

저탄소/무탄소 선박 건조를 위한 친환경 기술개발 현황

2023.12.22

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발표 순서

1. 신조 시장의 변화

- Green House Gas 규제
- 이슈 사항과 통계

2. 탈탄소 선박

- 친환경 대체연료 선박

3. 친환경 기술

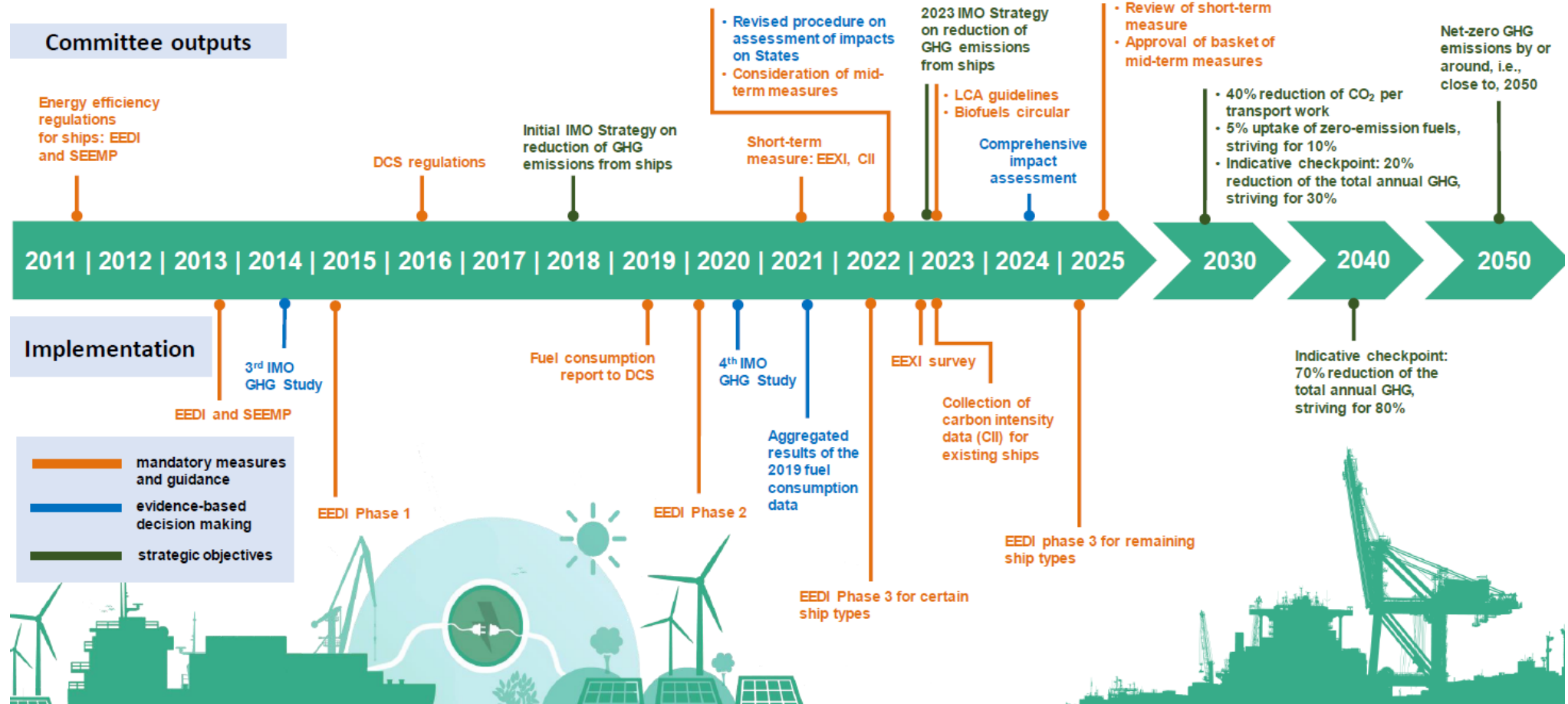
- 에너지 저감 장치 (Energy Saving Devices)
- GHG 저감 시스템

4. 결론

국제해사기구(IMO)의 GHG 규제

Addressing climate change

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



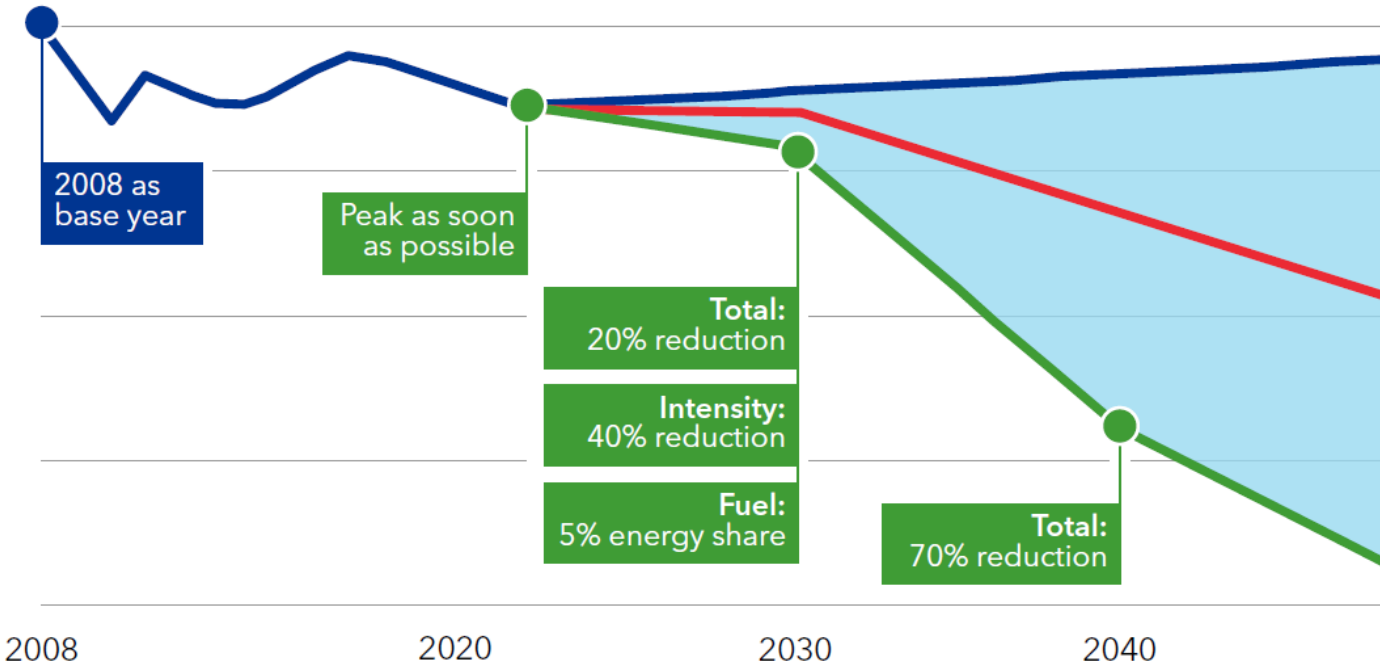
(Source: <https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx>)

1. Change in Shipping Market

해사 관련 GHG 규제

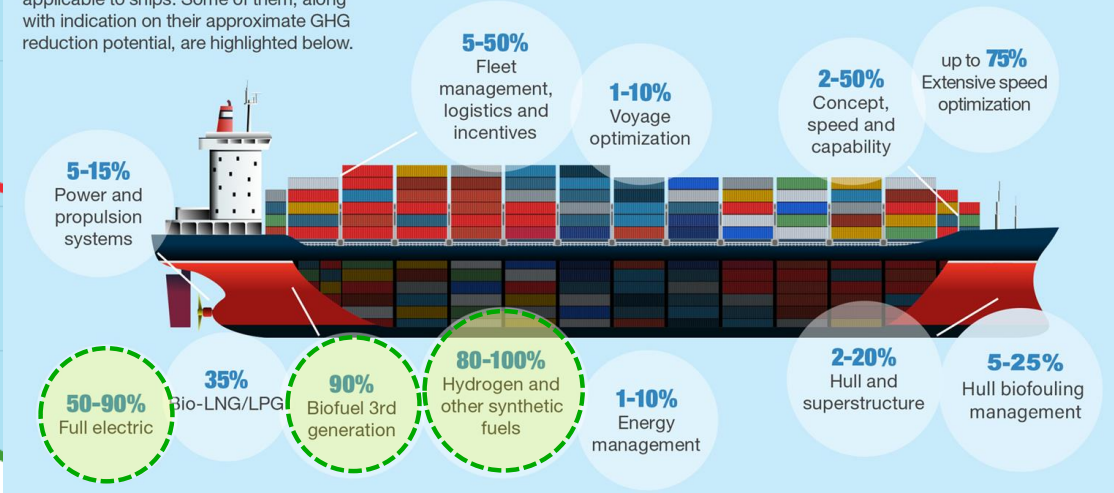
Outline of ambitions and minimum indicative checkpoints in the revised IMO GHG strategy

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>)

〈규제 변화의 동향〉

- ❖ 기술적 & 운용 관점에서의 대응 (EEDI/EEXI/CII)
- ❖ CO₂ 배출 규제 (EEDI/EEXI/CII)
- ❖ Tank to Wake 배출 규제 (EEDI/EEXI/CII/ETS)
- ❖ 개별 선박

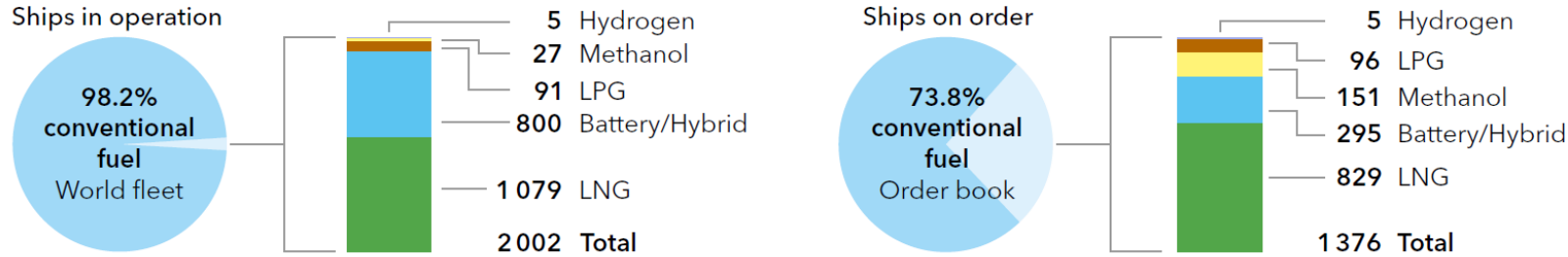
- ➔ 종합적 관점에서의 대응 (기술 & 경제적 대응)
- ➔ GHG (CO₂, CH₄, N₂O) 배출 규제 (GFS, ETS, FuelEU)
- ➔ Well to Wake 배출 규제 (GFS, FuelEU)
- ➔ 개별 선박 및 선대

1. Change in Shipping Market

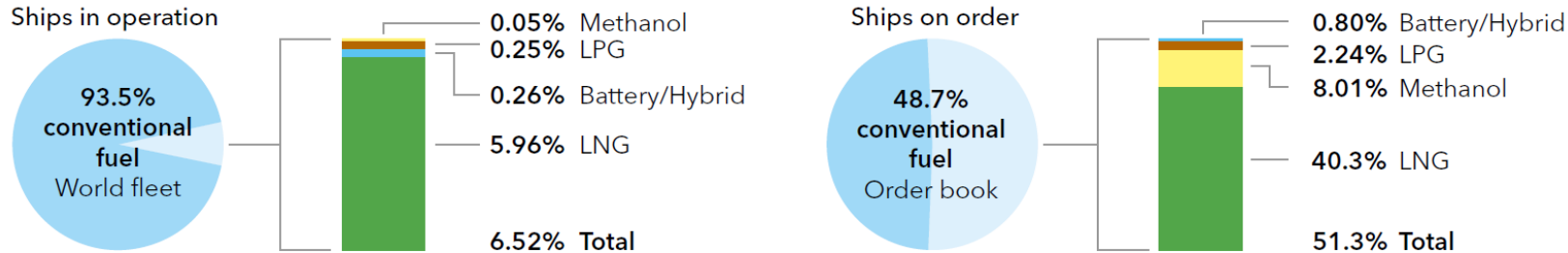
2023 시장 이슈 사항과 통계

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

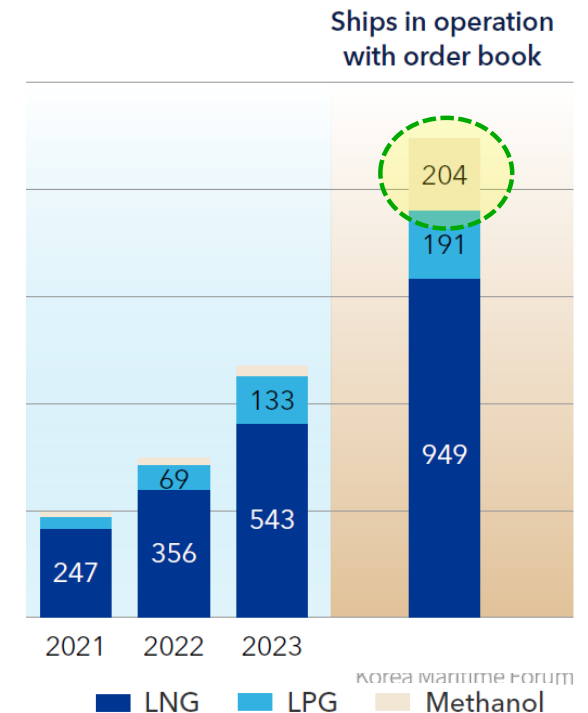


Sources: IHSMarkit (ihsmarkit.com) and DNV's Alternative Fuels Insights for the shipping industry - AFI platform (afi.dnv.com)



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

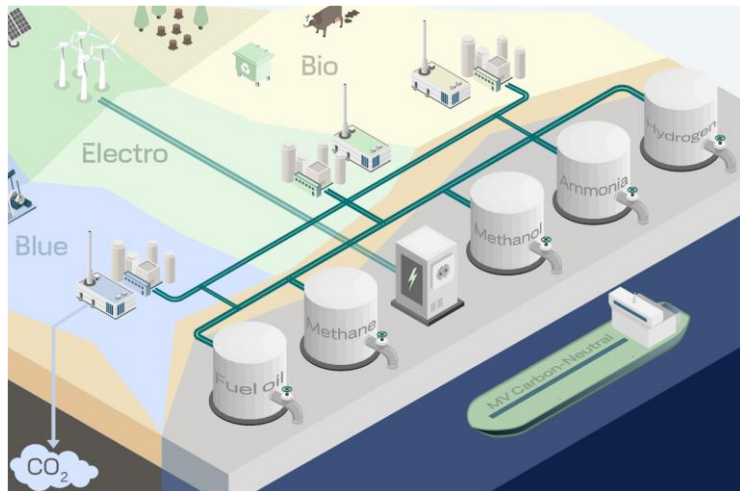
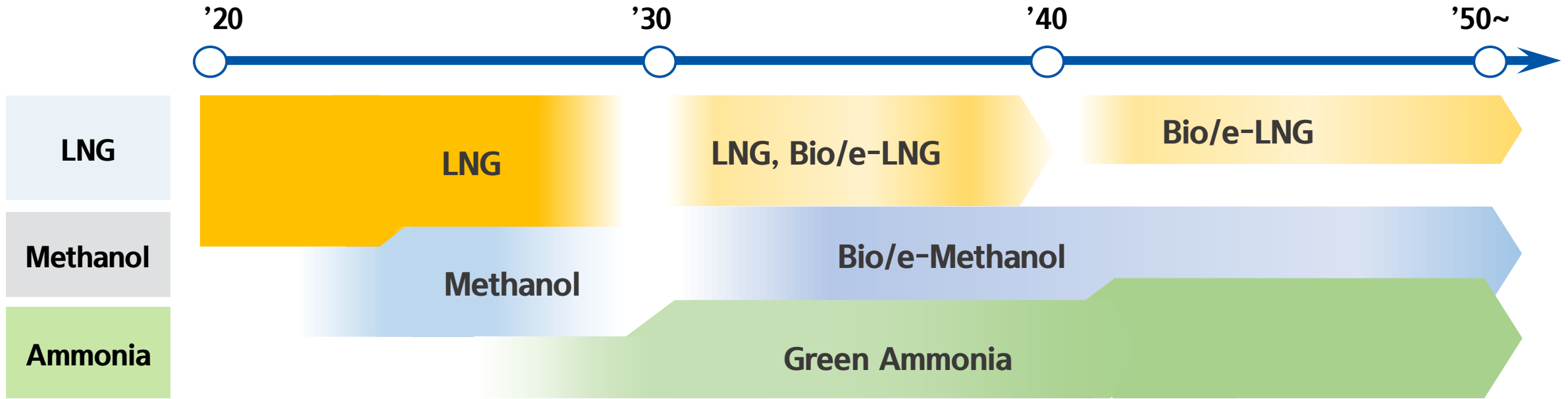
- (GT 기준) 운항선의 6.5%가 대체 연료 사용
- (GT 기준) 신조 예정선의 51.3%가 대체 연료 채택 예정
- : LNG 이중연료 추진선이 전체 신조 예정선의 40.3%
- 메탄올 이중연료 추진선의 급격한 증가



1. Change in Shipping Market

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HD 현대 그룹의 시장 변화 전망



(Source: DNV Maritime Forecast to 2050)

연료

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



기술

- 에너지 저감 장치
- GHG 저감 시스템
- 전기 추진 시스템

LNG 이중 연료 추진선

- **현 시점에서 가장 적용 가능한 해결책**
- **에너지 절감 장치를** 이용한 에너지 밀도 문제 해결
- **이산화탄소(CO₂) / 메탄(CH₄) 포집을 통한 친환경 인증**
- **탈 탄소 연료로의 확장 가능성 (Bio-LNG, H₂ 혼소)**

➡ 지속 가능하도록 유지

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

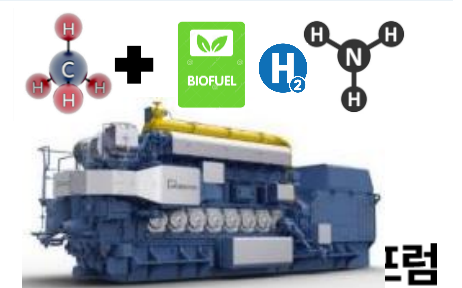


Methane Slip Reduction System



CO₂ Capture/Reduction

Mixed Combustion



Mixed Combustion Engine

메탄올 이중 연료 추진선

- 기존 HFO와 유사한 특성의 **성숙된 기술**.
- Tank to Wake 기준 11% CO₂ 절감 + 추가적인 배출물질(PM/Smoke, SOx, NOx) 저감
- **그린 메탄올 연료 공급망 확대**가 필요함 (병커링 설비 등)
- 세계 최초의 메탄올 추진 대형 컨테이너 운반선 인도 (23년 9월)



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



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

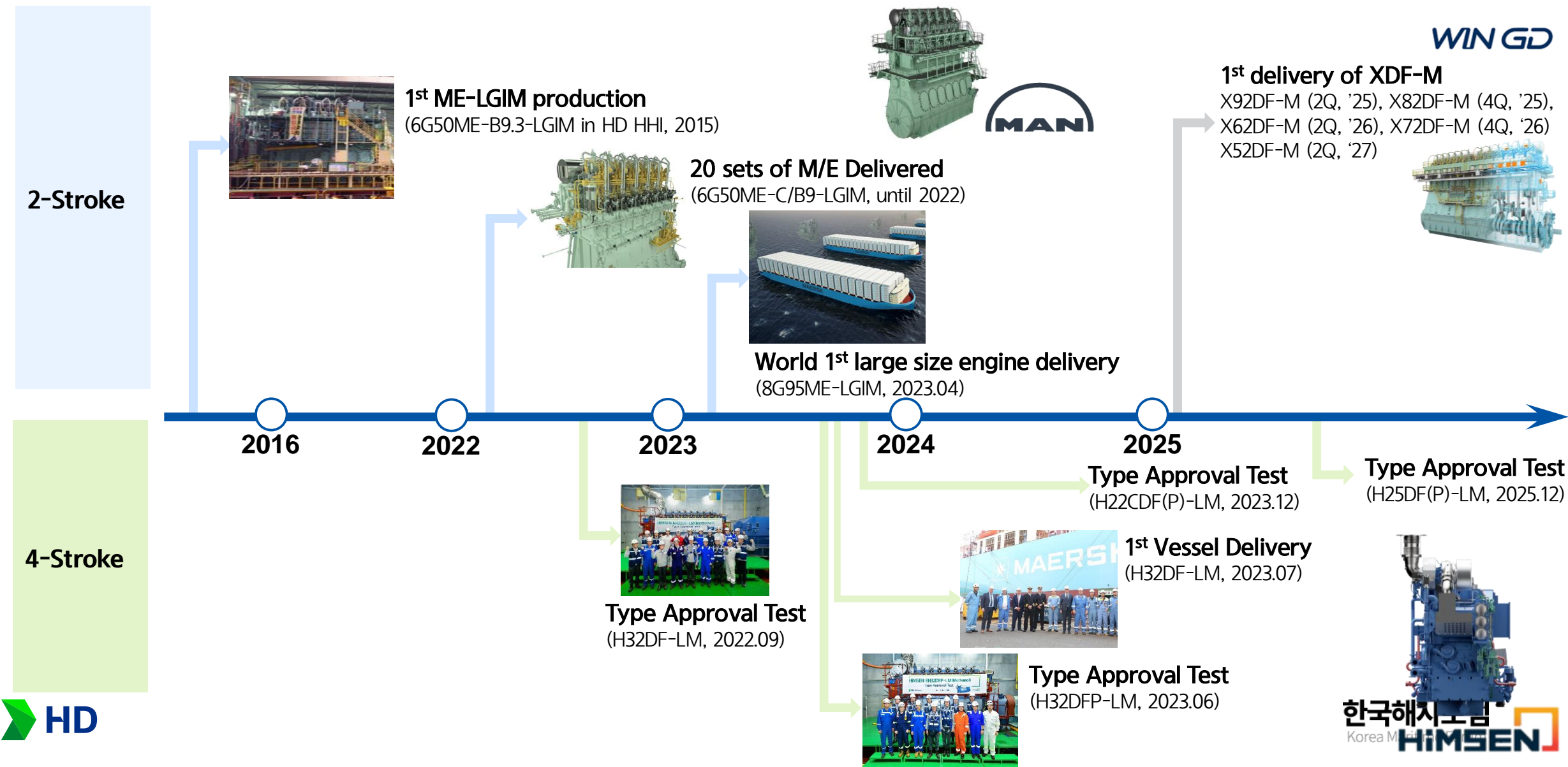
〈Maersk’s Strategy for Green Methanol Supply 〉

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



선박용 메탄올 엔진

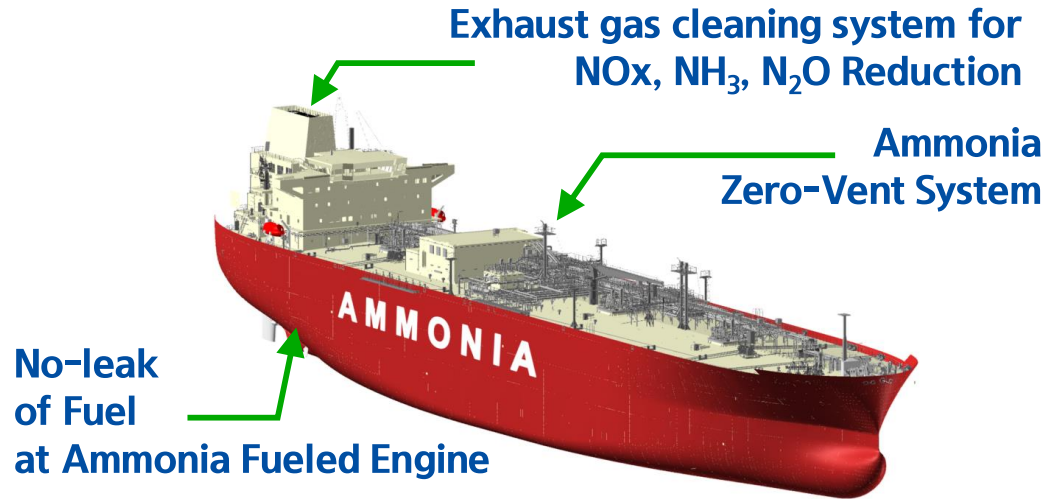


2. Decarbonized Ship

암모니아 이중 연료 추진선

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- 암모니아의 독성과 낮은 점도를 고려한 선박과 의장품 설계 필요.
- 엔진 입장에서는 상대적으로 발화하기 어려운 점을 극복할 필요가 있음.
- 조선소에서는 LFSS, 독성 제어 시스템, EGCS 등을 개발하고 있음.
- 세계 최초의 암모니아 연료 LPG 운반선 인도 (23년 10월).
- 주/보기 암모니아 연소 라인업은 24년 완비될 예정.
- 암모니아 이중연료 추진 탱커선이 25년 인도 예정 (EPS-HHI MOU).



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



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



〈 World's 1st Ammonia-Fueled
Ship Order 〉
한해사포럼
(Oct. 2023, HMD / Exmar)

선박용 암모니아 엔진

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)



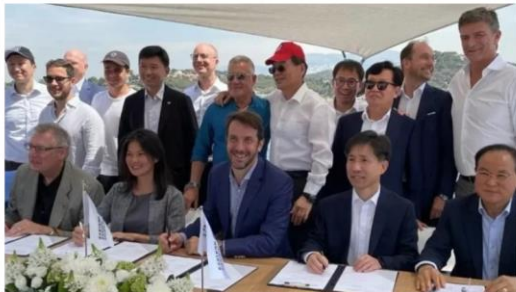
[WinGD]

- 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

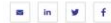


EPS has collaborated with HHI and ABS for the new ammonia-driven vessel. Credit: Eastern Pacific Shipping

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



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

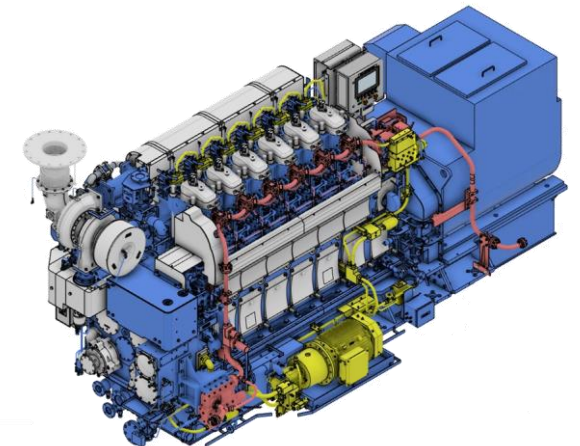


[HHI]

- Test approval test in 2024



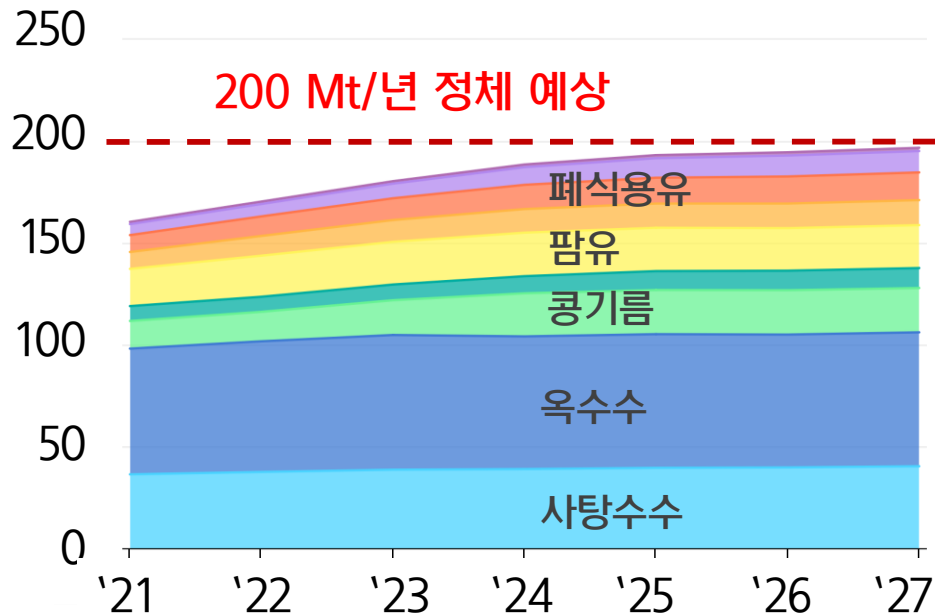
〈 Single cylinder test : SCH32 〉



한국해사포럼
〈 Ammonia Himssen concept 〉

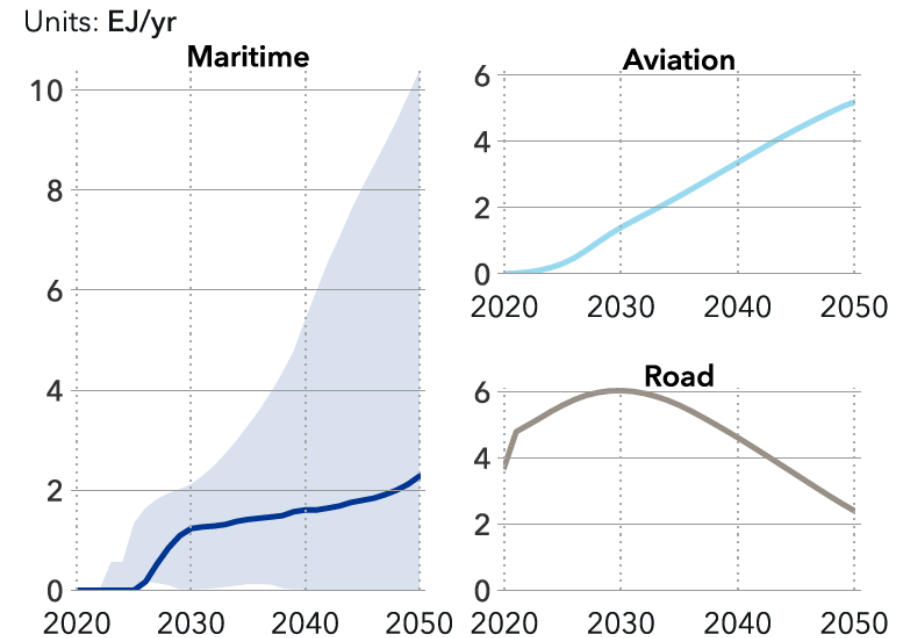
바이오 연료

- (공급) 원료(바이오메스) 확보 제약으로 **생산량 정체** 예상
 : 27년 약 200Mt/년 정체 vs. 22년 해운에너지 수요(227Mt) 유사
 : EU의 지속적 규제 강화 (GHG 저감 65% 이상)
- (수요) 도로/**항공 분야와 경쟁** 전망.
 : 30년 이전에는 도로, 30년 이후에는 항공 분야 사용 확대 ⇒ **한정된 공급 대비 수요 초과로 산업간 경쟁** 예상



(Source: IEA, 'Is the biofuel industry approaching a feedstock crunch?' ('22.12))

〈 바이오 연료 생산량 추정 〉



(Source: DNV, Transport in transition)

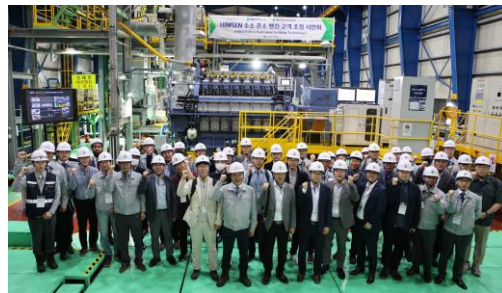
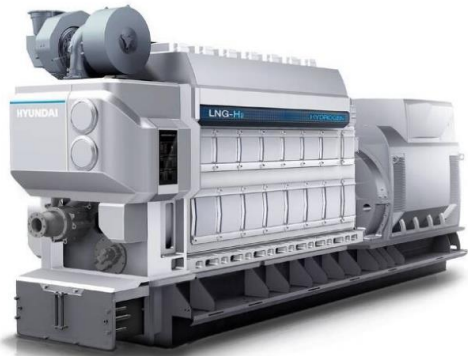
〈 바이오 연료 수요량 추정 〉

수소연료

- 에너지 밀도, 저온 보관성, 공급 설비, 가격 등 전반적인 개선이 필요함.
- 2023년 5월 LNG-H₂ 이중 연료 엔진 실증 완.
: 액화수소 운반선의 BOG H₂를 활용한 LNG-H₂ 이중 연료 엔진 적용 고려.
- 2025년 H₂ 전소 4행정 엔진 출시 예정.

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

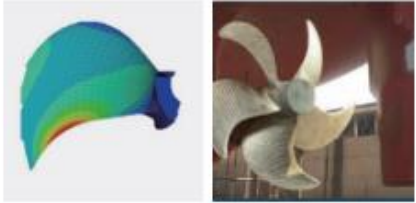


Development of liquefied H₂ carrier



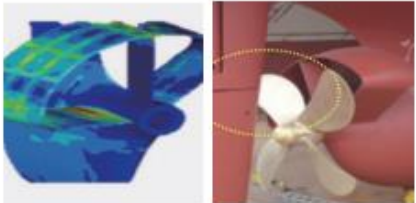
선박용 에너지 저감 장치: Energy Saving Devices

Propeller Re-design



- 약 2~3% FOC 절감
- 저속 운항 선박에 효과적

Hi-PSD (Pre Swirl Duct)



- 약 2~6% FOC 절감
- 가장 효과적인 장치

Hi-Fin (PBCF)



- 약 0.5~1.5% FOC 절감
- 적용 용이

Bulbous Bow Retrofit



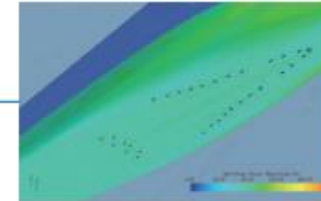
- 약 2~3% FOC 절감
- 저속 운항 선박에 효과적

Hi-Rudder Bulb

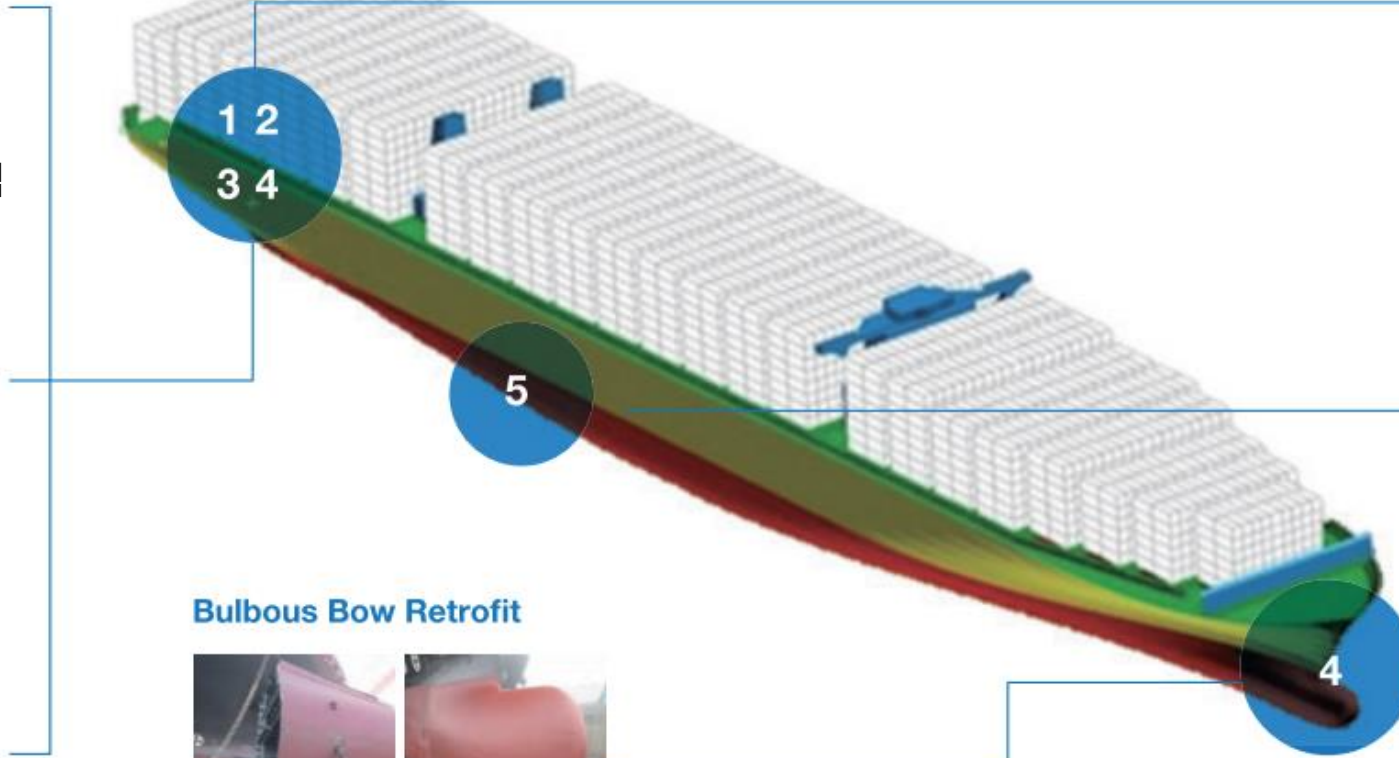


- 약 1~2% FOC 절감
- 프로펠러 허브 보우텍스 해소

Hi-ALS



- 약 5~8% FOC 절감
- 마찰저항 저감 효과



Energy Saving Device (ESD)

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



GHG 저감 시스템

On-board CCS

- **고효율의 흡수제** 발굴 및 적용 및 **폐열 회수**를 통한 에너지 효율 향상 필요
- 선상 탑재를 고려한 크기/시스템 최적화 진행 중



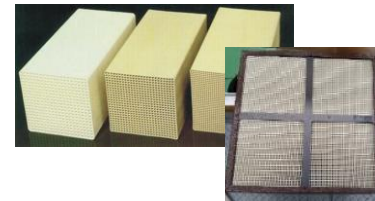
〈 0.7MW Pilot Scale Test, 1Q 2023 〉



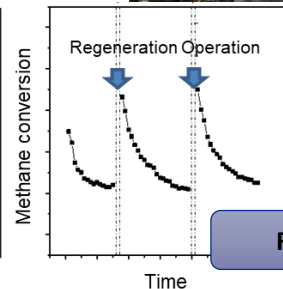
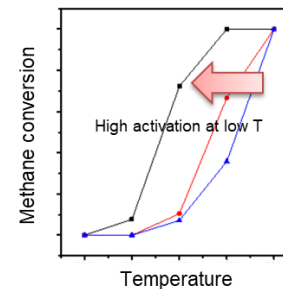
〈 Onboard Carbon Capture Storage System 〉

Methane oxidation catalyst system

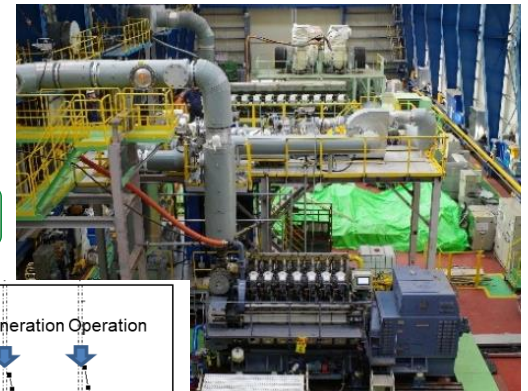
- **저온 산화 성능**이 높은 효과적인 촉매 개발 필요
- 실 운항 조건의 **수분/황 피독에 의한 성능 저하**를 극복하는 방안 필요



High activation catalyst



Reasonable regeneration



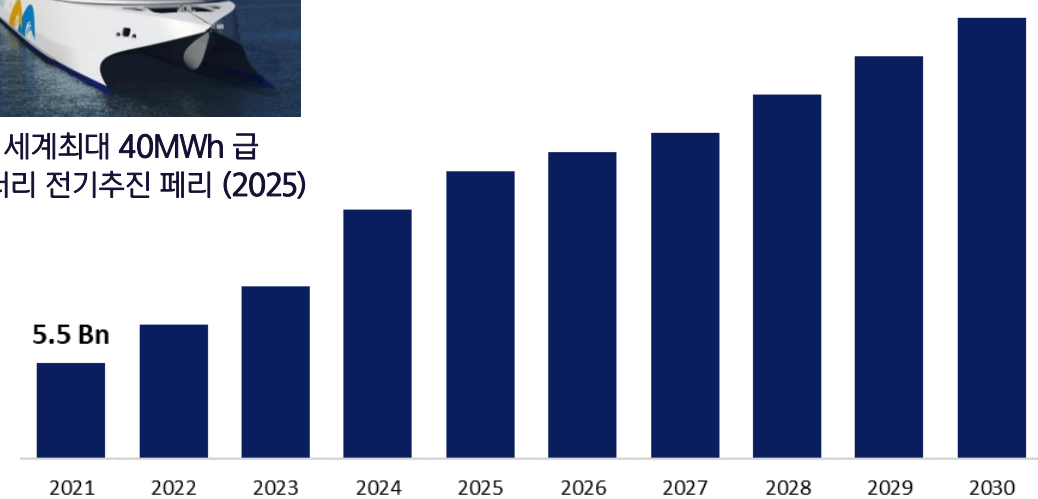
연료 전지 및 전기추진 시스템



세계최대 40MWh 급
배터리 전기추진 페리 (2025)

Global Electric Ships Market

11.5 Bn



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

유럽



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

중국



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

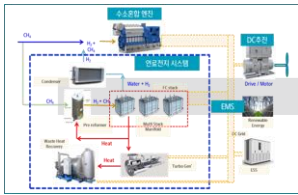
일본



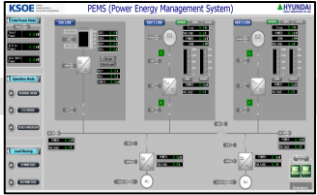
- KHI's Electric Propulsion Product Carrier (2022)
: 3,480 kWh Lithium-ion Battery
- PowerX plan to build a power carrier (2025)

'17 '18 '19 '20 '21 '22 '23

TRL 1~3 : Basic Tech. Research



다중연료 전기추진 시스템
DNV AiP (2017)

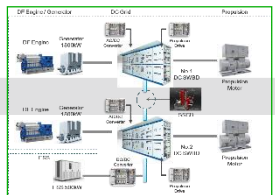


통합제어시스템
파일럿 제품 (2018)

TRL 4~6 : Application Research

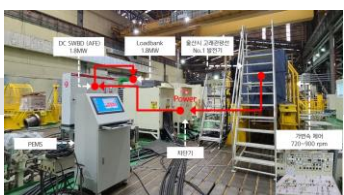


HiMSEN (LNG DF) 엔진
전기추진 시스템
KR AiP (2020)



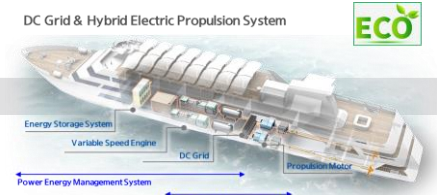
4MW DC
전기추진 시스템
KR 인증 (2021)

TRL 7~8 : Onland



국내 최초 1.8MW
고효율 VFD 발전 시스템
(2021)

TRL 9 : Actual System



울산 태화호 (2,800DWT)
전기추진 시스템 실증
(Jun.~Nov. 2022)



VLCC 대상
전기추진 시스템
LR AiP (2023)

환경 변화에 대한 신속한 적응이 필요

규제

엄격한 규제가 적용 가속화

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

연료

2040년 이후 다양한
시나리오가 존재

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

경청해 주셔서 고맙습니다.

AI에게 물어본 선박의 친환경 연료 전환

Q1. Forecast on the fuel transition of ship and the related challenges

The transition to eco-friendly fuels in the shipping industry is a critical step towards reducing the sector's environmental impact.

Several alternative fuels and technologies are being explored and implemented to achieve this goal, including:

1. **LNG**: Currently **the most widely adopted** eco-friendly fuel in shipping. It emits significantly **lower levels of sulfur oxides (SOx), nitrogen oxides (NOx), and particulate matter** compared to traditional heavy fuel oil. However, LNG still emits greenhouse gases (GHGs), and its production and transportation can have environmental impacts.
2. **Biofuels**: Biofuels, such as biodiesel and bioethanol, are derived from renewable sources like plant oils or algae. They offer the **potential to reduce GHG emissions** significantly compared to fossil fuels. However, challenges include ensuring **sustainable feedstock production, scalability, and cost-competitiveness**.
3. **Hydrogen**: Hydrogen fuel cells have the potential to eliminate GHG emissions from ships entirely. However, significant technological advancements are needed to develop **efficient and cost-effective hydrogen production, storage, and fuel cell systems for marine applications**.
4. **Ammonia**: Ammonia is another **promising zero-emission fuel**. It is relatively **easy to store and transport**, and it can be produced from **renewable energy sources**. However, challenges include developing **efficient and reliable ammonia combustion engines and addressing safety concerns related to its toxicity and flammability**. ...



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Challenges associated with the eco-friendly fuel transition in shipping include:

1. **Cost**: Alternative fuels and technologies are **often more expensive than traditional fossil fuels**, making it challenging for ship owners and operators to justify the investment.
2. **Infrastructure**: The development of **bunkering infrastructure** for alternative fuels, such as LNG, hydrogen, and ammonia, is crucial to enable widespread adoption. This requires significant investments and coordination among ports, fuel suppliers, and shipping companies.
3. **Regulations**: **Clear and harmonized regulations** are needed to drive the adoption of eco-friendly fuels and technologies. This includes setting emissions standards, providing incentives for the use of alternative fuels, and addressing safety and environmental concerns.
4. **Technology Readiness**: Some alternative fuel technologies, such as **hydrogen fuel cells and ammonia combustion engines**, are still in the **early stages of development** and require further testing and validation before they can be widely adopted in commercial shipping.
5. **Fuel Availability**: Ensuring a **reliable and consistent supply of alternative fuels** is critical to support the transition. This requires investments in production facilities, supply chains, and bunkering infrastructure.
6. **International Cooperation**: The eco-friendly fuel transition in shipping requires international cooperation and collaboration among countries, ports, and shipping companies to establish global standards, promote technology development, and facilitate the adoption of alternative fuels.

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Q2. How can we enhance the safe use of Ammonia as a marine fuel?

1. Storage and Handling:

- Develop safer storage and handling protocols for ammonia, including proper ventilation, leak detection systems, and emergency response plans.
- Implement strict regulations and training for personnel involved in the handling and storage of ammonia.
- Utilize double-walled tanks and secondary containment systems to minimize the risk of leaks and spills.

2. Fuel Cell Technology..., 3. Ammonia-Water Mixtures ..., 4. Catalytic Combustion ...,
5. Emission Control Technologies ..., 6. Risk Assessment and Mitigation ..., 7. Regulatory Framework ...,

8. Public Awareness and Education:

- Raise awareness among stakeholders, including ship owners, operators, and port authorities, about the benefits and risks of using ammonia as a marine fuel.
- Provide training and education programs to personnel involved in the handling, storage, and use of ammonia to ensure they have the necessary knowledge and skills to operate safely.

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Q3. Is it possible to use the Hydrogen as a marine fuel especially for the large commercial vessel?

Yes, it is possible to use hydrogen as a marine fuel, especially for large commercial vessels.

Hydrogen offers several advantages as a marine fuel:

1. Zero Emissions...
2. High Energy Density...
3. Reduced Noise and Vibration...
4. Scalability...

However, there are also challenges associated with using hydrogen as a marine fuel:

1. Hydrogen Production...
2. Storage and Transportation...
3. Fuel Cell Technology...
4. Infrastructure Development...

Despite these challenges, significant progress is being made in the development and implementation of hydrogen-powered marine vessels.

Several pilot projects and demonstrations are underway, and major shipping companies are exploring the use of hydrogen as a future fuel.

In summary, while there are challenges to overcome, the potential benefits of hydrogen as a marine fuel are significant. With continued research, development, and investment, hydrogen has the potential to play a major role in decarbonizing the maritime industry and reducing the environmental impact of shipping.