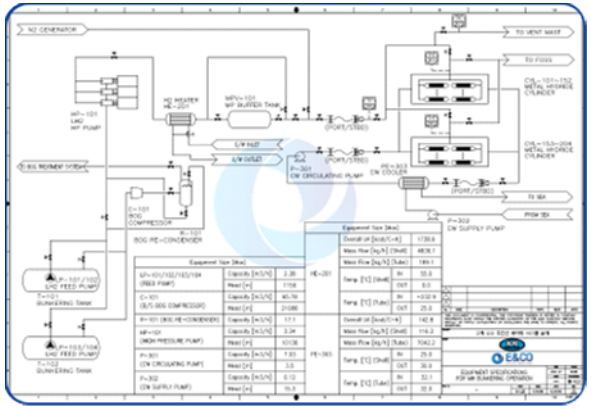
MASTC: Electric propulsion



LSC: LNG bunkering simulation

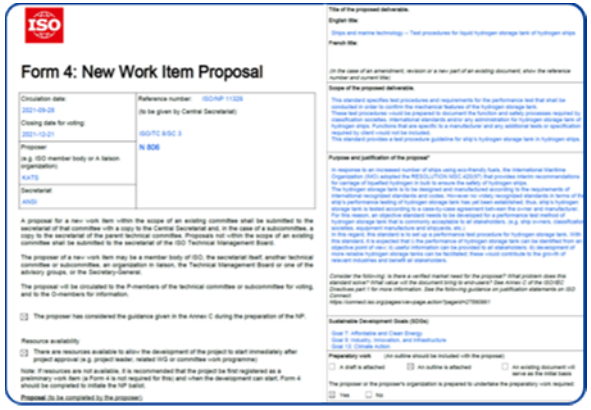
KR Activity (Hydrogen carrier/propulsion)

- Conceptual Design of LH2



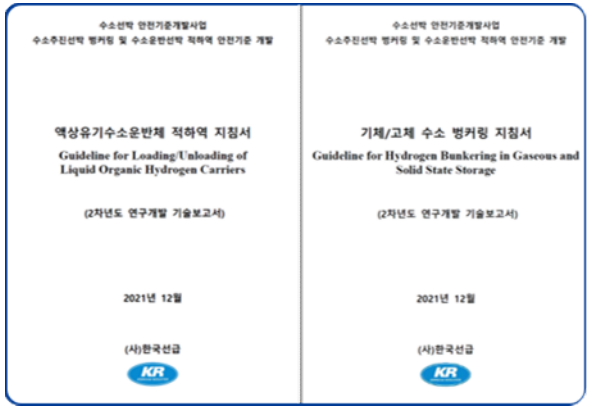
- Risk analysis for H2 Propulsion

- Test Procedure for H2 Handling

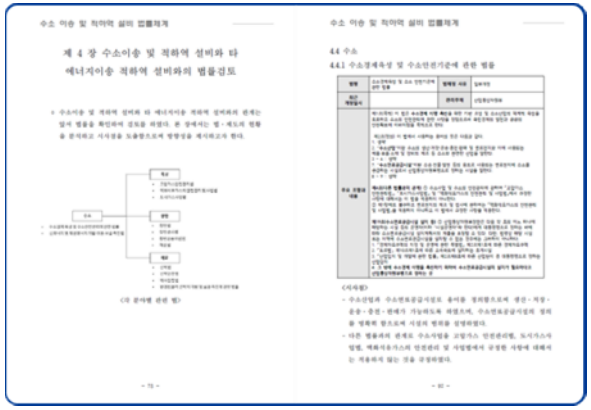


- AIP for HHI LH2

- Loading / Unloading / Bunkering Procedure



- Korea ship safety act



Providing the **best services,**
Creating a **better world**

Thank you

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