

## Decarbonization strategies for ocean-going vessels





# Agenda



- Global maritime trends and decarbonization target
- E-fuel-based engine concepts
- Onboard carbon capture
- Outlook





# Maritime Transport – Facts and Trends



## → The backbone of global trade

- About **100,000** oceangoing vessels
- Over **90%** of worldwide transport and over **90%** of EU foreign trade

## → Trend towards mega ships

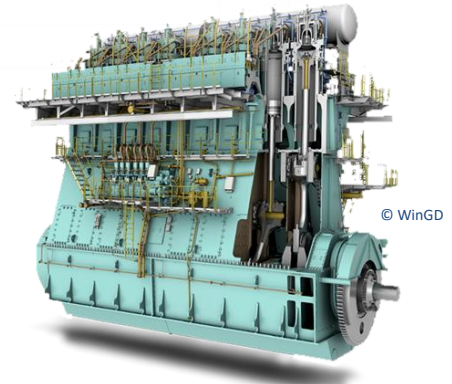
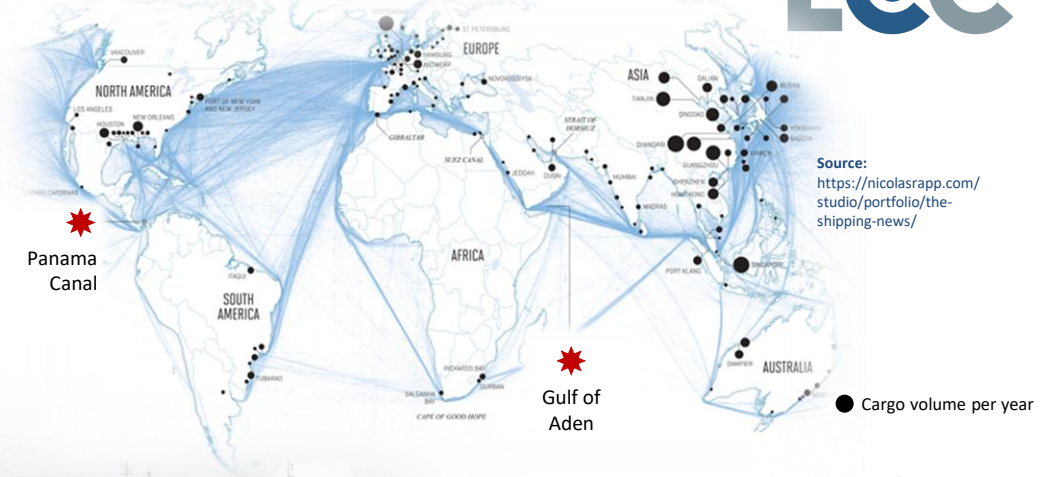
- Post Panamax, Post Suezmax, etc.
- Container vessels for shipping of more than **24,000 TEU**
- Cruise ships for over **7,000 passengers** (crew members not included)

## → Mainly IC Engine as prime mover

- Power output up to **80 MW**
- Almost exclusively **HFO** (Heavy Fuel Oil), **MGO** (Marine Gas Oil) and **LNG**

## → Retrofitting – a viable option?

- Investments of well-over **100 million dollars**
- **Lifetime** of vessels **25+ years**



Source: [https://maritimeoptima.com/public/vessels/pages/imo:9929429/mmsi:636022601/MS\\_C\\_IRINA.html](https://maritimeoptima.com/public/vessels/pages/imo:9929429/mmsi:636022601/MS_C_IRINA.html)

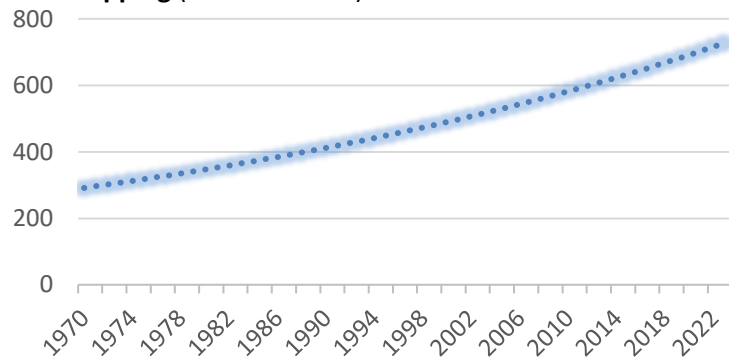
Source: Wimmer, A. et al.: "Pathways to the Decarbonization of Oceangoing Vessels – From Hydrogen Engines to On-board Carbon Capture Concepts", in: in: Lenz, H. P. (ed.): 46. Internationales Wiener Motorensymposium.



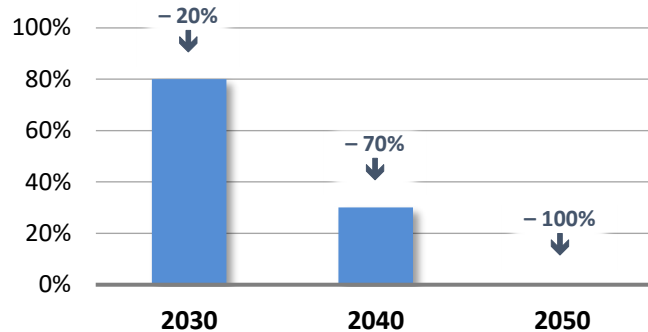
# IMO Net-Zero Framework



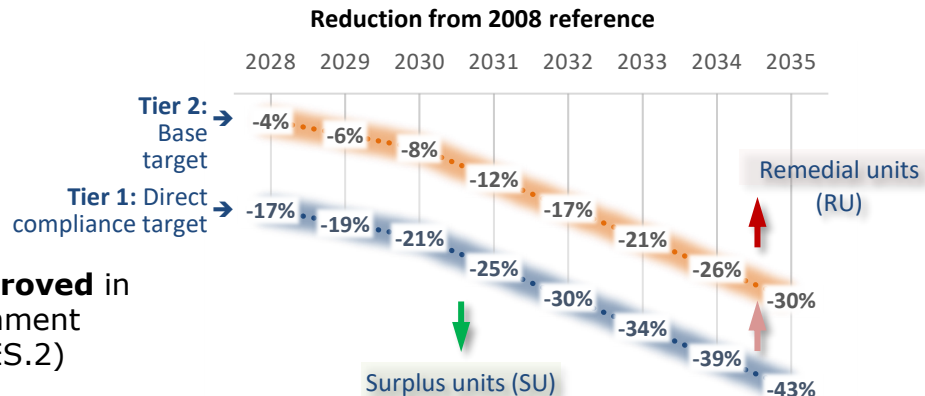
Development of CO<sub>2</sub> emissions from global shipping (in million tons)



Targeted reduction in greenhouse gas emissions from global shipping – base year 2008

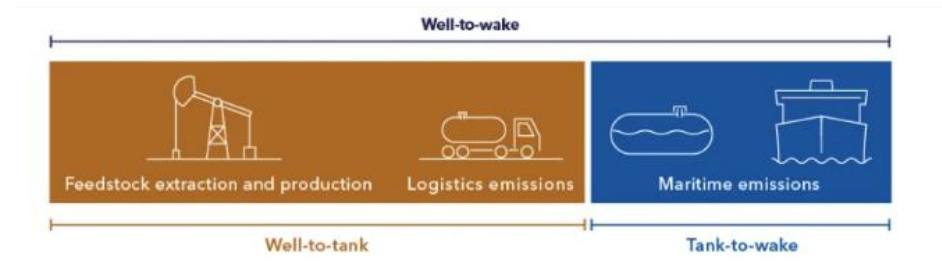


Net-zero-Framework **not approved** in October 2025 (Marine Environment Protection Committee MEPC/ES.2)

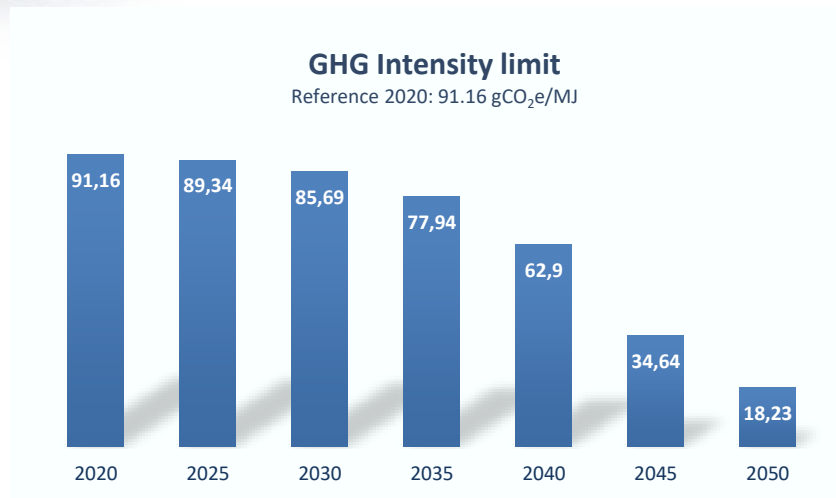




# FuelEU Maritime

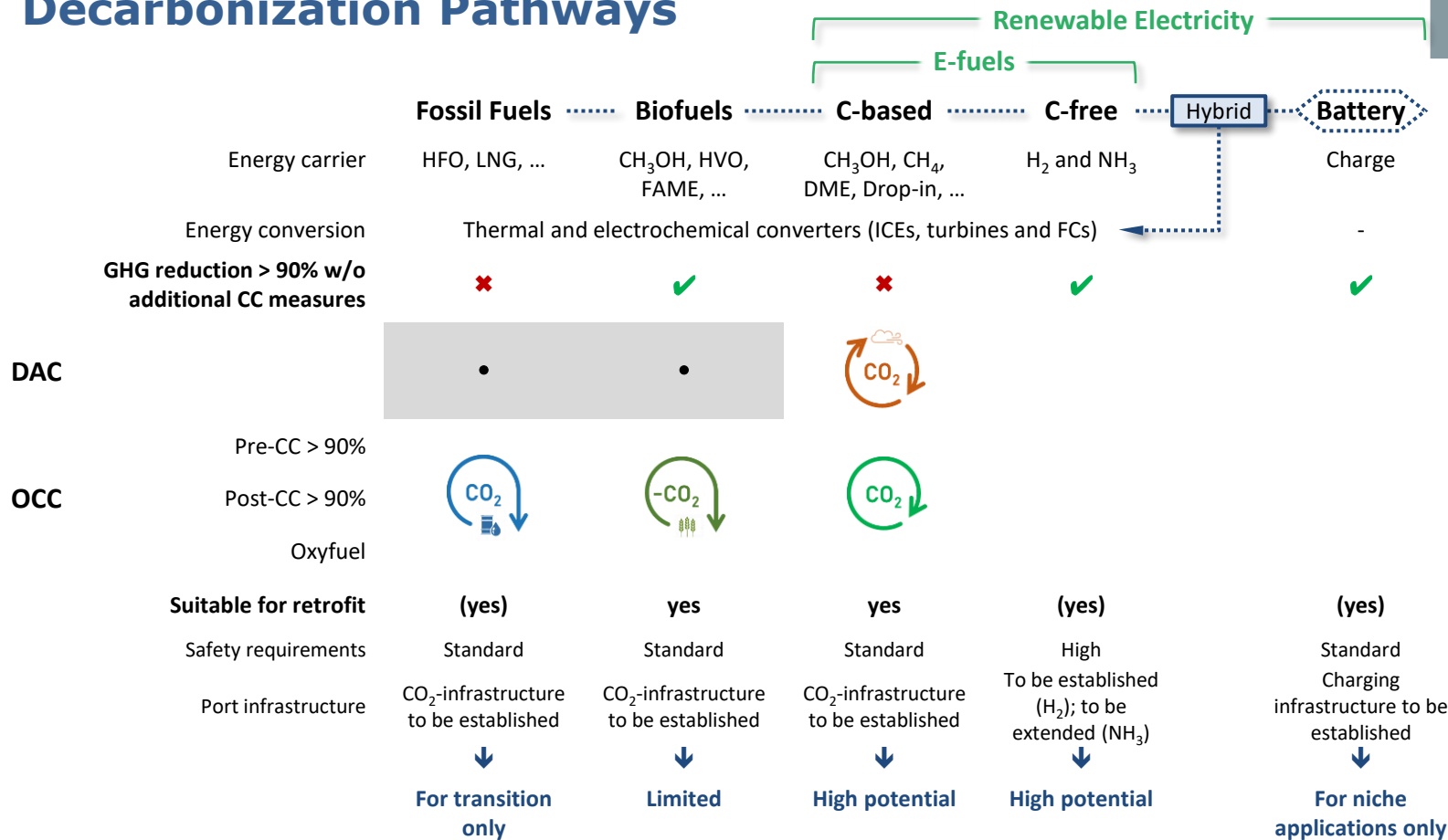


*FuelEU Maritime*





# Decarbonization Pathways

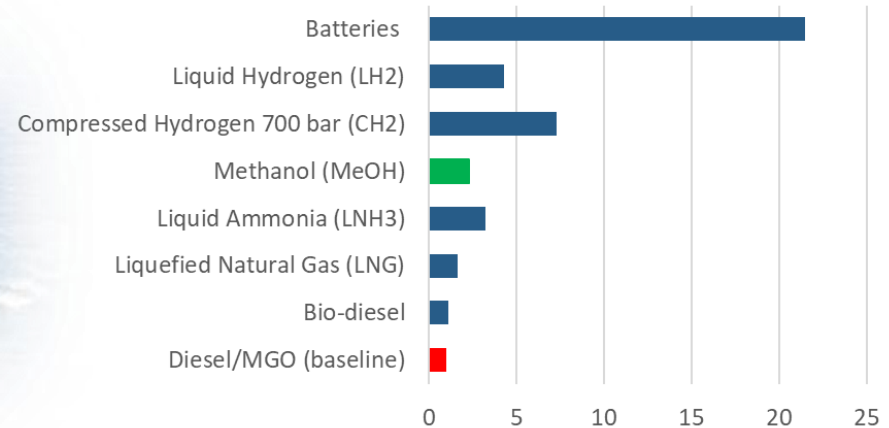




# Additional Storage Space



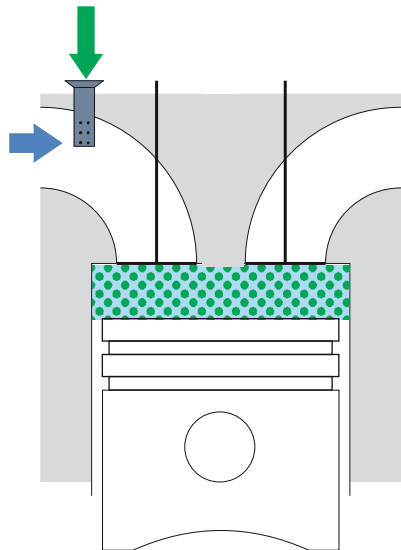
Estimated energy storage volume ratio [-]





# Fuel Admission Concepts for E-Fuels

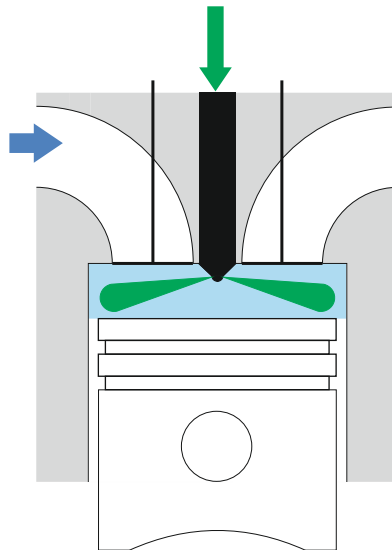
**Port Fuel Injection  
PFI**



**Fuel rail  
pressure:**

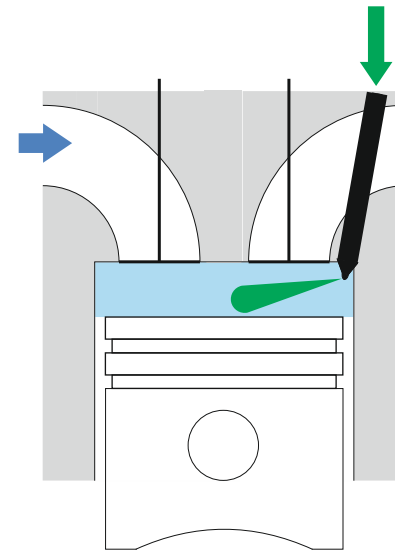
**10-50 bar**

**High Pressure Direct Injection  
HPDI**



**600-1200 bar**

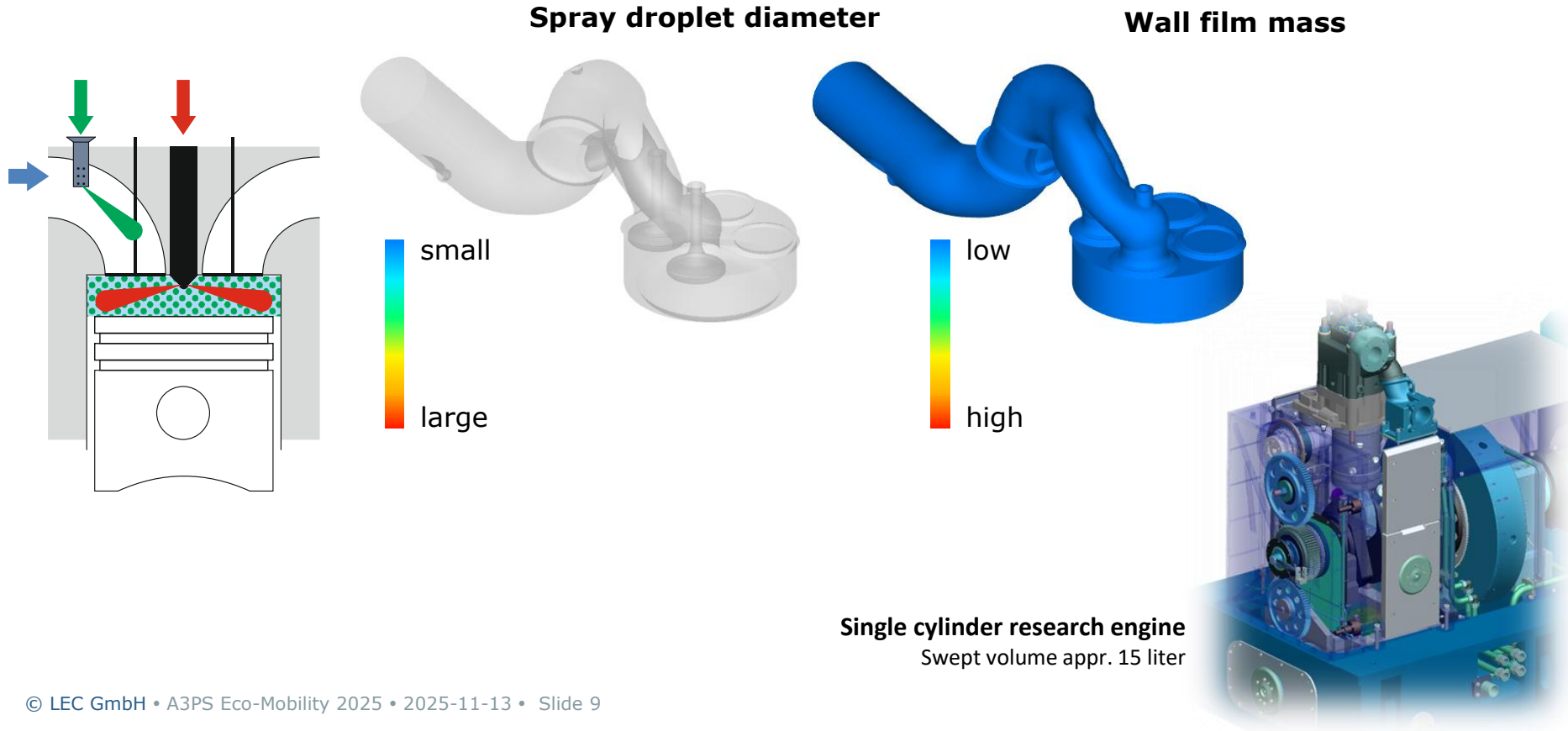
**Low Pressure Direct Injection  
LPDI**



**50-100 bar**



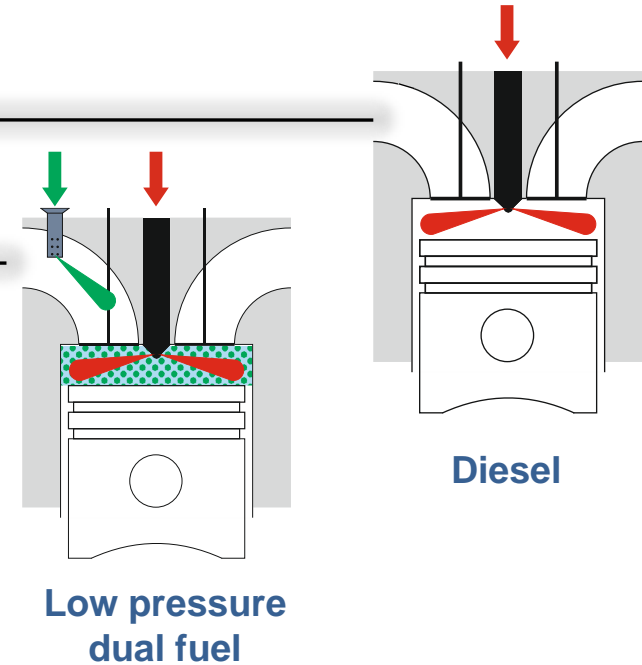
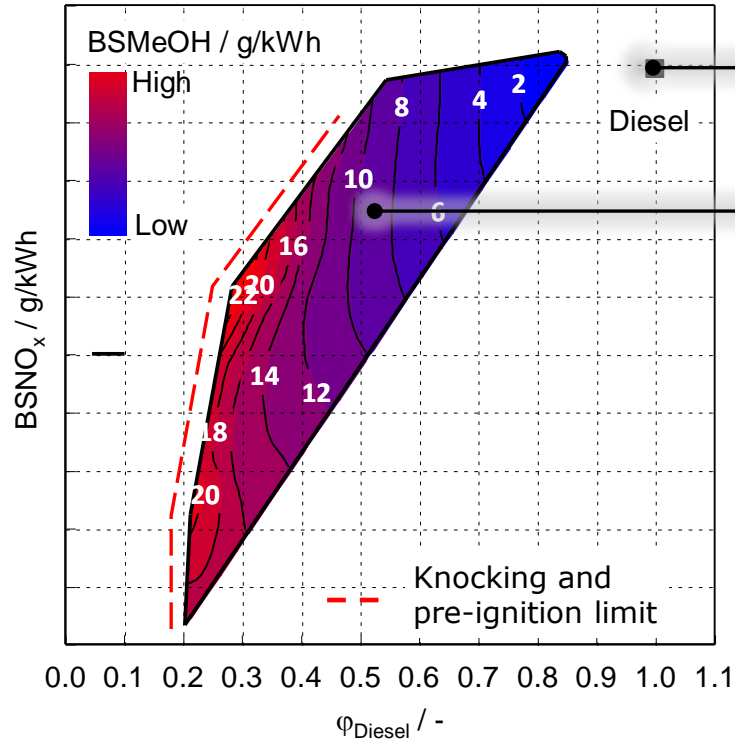
# Low-pressure Methanol Dual Fuel Concept





# Low-pressure Methanol Dual Fuel Concept

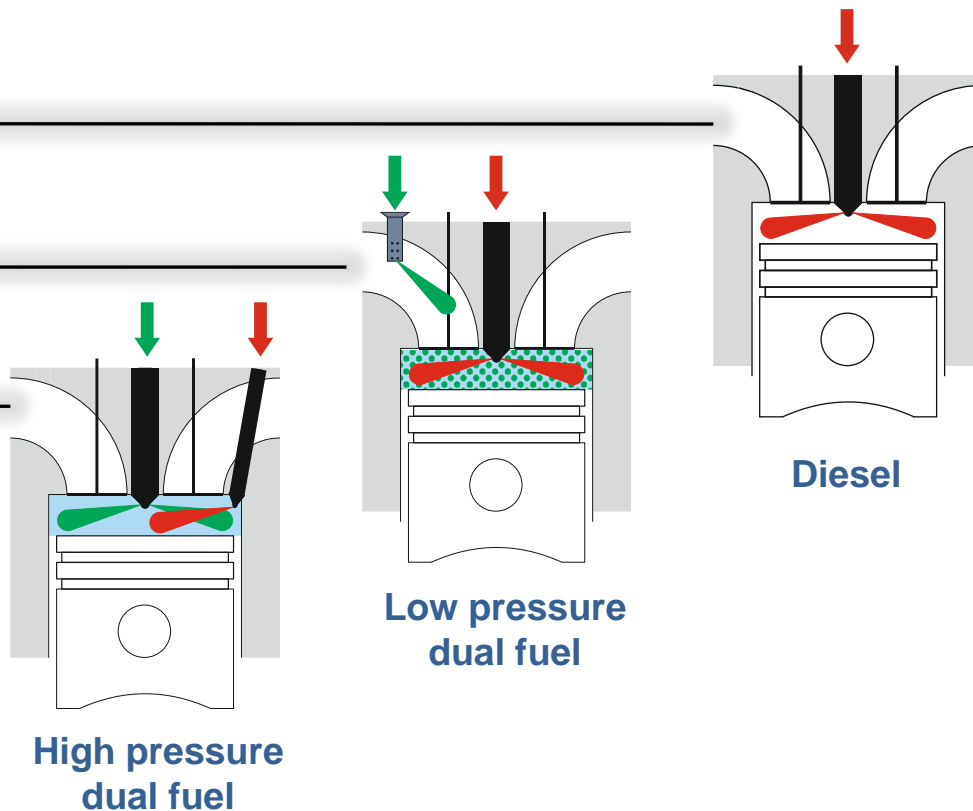
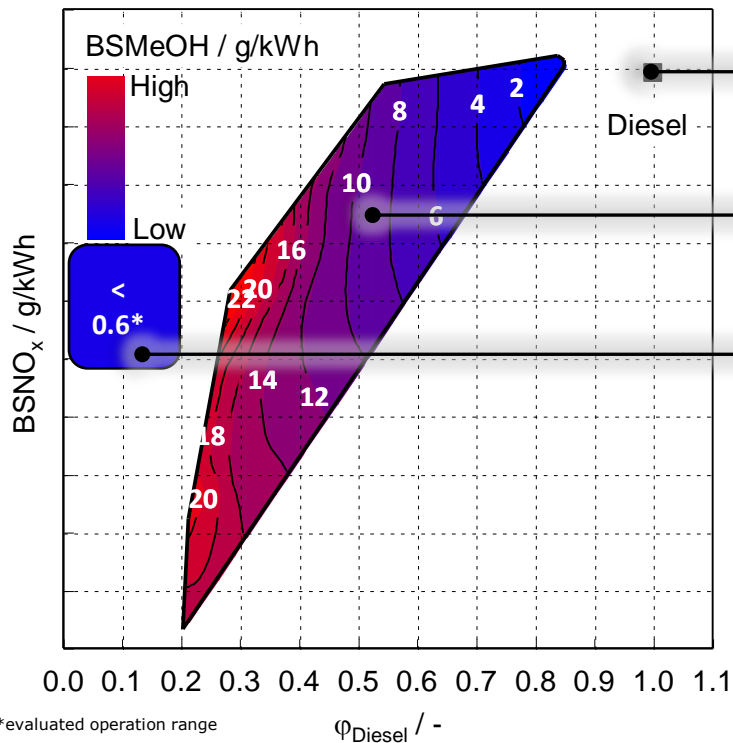
## Methanol emissions





# Low-pressure Methanol Dual Fuel Concept

## Methanol emissions



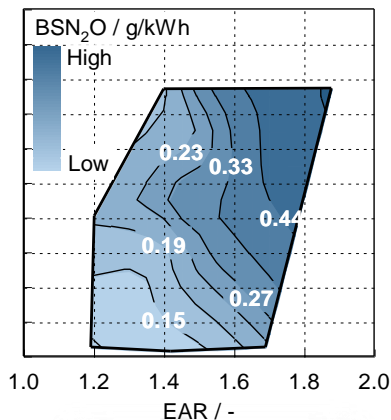
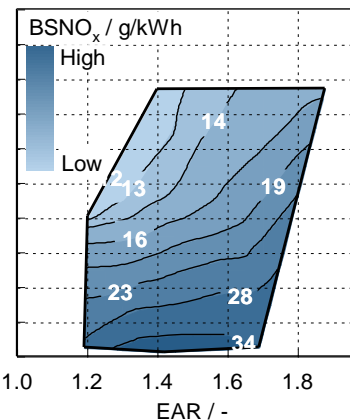
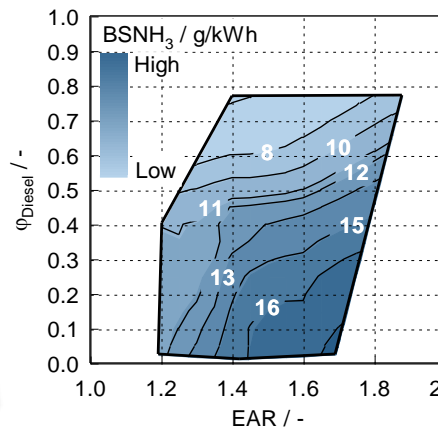
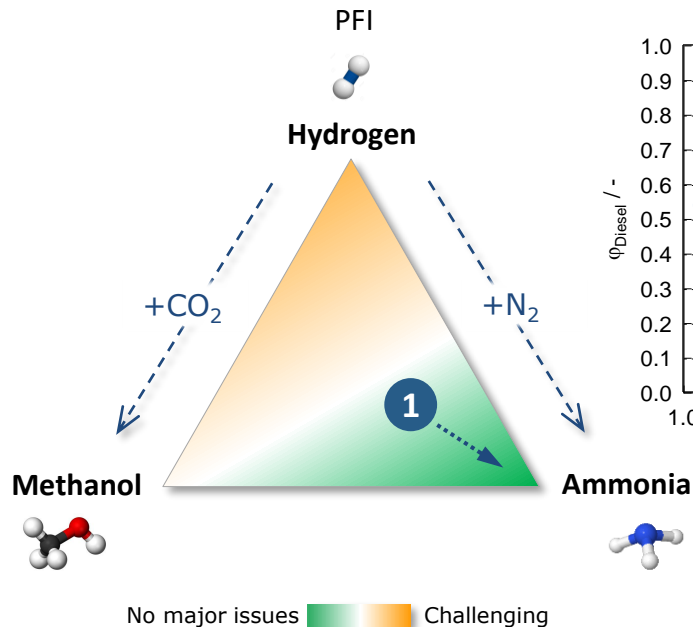


# Ammonia combustion and emissions

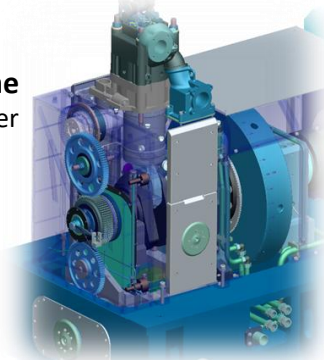
1

- Ammonia-Diesel Dual Fuel combustion
- Low-energetic diesel fraction
- 90+ % GHG emission reduction (w/o exhaust gas aftertreatment)

## Premixed combustion



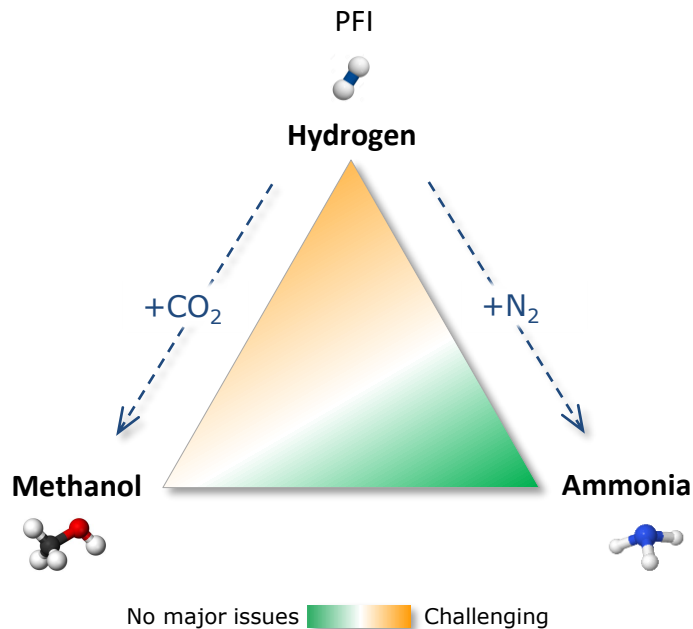
Single cylinder research engine  
Swept volume appr. 15 liter



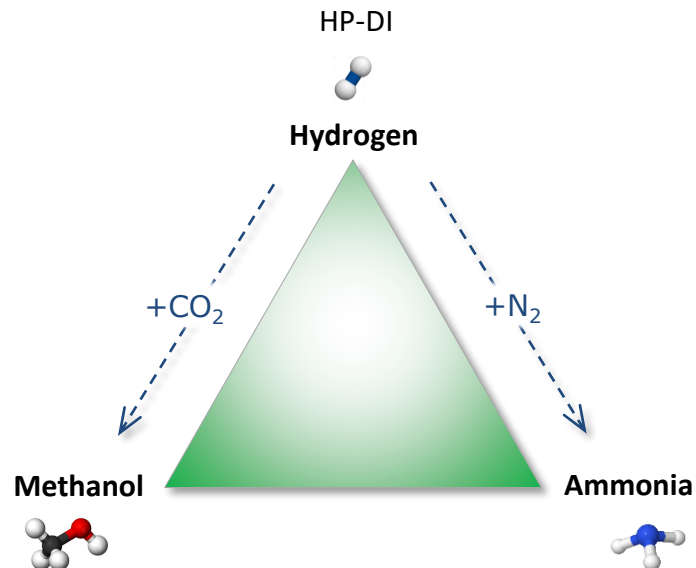


# Combustion concepts with green fuels

## Premixed combustion



## Non-premixed combustion





## Single cylinder engine testing



### WinGD talks up test data from its new dual-fuel ammonia engine

First units to be delivered for Exmar LPG and CMB.Tech newbuildings from mid-year

13 March 2025 10:22 GMT | UPDATED 13 March 2025 11:04 GMT

By Lucy Hine in London

Chinese-controlled, Swiss marine power company WinGD has firmed up the performance and emissions data for its new X-DF-A ammonia-fuelled engine which has been undergoing full-load testing.

#### Source:

<https://www.tradewindsnews.com/gas/wingd-talks-up-test-data-from-its-new-dual-fuel-ammonia-engine/2-1-1792004>

## Full engine testing

### MITSUI E&S Commences full-scale ammonia testing

First commercial ammonia two-stroke engine takes next step towards market entry

MARPRO 4 weeks ago

1,040 1 minute read



MITSUI E&S has announced the beginning of the test phase for the world's first commercial, two-stroke, dual-fuel ammonia engine. The MAN B&W 7S60ME-LGIA (-Liquid Gas Injection Ammonia) Mk 10.5 prototype engine began its ammonia fuel test-run at MITSUI E&S's Tamano Factory in Japan.

#### Source:

<https://maritime-professionals.com/mitsui-es-commences-full-scale-ammonia-testing/>

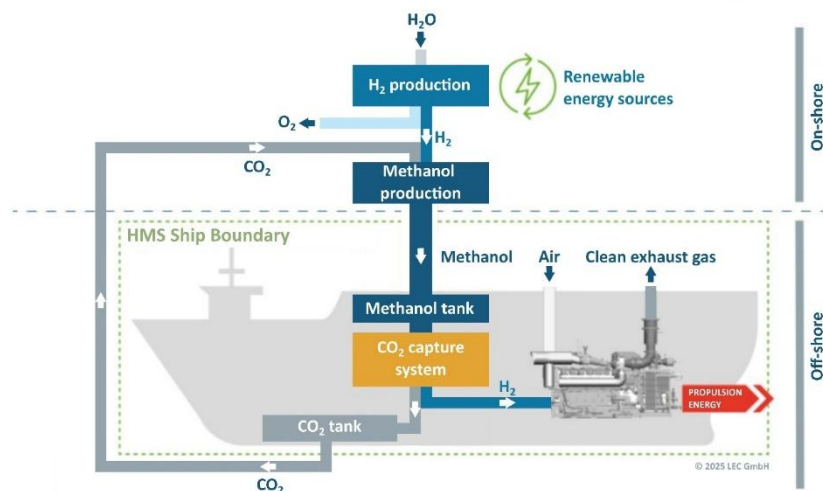
Engine OEM	Planned market introduction
MAN	Operation onboard a commercial vessel from around 2026
Wärtsilä	Portfolio introduction in 2023; first commercial contract expected in 2025
WinGD	First engine delivery in 2025
Japan Engine Corporation	Development completed in 2025



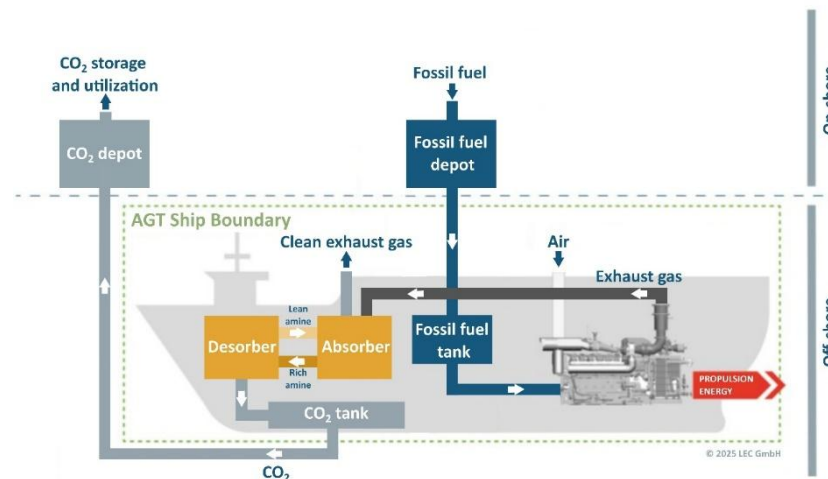
# Carbon-Capture in Maritime Applications



## Pre-combustion carbon capture HyMethShip



## Post-combustion carbon capture Amine gas treatment

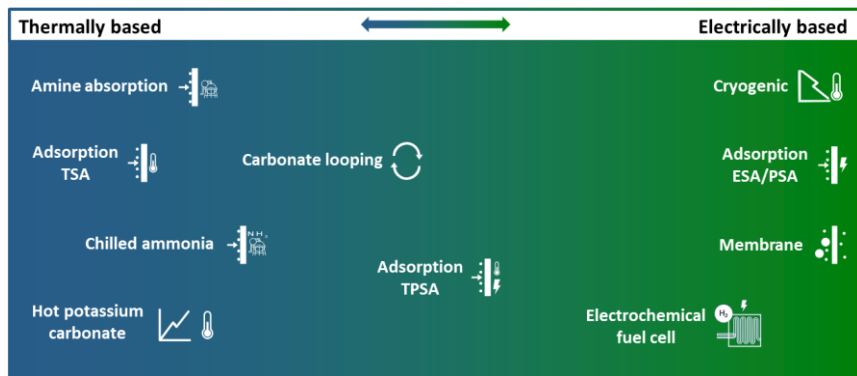




# Carbon-Capture in Maritime Applications



## Carbon capture technology



## World-first full-scale onboard carbon capture

The world's first ship with a full-scale carbon capture facility is ready for pilot testing. The hope is that this technology becomes a milestone for the world's trading fleet on route to zero emissions.



UPDATED 16. JANUARY 2025

Source:

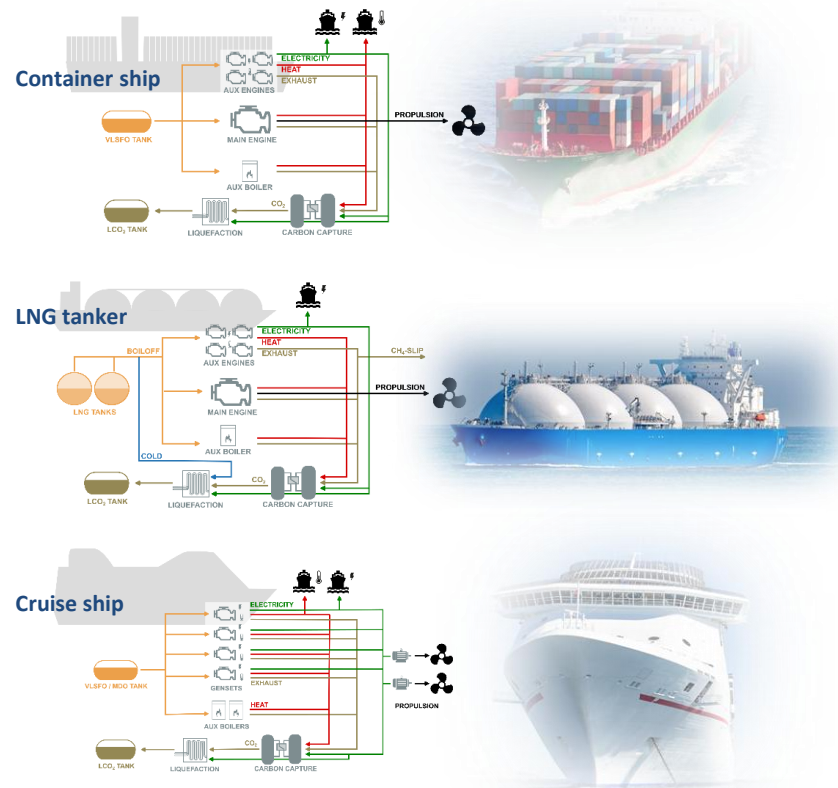
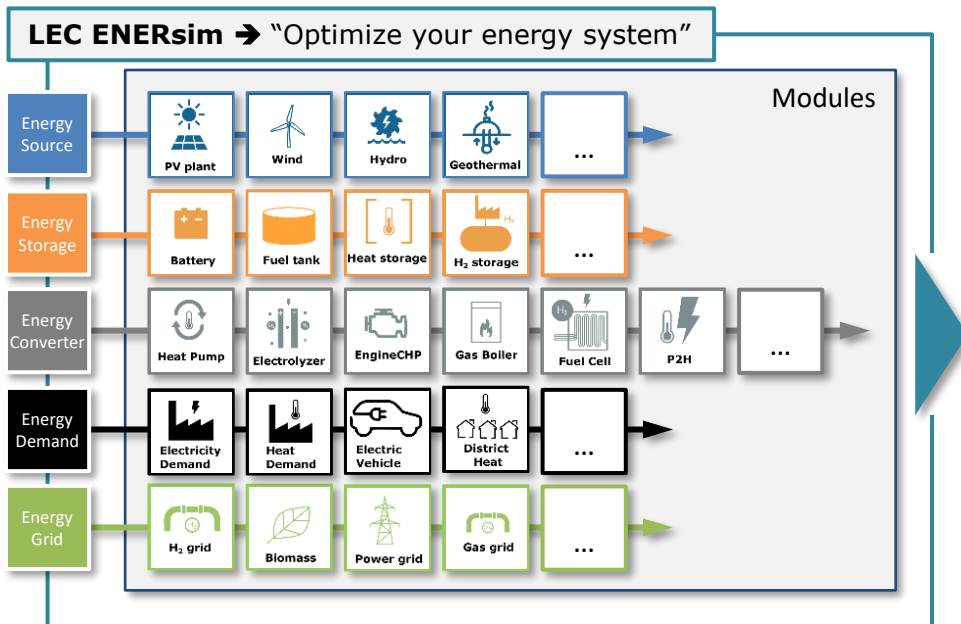
<https://solvangship.no/2025/01/16/world-first-with-full-scale-ccs-on-board/>



# On-board Carbon Capture (OCC)



## LEC ENERsim Models (MEA)

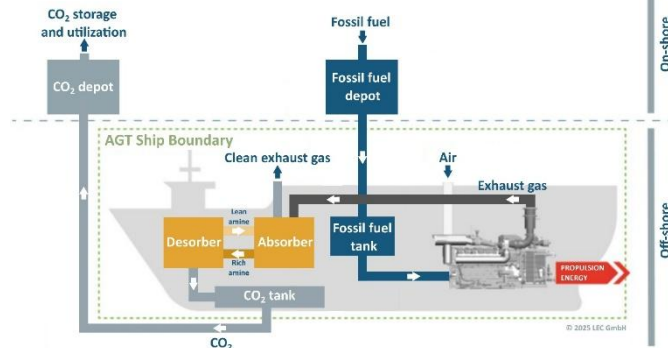




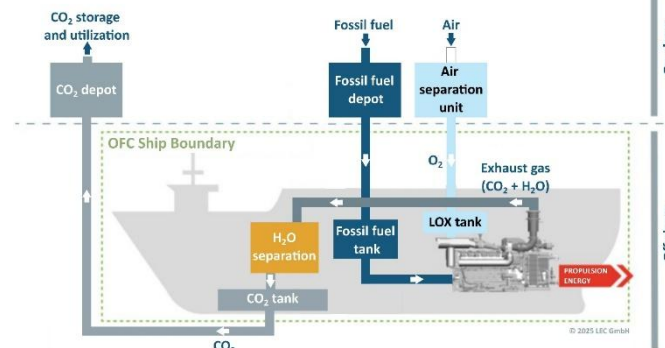
# Carbon Capture vs. E-Fuels in Maritime Applications



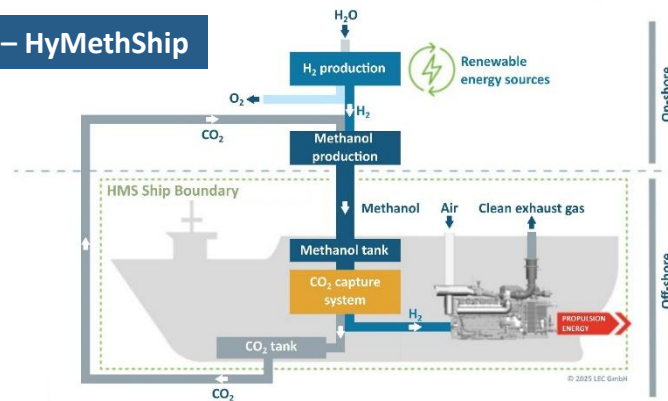
## Post-CC – Amine gas treating



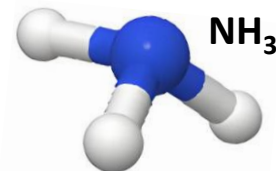
## Oxyfuel combustion



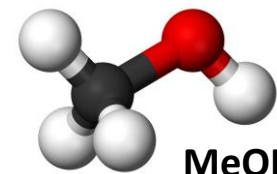
## Pre-CC – HyMethShip



## Renewable fuels



**NH<sub>3</sub> price 2030 / 2050:**  
190 / 90 €/MWh



**MeOH price 2030 / 2050:**  
225 / 125 €/MWh

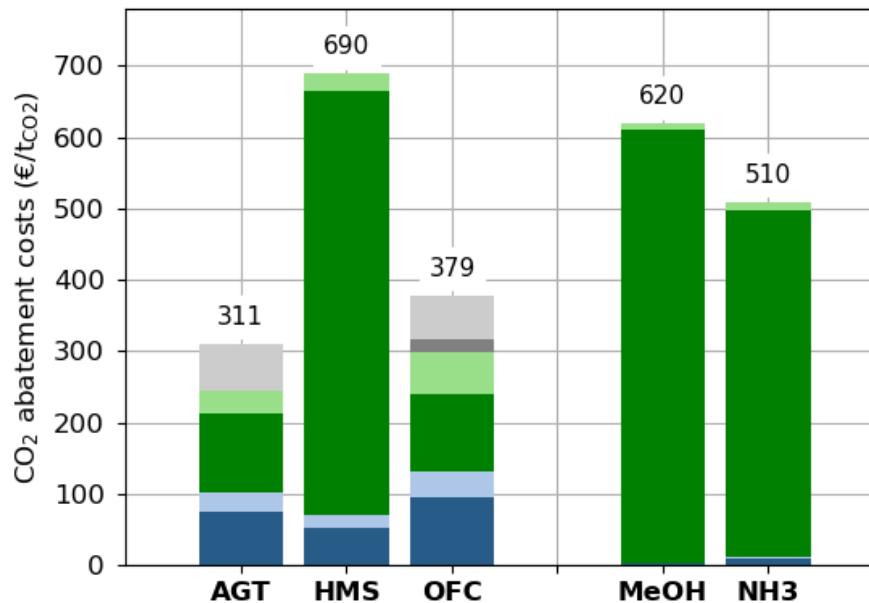


# Carbon Capture vs. E-Fuels in Maritime Applications



## CO<sub>2</sub> abatement cost

Short-term scenario 2030



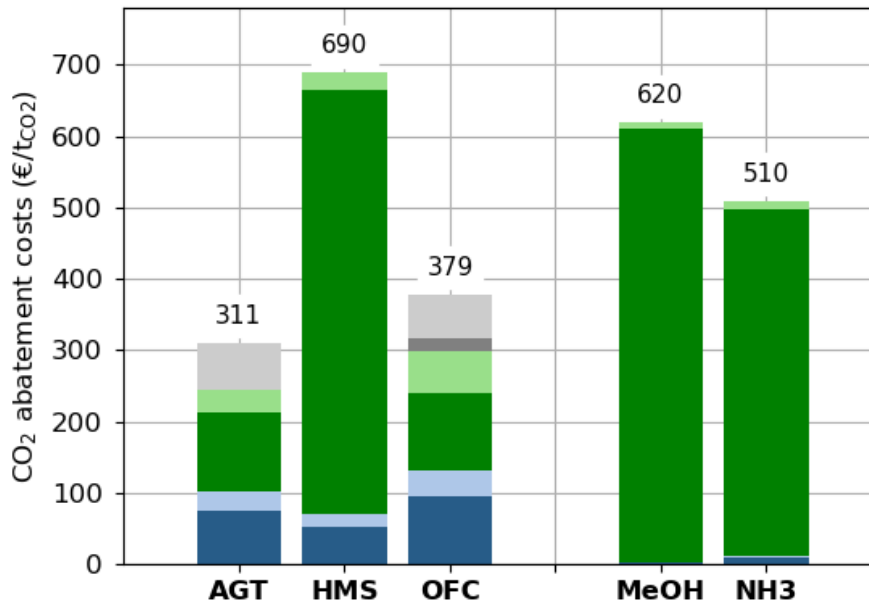


# Carbon Capture vs. E-Fuels in Maritime Applications

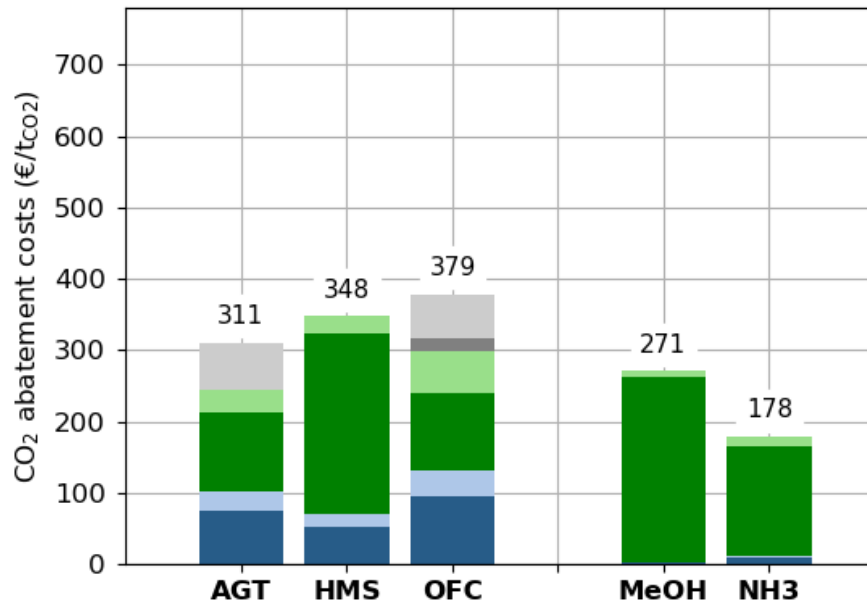


## CO<sub>2</sub> abatement cost

Short-term scenario 2030



Long-term scenario 2050

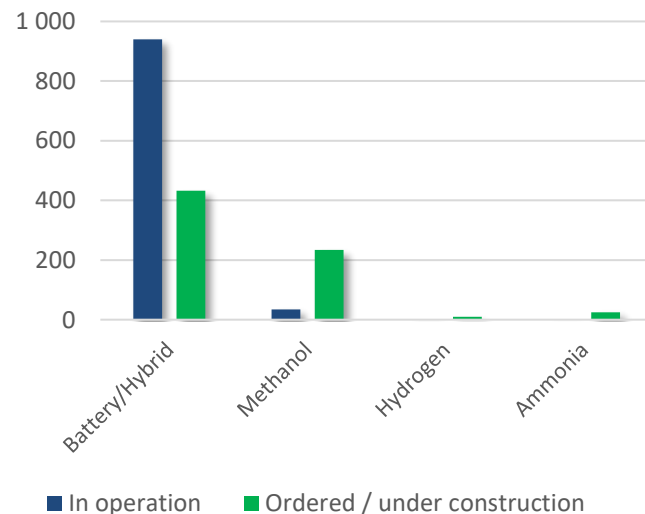


CAPEX Fuel LOX  
OPEX COLC Deposit



- **Internal combustion engines** will likely remain the dominant propulsion technology for deep-sea shipping
- The major **transformation** in the maritime sector will occur through new **fuel types**, driven by the choice of future **energy carriers** for storing and transporting renewable energy
- The **availability of renewable fuels** and supporting **infrastructure** will be a key enabler for the adoption of alternative marine fuels.
- Whether **retrofitting** will play a **decisive role** - either **with OCC or the conversion to new fuels** - remains an open question

Number of ships powered by **alternative propulsion systems**  
(status: June 2024)





# Thank you for your attention!

The logo consists of the letters 'LEC' in a bold, white, sans-serif font, centered within a large, light green circle. The background of the slide is a teal color with a dense pattern of small, white, line-art icons representing various scientific and technological fields like engineering, biology, and energy.

## Evolutionary Green Energy

## and Transport Systems

## for a Sustainable Tomorrow

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