

# 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

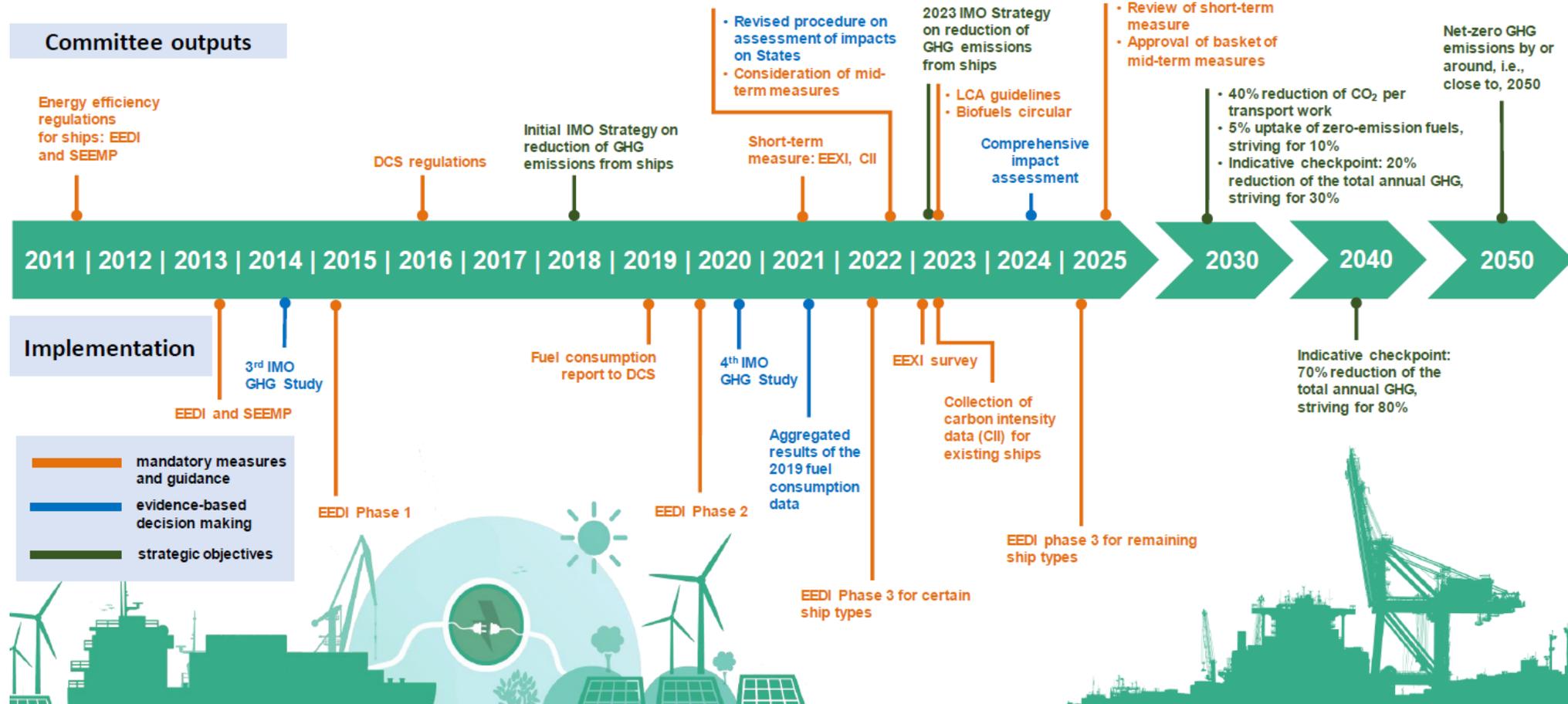
## 4. 결론

# 국제해사기구(IMO)의 GHG 규제



## Addressing climate change

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



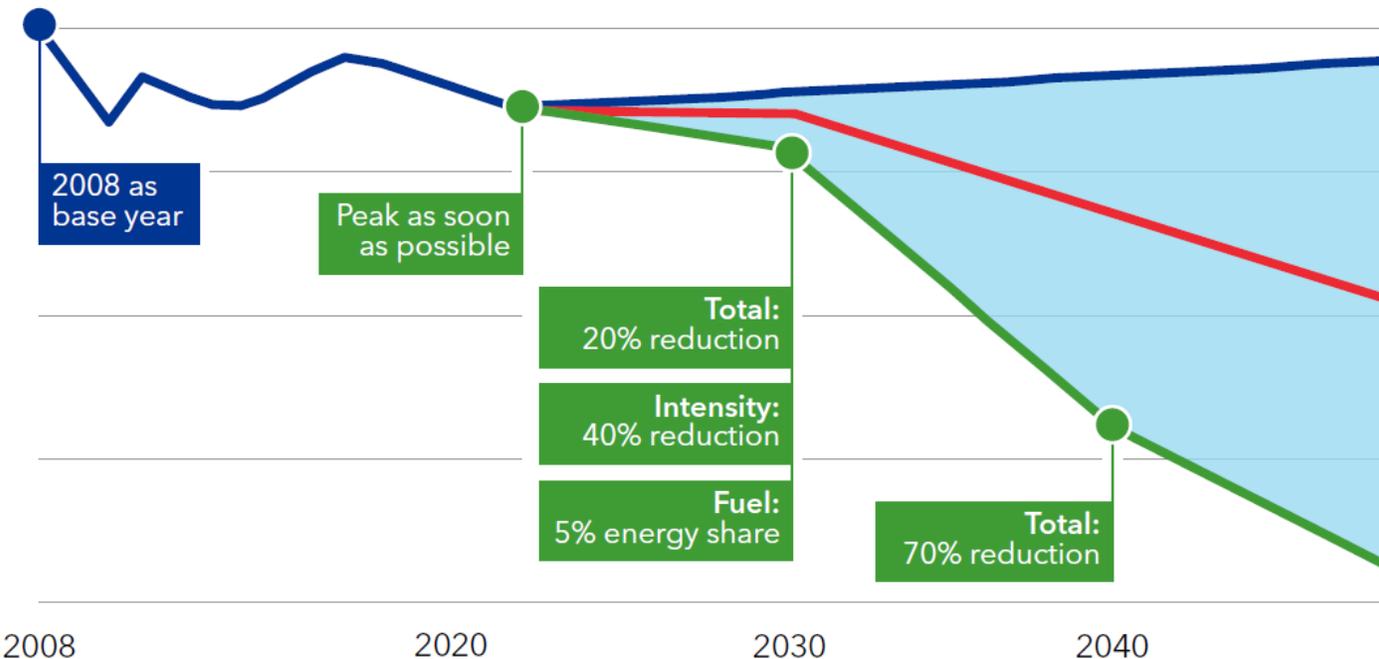
(Source: <https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx>)

# 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

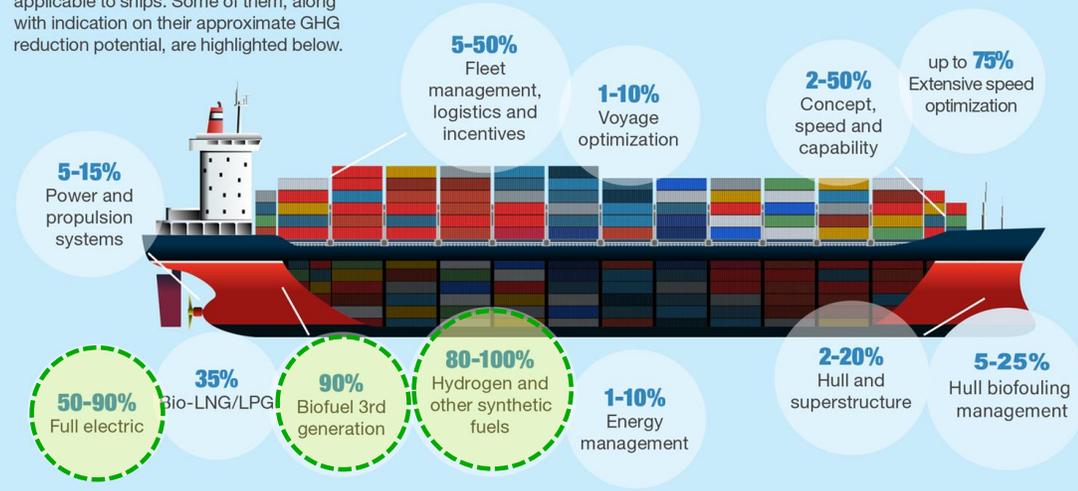


### <규제 변화의 동향>

- ❖ 기술적 & 운용 관점에서의 대응 (EEDI/EEXI/CII)
- ❖ CO<sub>2</sub> 배출 규제 (EEDI/EEXI/CII)
- ❖ Tank to Wake 배출 규제 (EEDI/EEXI/CII/ETS)
- ❖ 개별 선박

### 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>)

- ➔ 종합적 관점에서의 대응 (기술 & 경제적 대응)
- ➔ GHG (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O) 배출 규제 (GFS, ETS, FuelEU)
- ➔ Well to Wake 배출 규제 (GFS, FuelEU)
- ➔ 개별 선박 및 선대



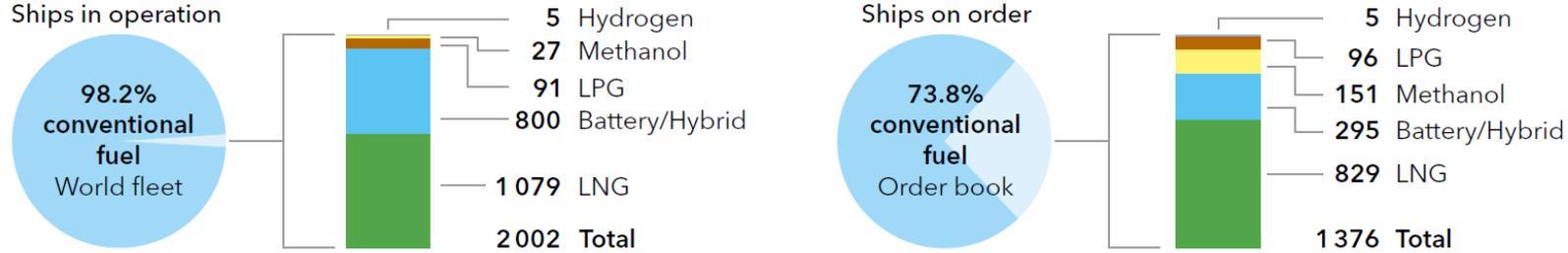
(1) EEDI: Energy Efficiency Design Index (2) EEXI: Energy Efficiency Existing-ship Index (3) CII: Carbon Intensity Indicator (4) ETS: Emissions Trading System

# 1. Change in Shipping Market

## 2023 시장 이슈 사항과 통계

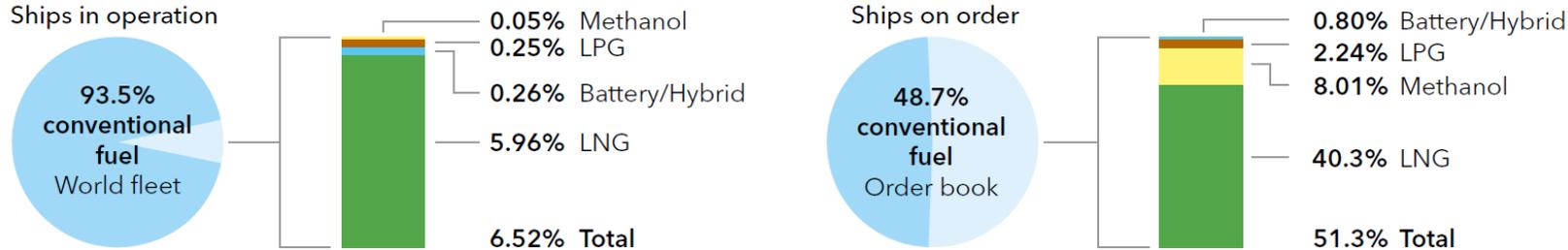
Alternative fuel uptake in the world fleet in number of ships (upper) and gross tonnage (lower), as of July 2023

### NUMBER OF SHIPS



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

### GROSS TONNAGE

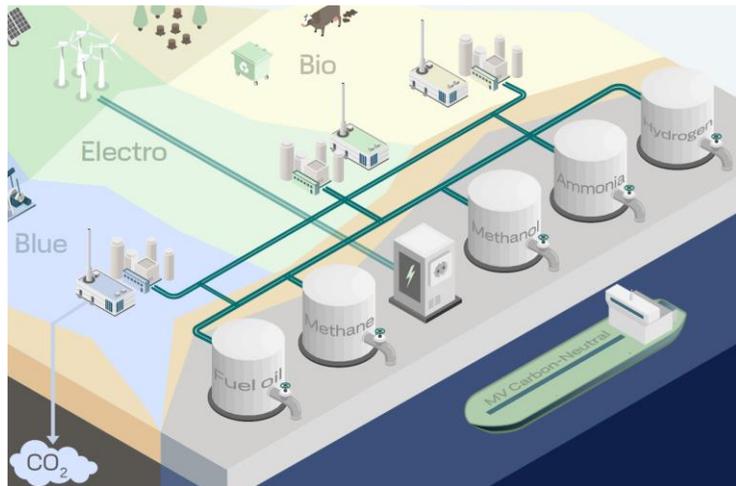
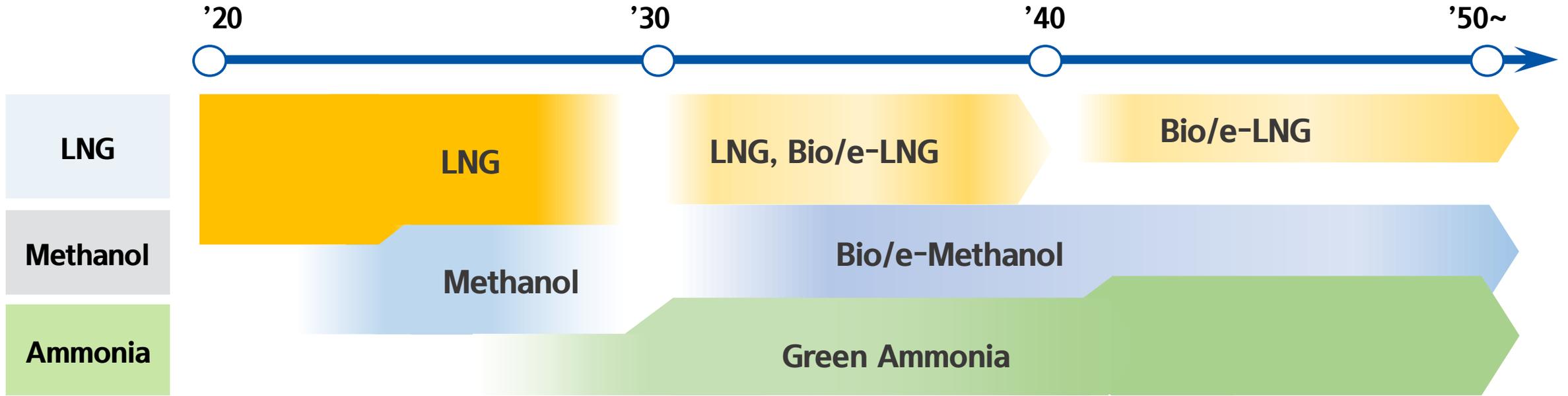


Sources: IHSMarkit (ihsmarkit.com) and DNV's Alternative Fuels Insights for the shipping industry - AFI platform (afi.dnv.com)

- (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



# 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(CO<sub>2</sub>) / 메탄(CH<sub>4</sub>) 포집을 통한 친환경 인증**
- **탈 탄소 연료로의 확장 가능성 (Bio-LNG, H<sub>2</sub> 혼소)**

➔ 지속 가능하도록 유지

**Record of HHI Group**

World's 1<sup>st</sup> LNG DF Aframax tanker ('18)

World's 1<sup>st</sup> LNG DF large Container ('20)

180K LNG DF Bulk Carrier ('20)

**Energy Saving Devices**

Engine Mounted Generator

Air lubrication system

**GHG Reduction Systems**

Methane Slip Reduction System

CO<sub>2</sub> Capture/Reduction

**Mixed Combustion**

Mixed Combustion Engine

$\text{C}_x\text{H}_y + \text{Biofuel} + \text{H}_2$

# 메탄올 이중 연료 추진선

- 기존 HFO와 유사한 특성의 **성숙된 기술**.
- Tank to Wake 기준 11% CO<sub>2</sub> 절감 + 추가적인 배출물질(PM/Smoke, SOx, NOx) 저감
- **그린 메탄올 연료 공급망 확대**가 필요함 (빙커링 설비 등)
- 세계 최초의 메탄올 추진 대형 컨테이너 운반선 인도 (23년 9월)



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

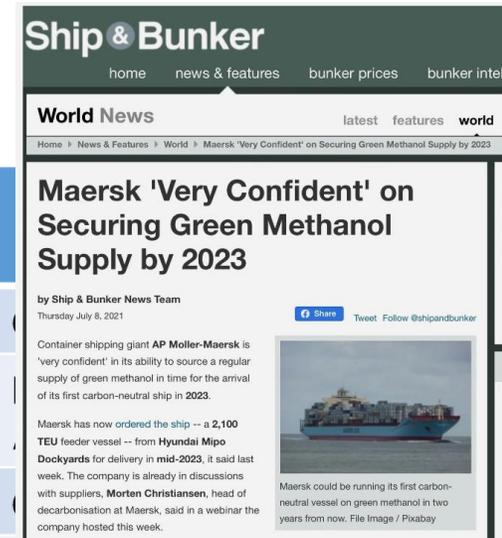


**HD** 〈 Methanol-Fueled Container 〉  
(2023, HHI / Maersk)

## 〈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 <sup>(1)</sup>	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	

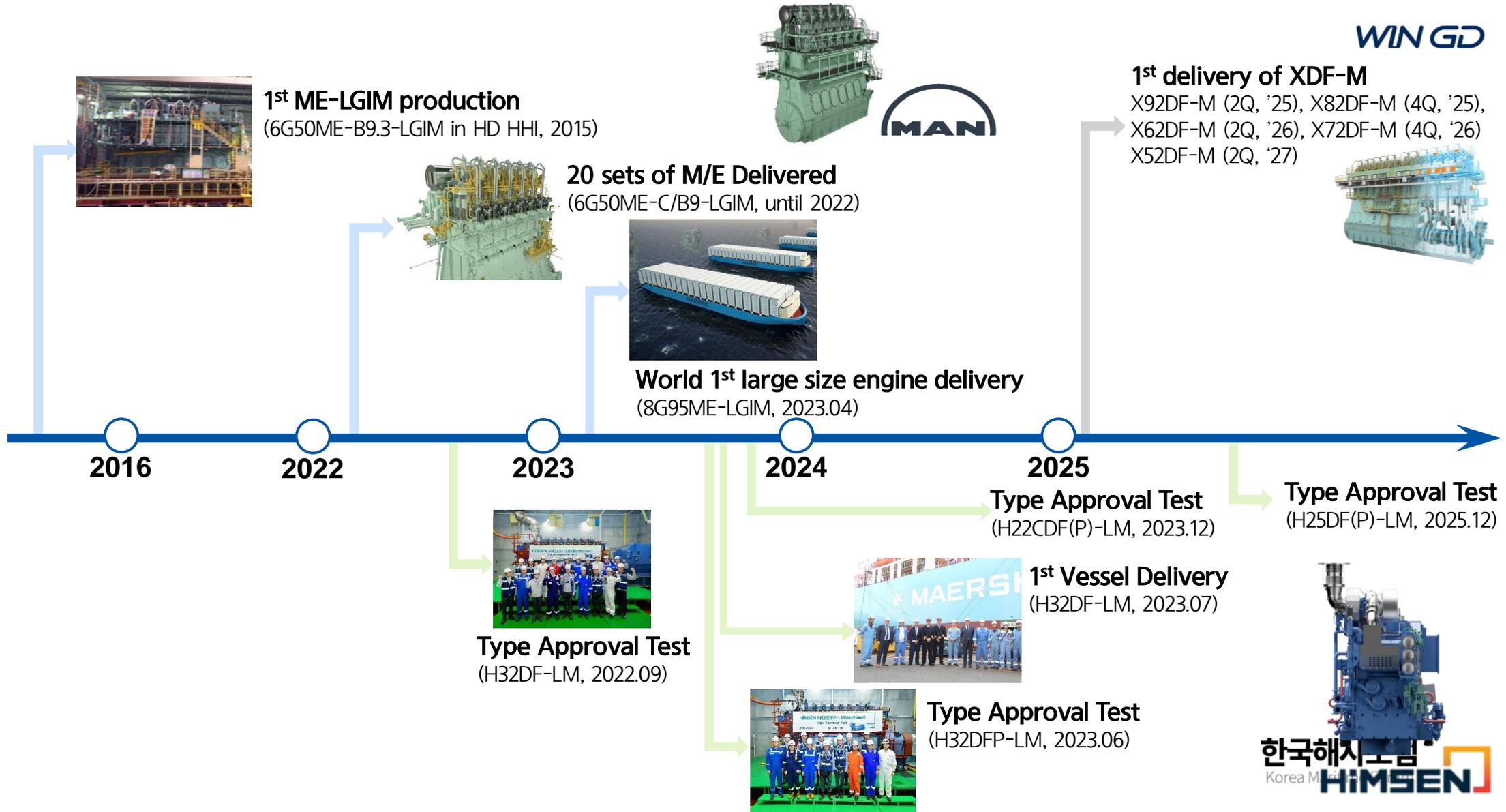
(1) GTB: Green Technology Bank



# 선박용 메탄올 엔진

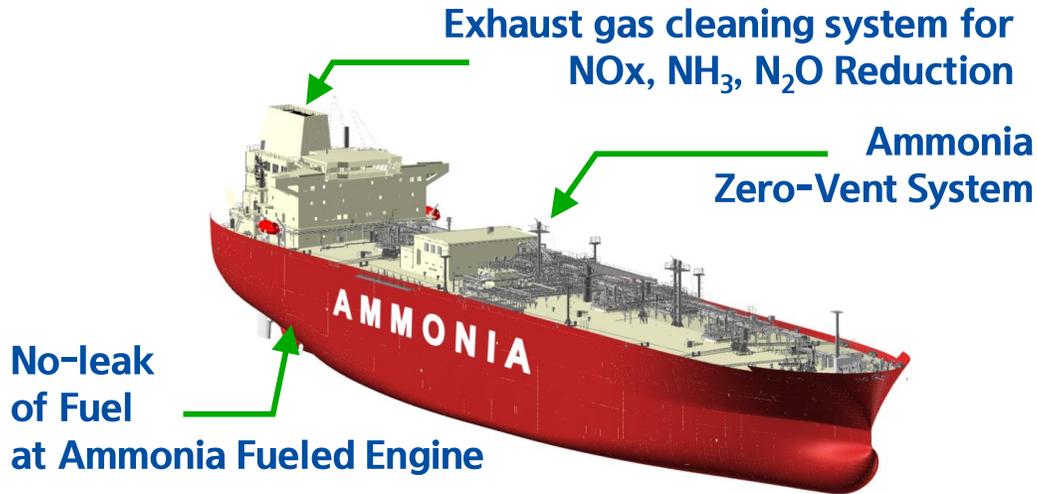
2-Stroke

4-Stroke



## 암모니아 이중 연료 추진선

- 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 〉  
한척해사포럼  
(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/ 1<sup>st</sup> Engine delivery in 2025)

## 4-Stroke



[MAN-ES]

- Ammonia Engine launch after 2025



[Wartsila]

- Tech. ready 2023, Volume ramp-up 2025



[HHI]

- Test approval test in 2024

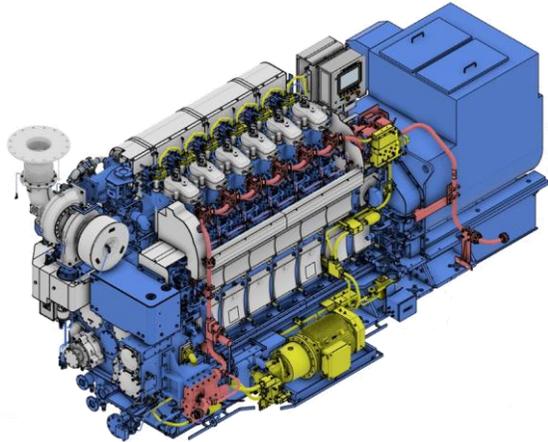
News  
**EPS signs MoU for new ammonia dual-fuel gas carrier**  
 The use of ammonia as an alternative marine fuel is expected to help cut down carbon dioxide emissions.  
 June 7, 2022



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



< Single cylinder test : SCH32 >

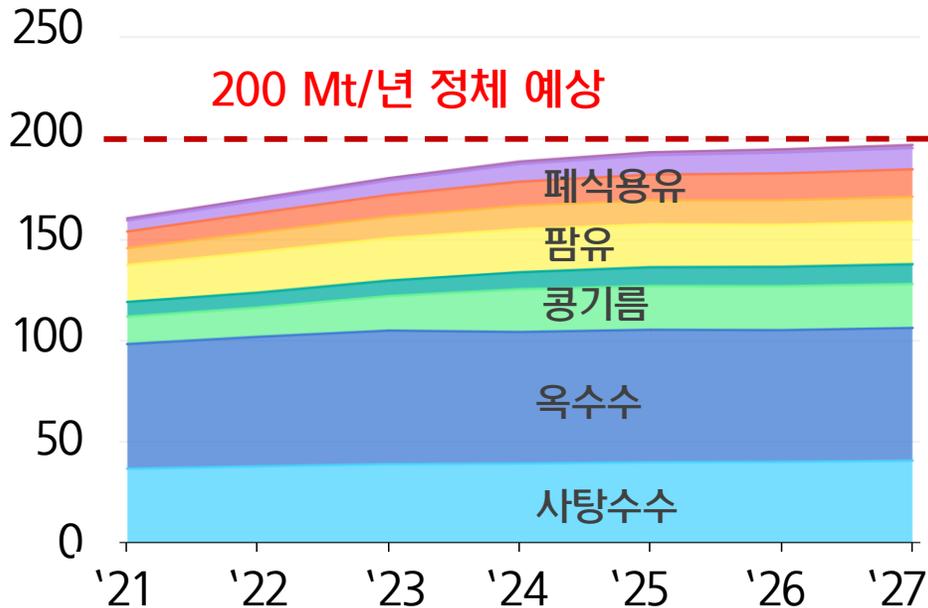


< Ammonia HiMSEN concept >



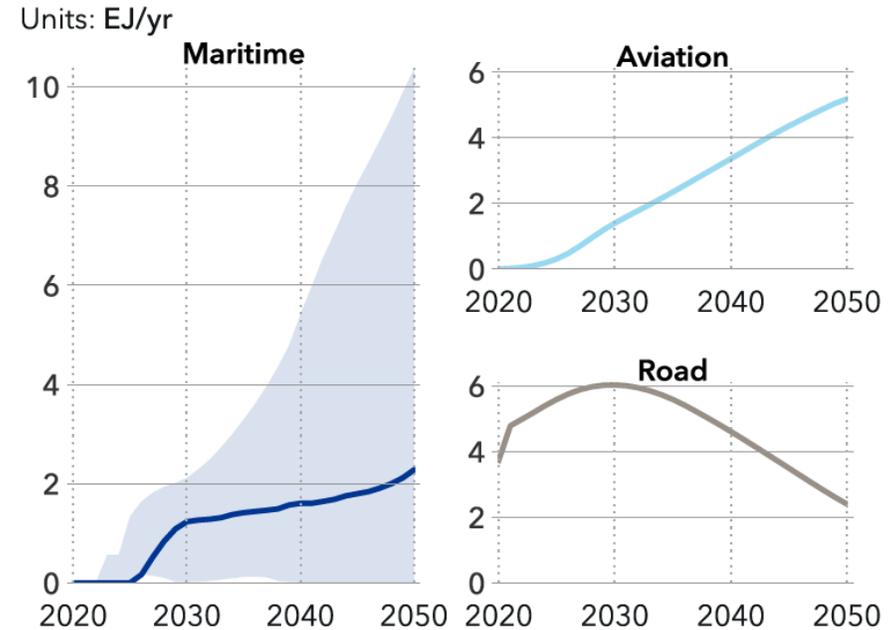
## 바이오 연료

- (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-H<sub>2</sub> 이중 연료 엔진 실증 완.  
: 액화수소 운반선의 BOG H<sub>2</sub>를 활용한 LNG-H<sub>2</sub> 이중 연료 엔진 적용 고려.
- 2025년 H<sub>2</sub> 전소 4행정 엔진 출시 예정.

## Hydrogen Engine

### Hydrogen Dual-fuel Engine



LNG-H<sub>2</sub> dual fuel engine demonstration (May, 2023)

Evaluation up to 25 % hydrogen (2023)

Evaluation 30 % and over hydrogen (~2024)

### Hydrogen Engine

Development in  
2025  
Sales release in  
Dec., 2025

## LH<sub>2</sub> Carrier



Development of liquefied H<sub>2</sub> carrier



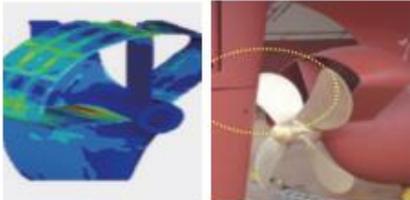
# 선박용 에너지 저감 장치: Energy Saving Devices

## 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



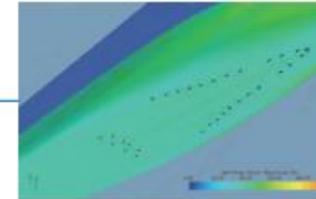
- 약 2~3% FOC 절감
- 저속 운항 선박에 효과적

## Hi-Rudder Bulb

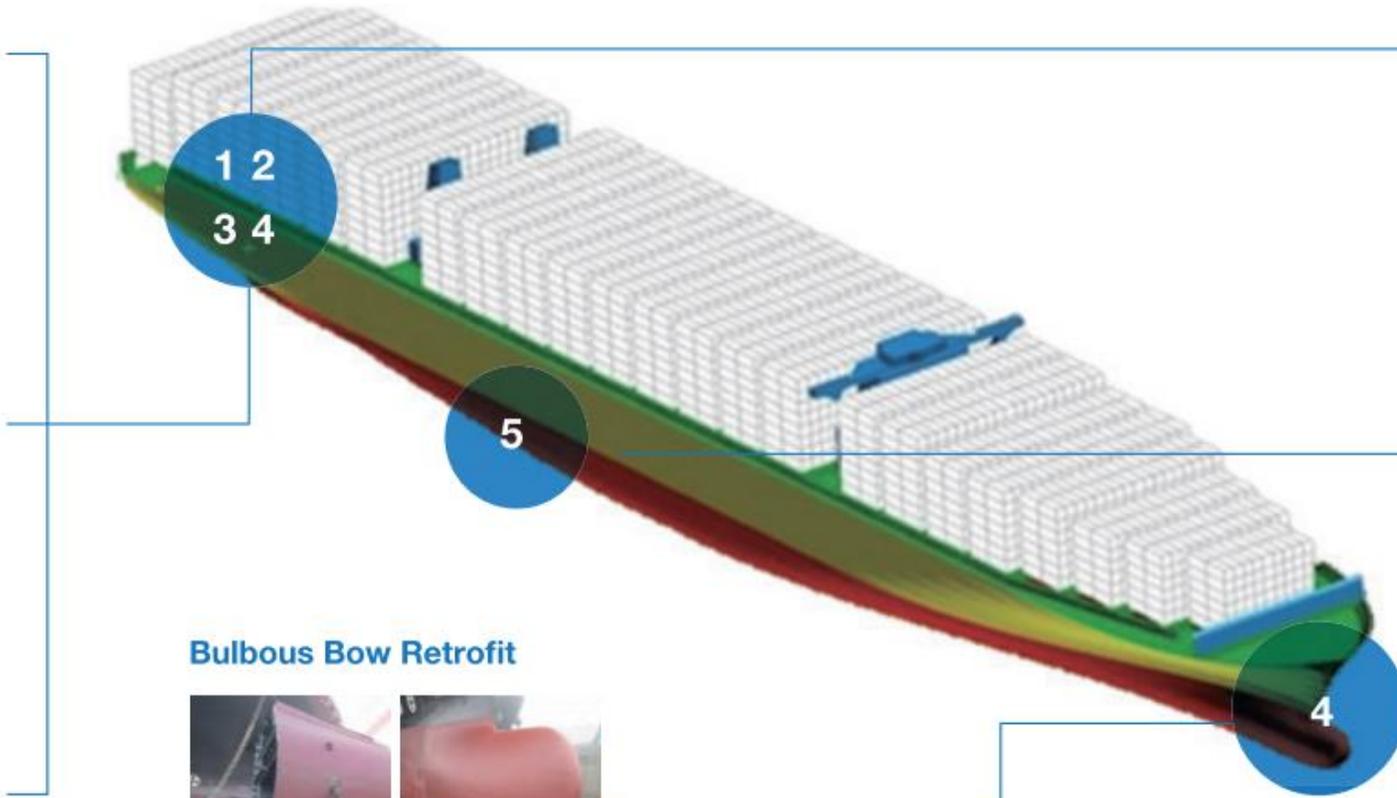


- 약 1~2% FOC 절감
- 프로펠러 허브 보우텍스 해소

## Hi-ALS



- 약 5~8% FOC 절감
- 마찰저항 저감 효과



## **Energy Saving Device (ESD)**

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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 탑재**를 고려한 크기/시스템 최적화 진행 중

## Methane oxidation catalyst system

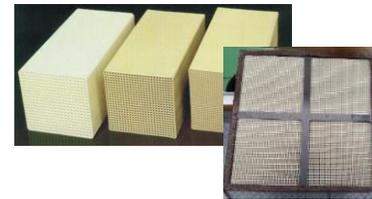
- **저온 산화 성능**이 높은 효과적인 촉매 개발 필요
- 실 운항 조건의 **수분/황 피독**에 의한 **성능 저하**를 극복하는 방안 필요



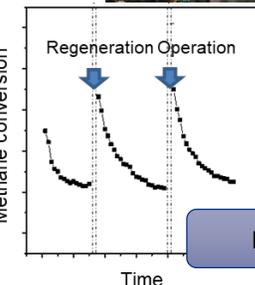
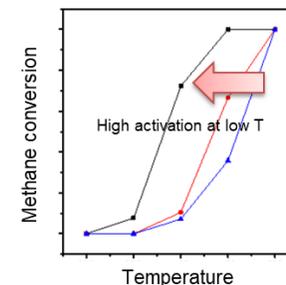
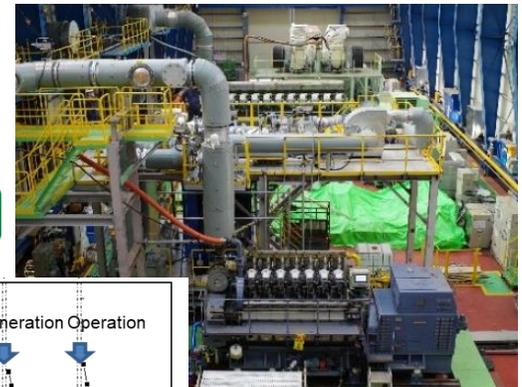
〈 0.7MW Pilot Scale Test, 1Q 2023 〉



〈 Onboard Carbon Capture Storage System 〉



High activation catalyst



Reasonable regeneration

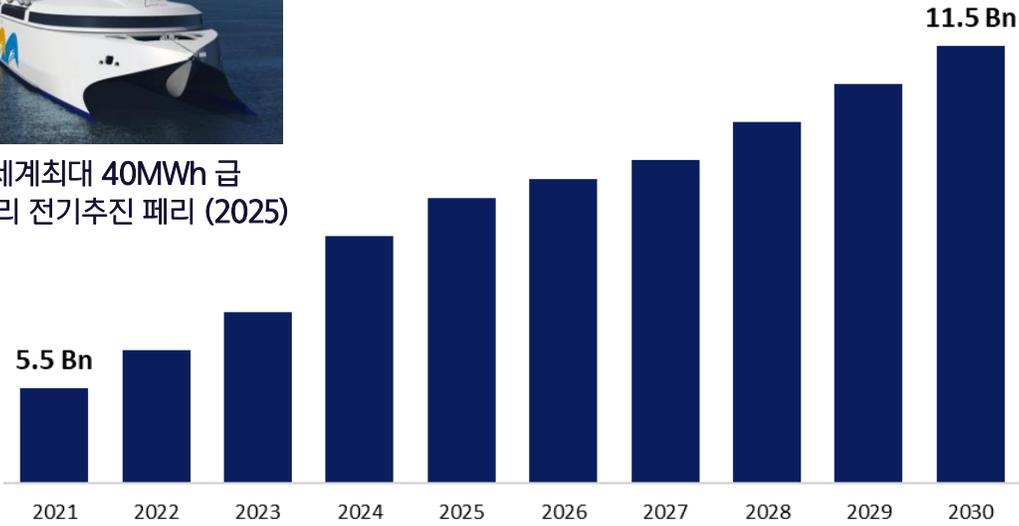


# 연료 전지 및 전기추진 시스템



세계최대 40MWh 급  
배터리 전기추진 페리 (2025)

Global Electric Ships Market



(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



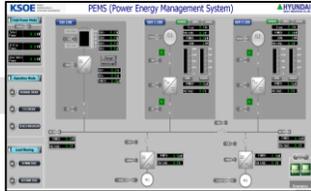
- KHI's Electric Propulsion Product Carrier (2022)
- : 3,480 kWh Lithium-ion Battery
- PowerX plan to build a power carrier (2025)

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

TRL 1~3 : Basic Tech. Research



다중연료 전기추진 시스템  
DNV AiP (2017)

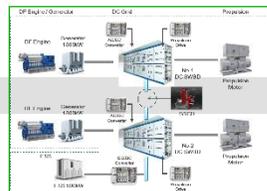


통합제어시스템  
파일럿 제품 (2018)

TRL 4~6 : Application Research



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



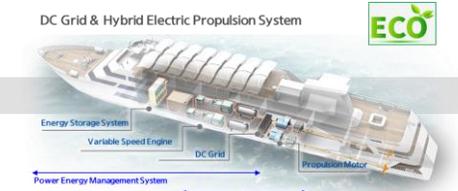
4MW DC  
전기추진 시스템  
KR 인증 (2021)

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**. ...



# AI에게 물어본 선박의 친환경 연료 전환

**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

# AI에게 물어본 선박의 친환경 연료 전환

## 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.

# AI에게 물어본 선박의 친환경 연료 전환

## 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.