



Large Engines Competence Center

On the way to zero emission shipping



Sustainable Shipping Technologies Forum, Sep. 26th 2019, Graz
Nicole Wermuth

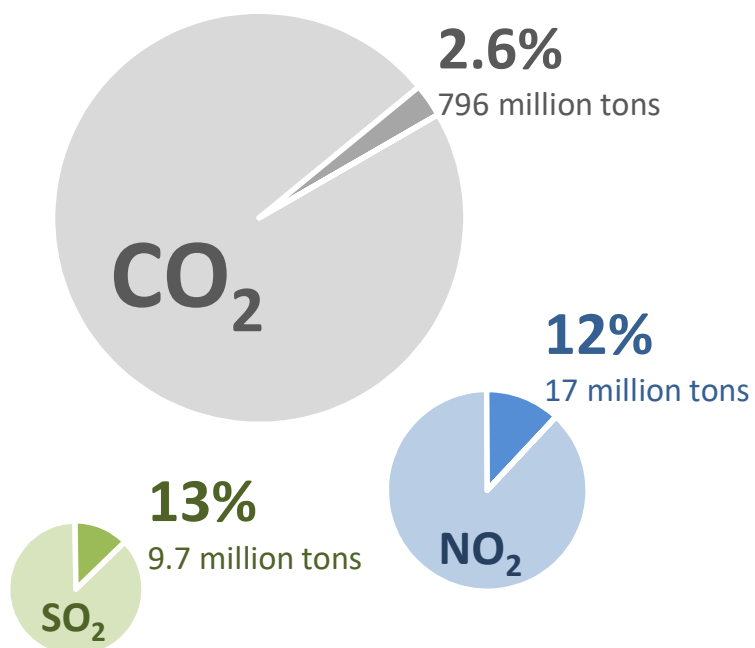


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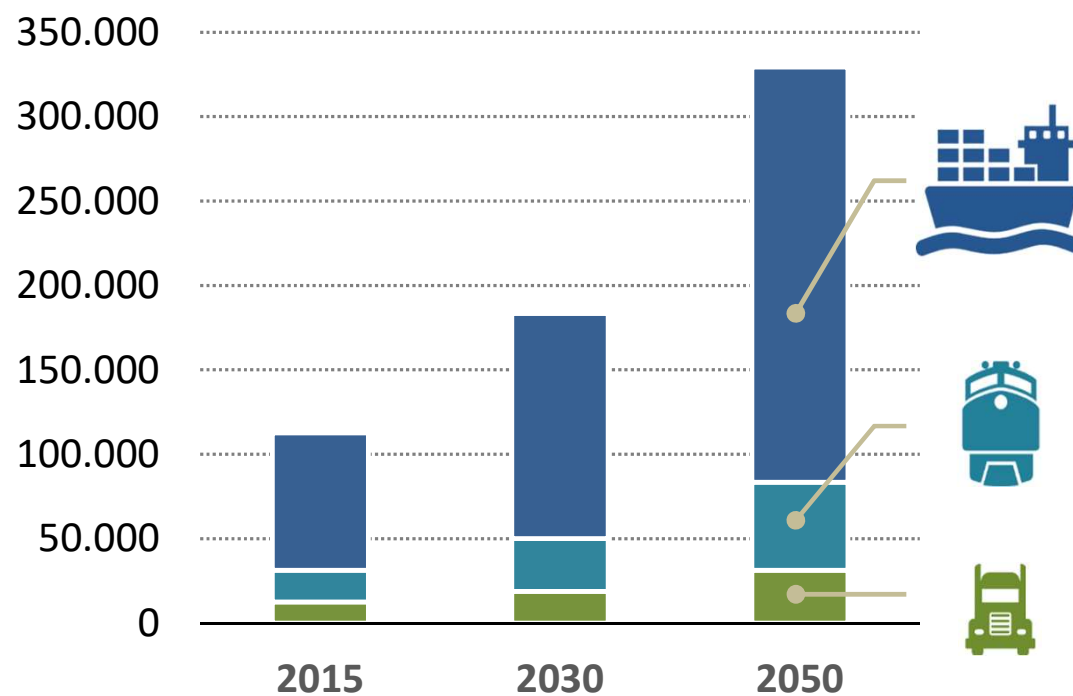
Emissions and Development of Transport



Ship emissions vs. total global emissions



Worldwide transport [Billion tons-kilometer]



Source: ITF Transport Outlook 2017

The Goals & the Path



Emissions reduction



97% reduction in CO₂ emissions

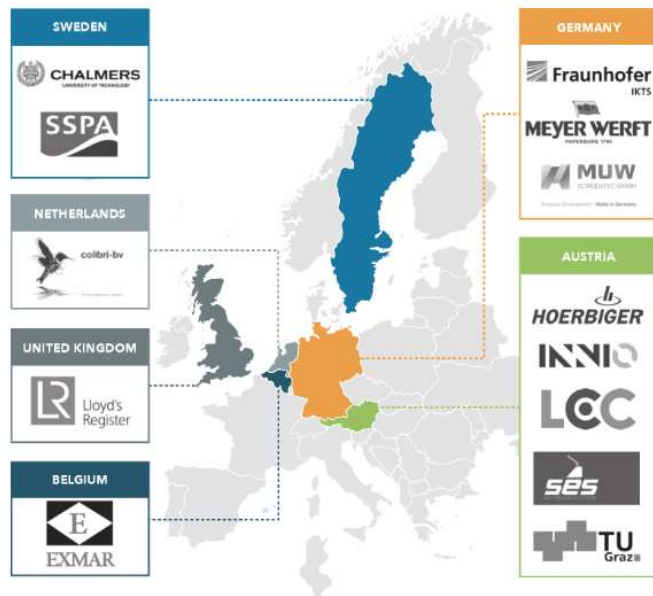
Elimination of SO_x and PM emissions

Reduction of NO_x emissions

45 % efficiency increase

- The HyMethShip concept
- Proof of environmental, economic, and safety performance
- Case study ship design
- Full-scale system demonstration

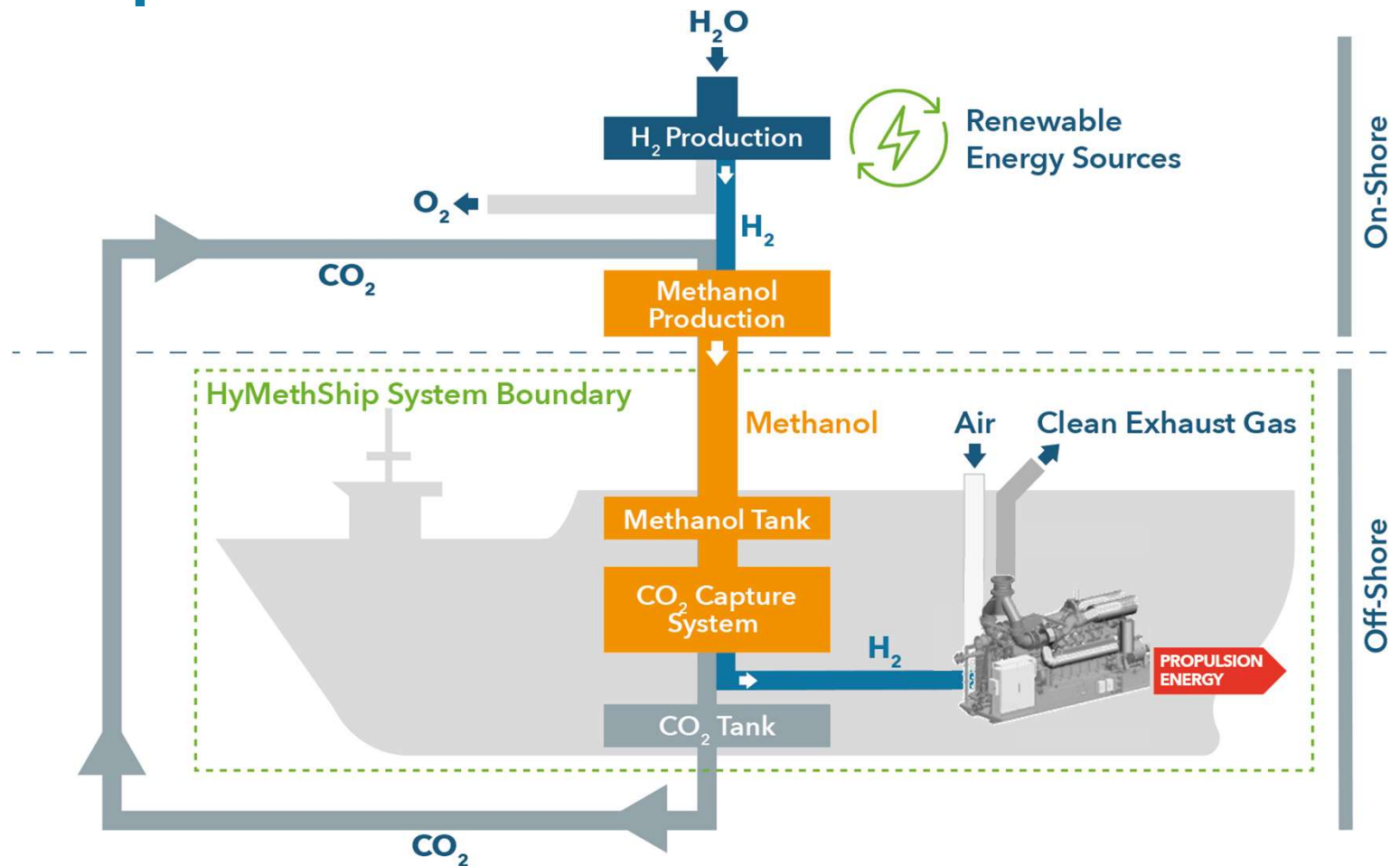
Powerful Consortium



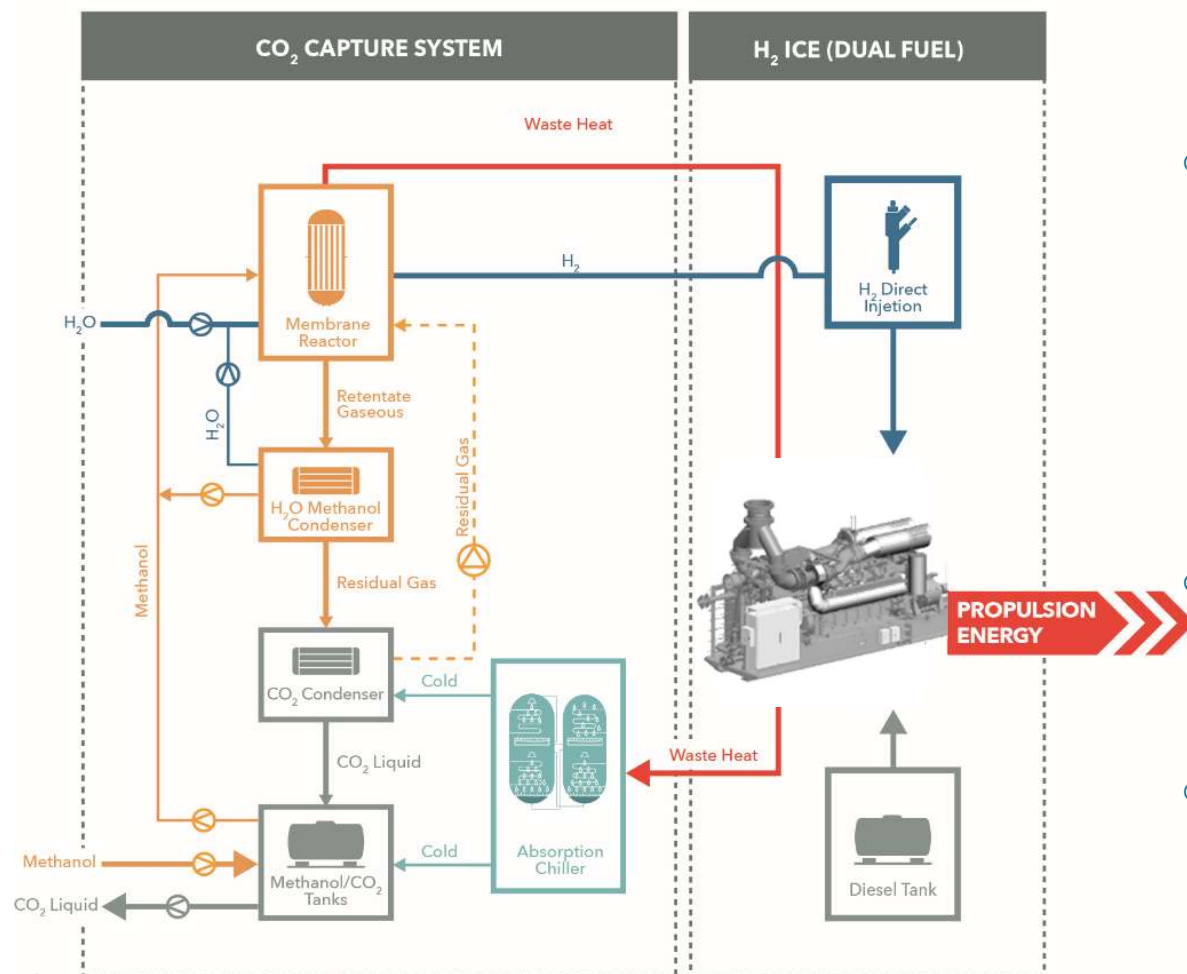
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The Concept



On-board Setup



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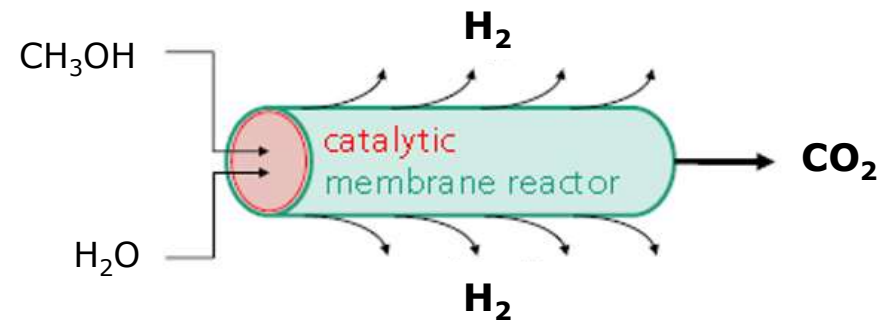
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- **Pre-combustion carbon capture system**
 - Receiving liquid methanol from the tank system
 - Supplying engine with fuel
 - Feeding liquid CO₂ back into the tank system
- **Dual fuel / bi-fuel ICE**
 - State-of-the-art ship propulsion
 - Waste heat usage for CCS
- **Control, monitoring and safety system**

Methanol Reformer

Two processes in the same reactor:

- Catalytic methanol reforming ($\text{CH}_3\text{OH} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + 3\text{H}_2$)
- H_2 separation via membrane permeation



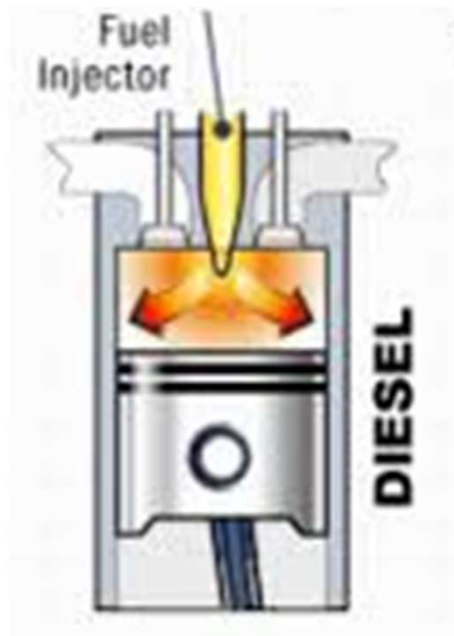
Ceramic-based carbon membrane technology:

- Free of precious metals
- Reaction pressures up to 50 bar
- H_2 pressures 10-20 bar
- Low risk of poisoning (e.g. from CO)



Photo by Fraunhofer IKTS

Dual-Fuel Reciprocating Engine

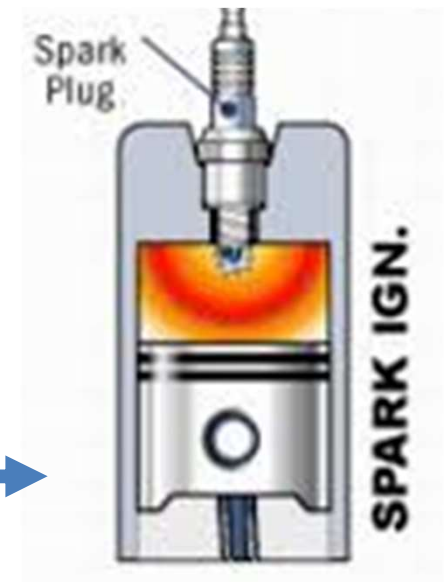


Hydrogen (main fuel)

- Hydrogen pressure 10 to 20 bar
- Spark ignition or diesel pilot ignition (~1-3 %)

Redundancy

- **Diesel** combustion – flexible diesel injection system required for diesel quantities from 1 % to 100 %
- **Methanol** combustion - spark ignition system for hydrogen as well as for methanol combustion. Reduced emissions, no diesel fuel tank required



On-board Methanol / CO₂ Storage

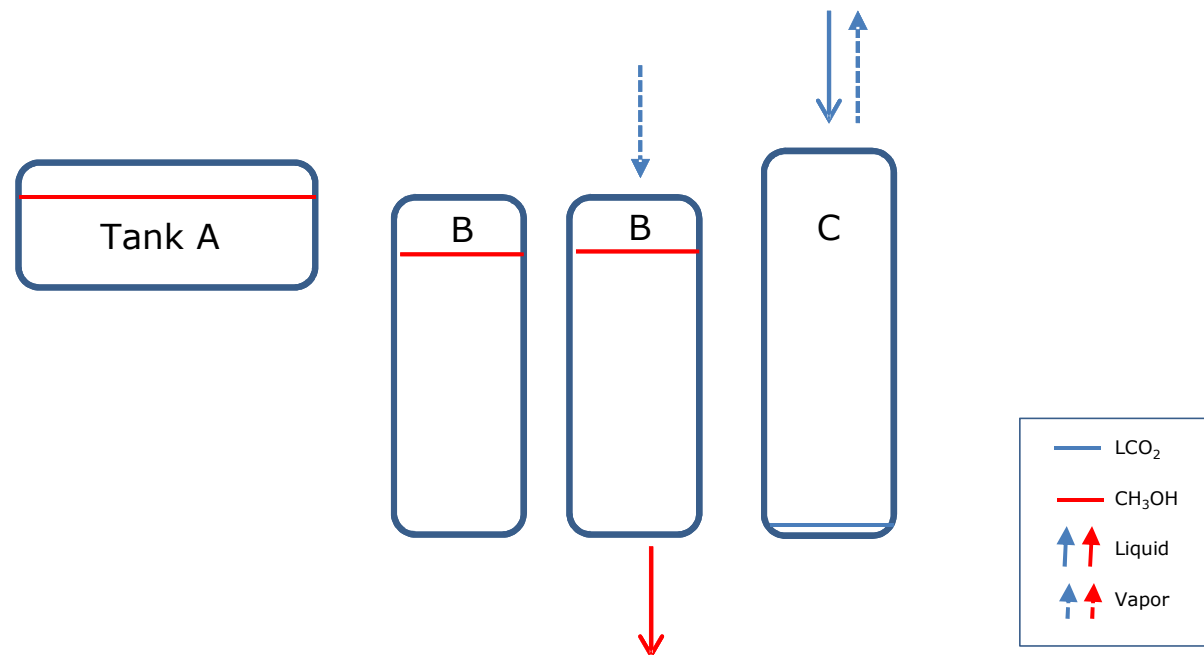


Separate storage solution

- Increased space demand

Combined storage solution

- Tank A for methanol storage only
- Tank C for CO₂ storage only
- Tanks B for methanol and CO₂ storage

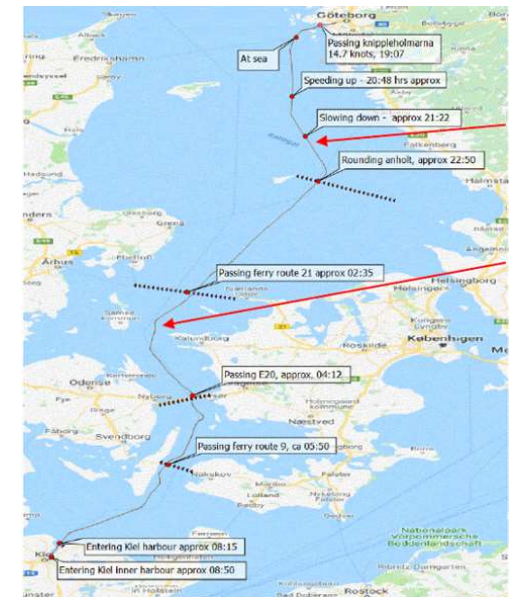
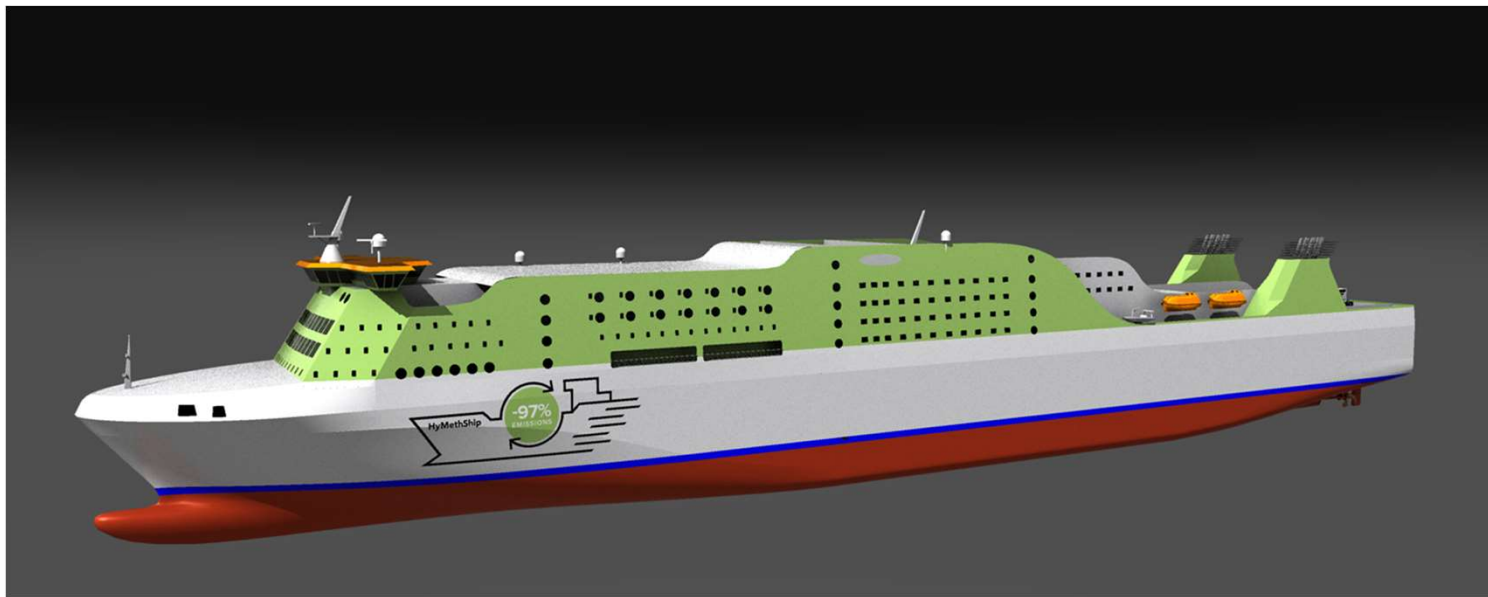


Sea passage = continuous/regular process of the HymethShip-system

Case Study Vessel Design



- **Ferry application with fixed operating route**
- **Propulsion power 4 x 5 MW**
- **Vessel model for detailed design**



System Demonstration



- **Onshore technology demonstration (1-2 MW)**
- **Duty cycle based on the case study vessel**



The Outlook



Onshore system demonstration

Case study ship design

Life cycle assessment

Application driven concept design:

Combined / separate tank systems

Diesel vs. methanol back-up operation

Transient operating strategies





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