HyMethShip

HYDROGEN IN COMBUSTION ENGINES

HyMethShip -97% EMISSIONS

ON THE WAY TO ZERO EMISSION SHIPPING

MODERNISATION OF DANUBE FLEET

Know How Transfer Event, Vienna, 7-8 March 2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 768945

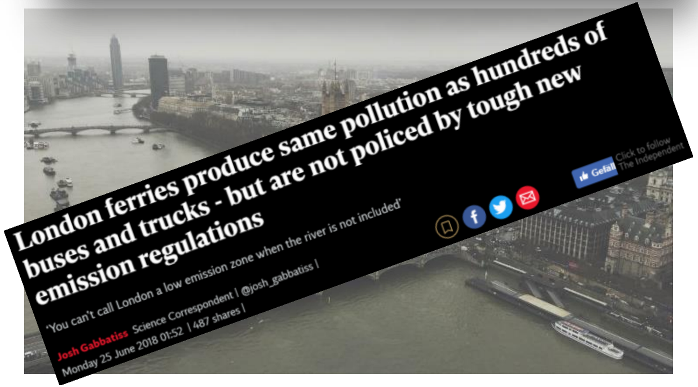
Large Engines Competence Center

As the leading research institution for large engine technologies, we serve as a global innovation hub for sustainable energy and transportation systems. Our research focus is on the massive reduction of CO_2 and pollutants towards zero emissions. Key features are the use of renewable energy sources as well as the optimization of the overall system by closing resource loops.

PARTNER NETWORK

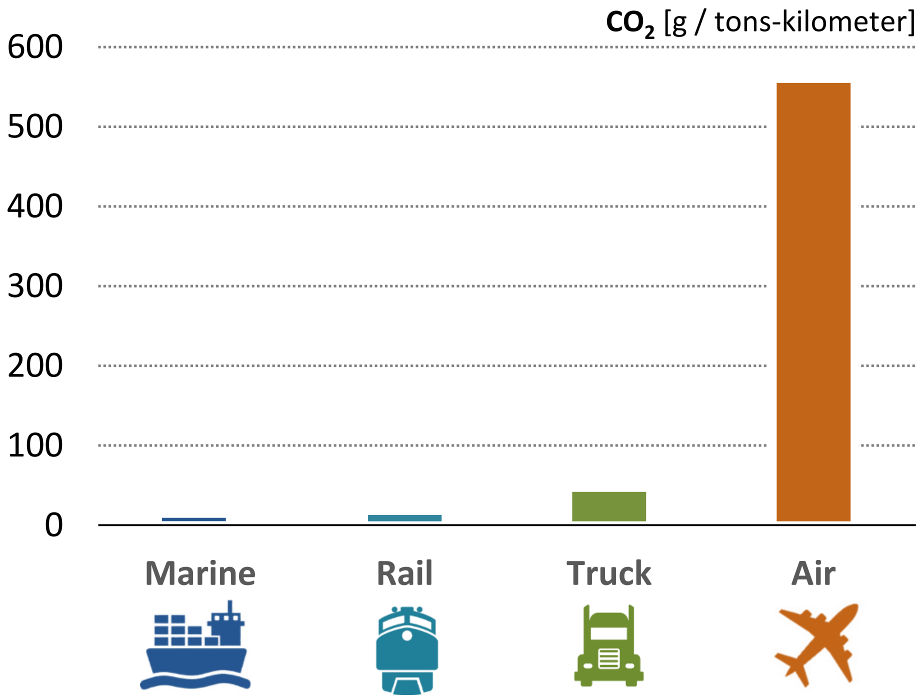
Shipping

Perception

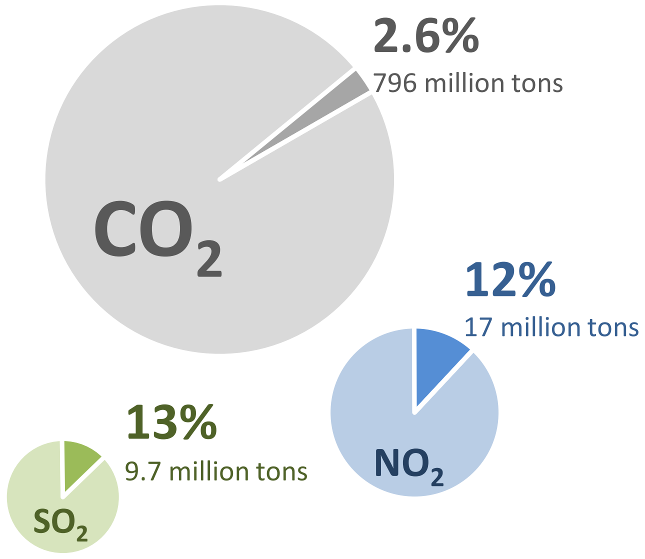


Transportation Sector Emissions

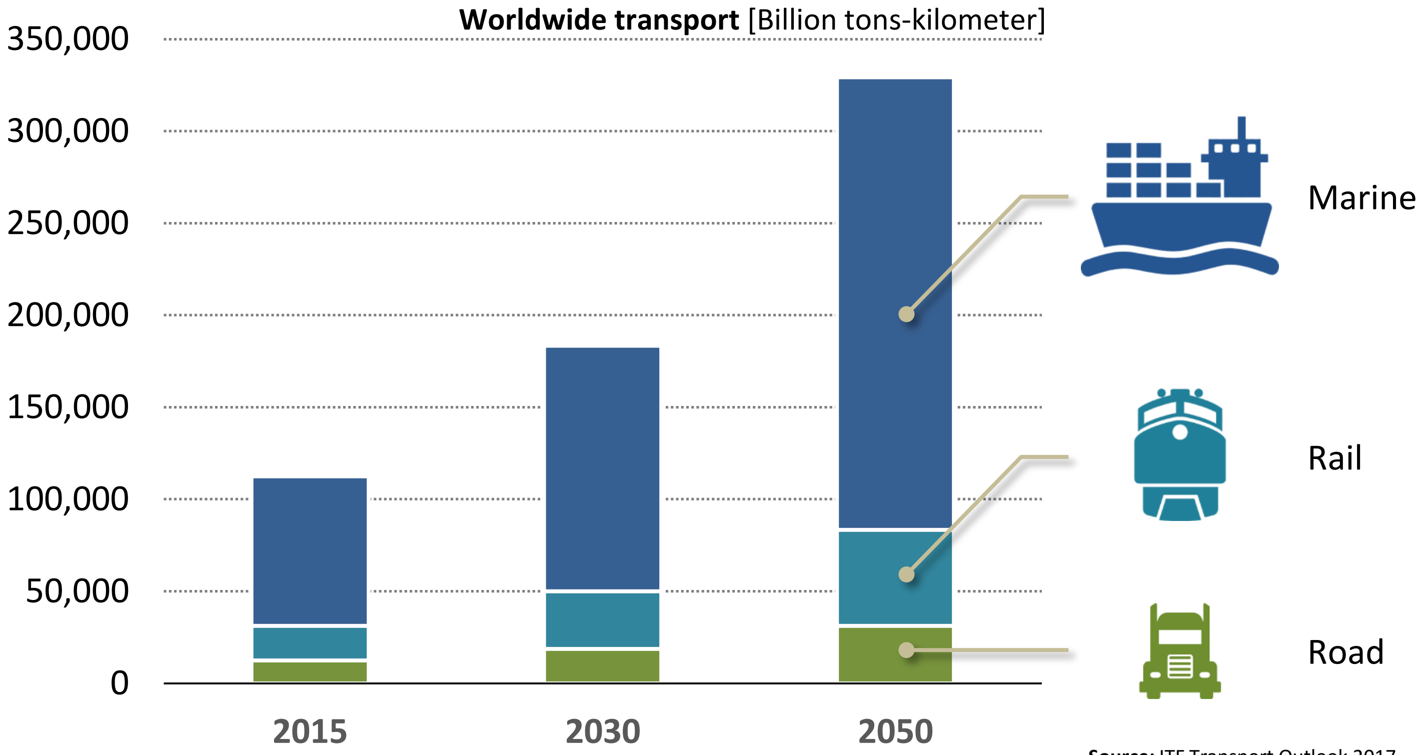
Facts



Percentage of ship emissions vs. total global emissions

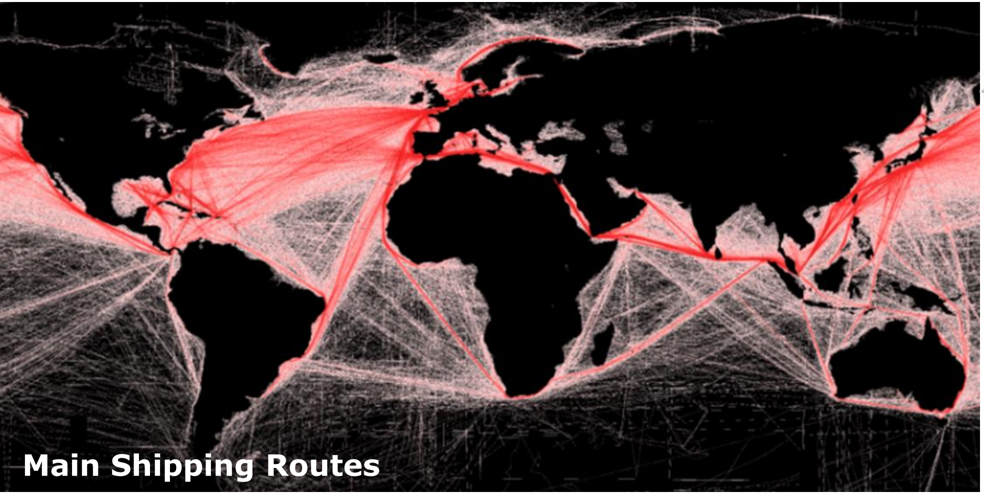


Development of Transport

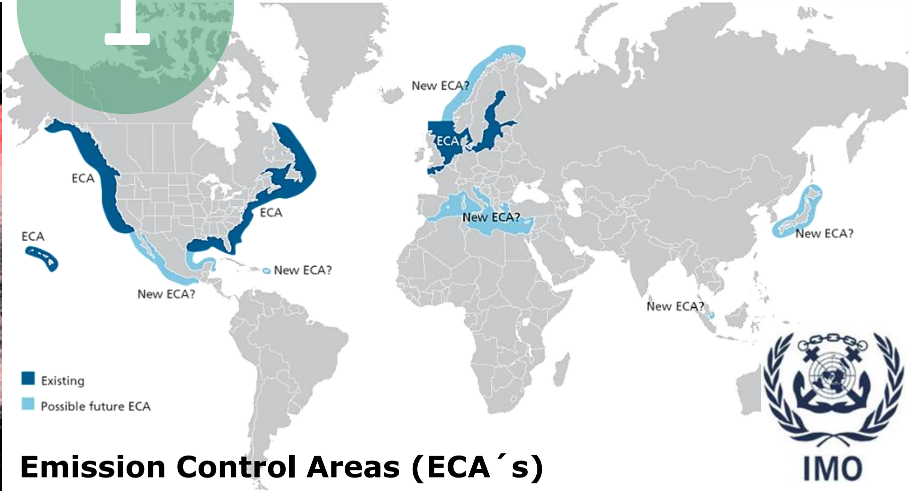


Source: ITF Transport Outlook 2017

Ship Emission Regulations


Main Shipping Routes

1



Emission Control Areas (ECA´s)

2

October 2016

Global Sulphur Cap 2020

… the decision to implement a global sulphur limit of 0.50% m/m (mass/mass) in 2020 …

3

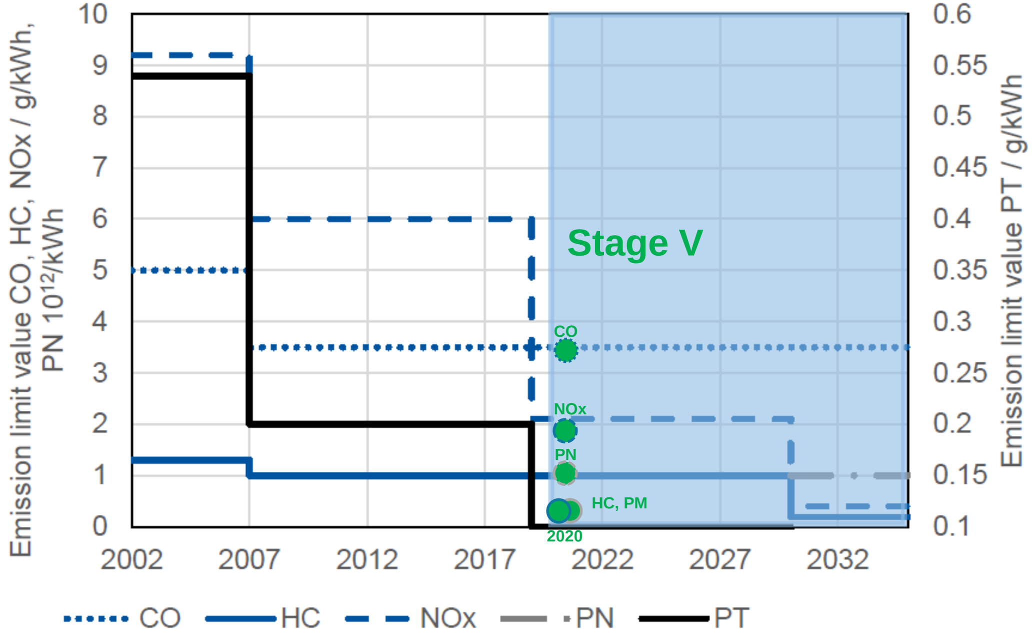
April 2018

GHG Target 2050

… to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 …

Emission Limits for IWT

Stage V emission limit values for engines > 130 kW



Source: Perspectives for the Use of Hydrogen as Fuel in Inland Shipping, MariGreen 2018

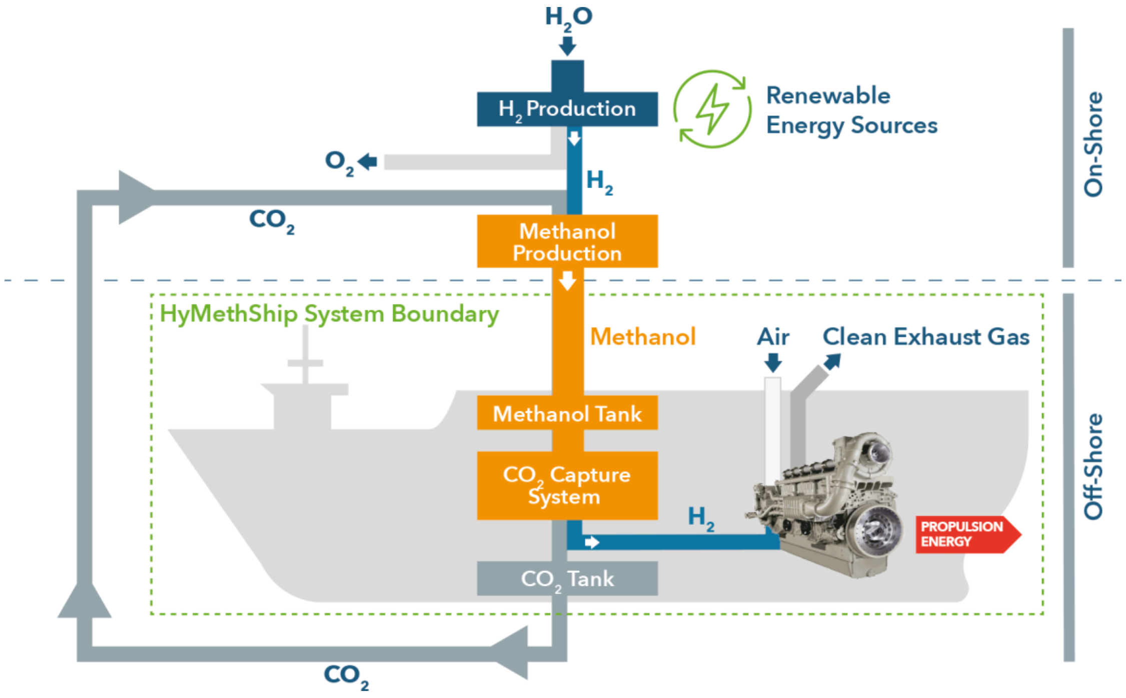
Category	Net P	Date	CO	HC[a]	NOx	PM	PN
	kW		g/kWh				1/kWh
IWP/IWA-v/c-4	P ≥ 300	2020	3.50	0.19	1.80	0.015	1×10^{12}

[a] A = 6.00 for gas engines

Source: https://www.dieselnet.com/standards/eu/nonroad.php#vessel

Emission-free Ship Propulsion

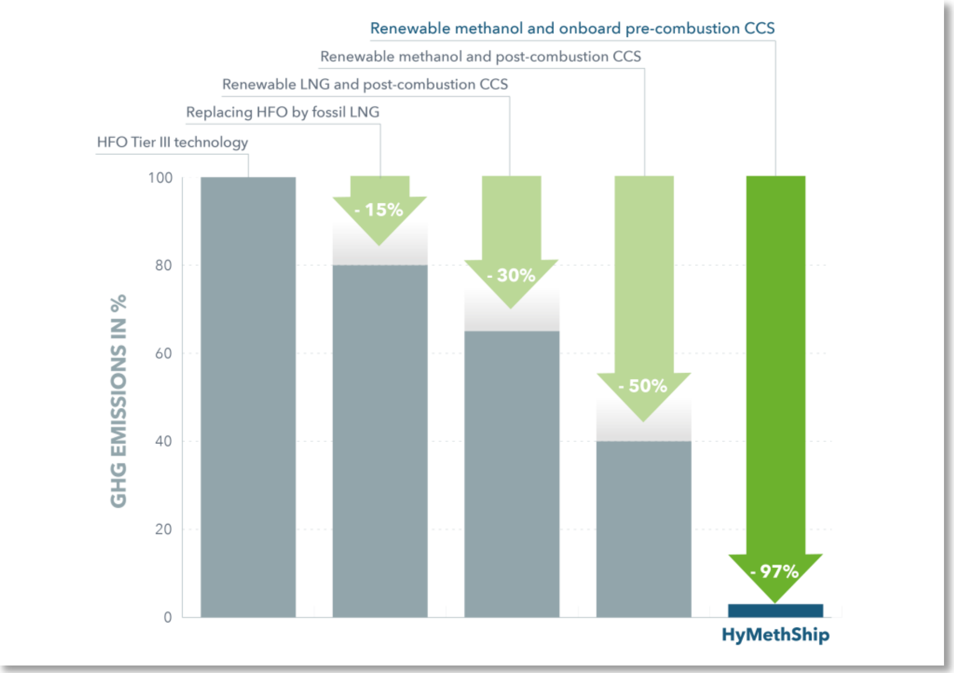
The Concept



Goals and Objectives

Emissions reduction

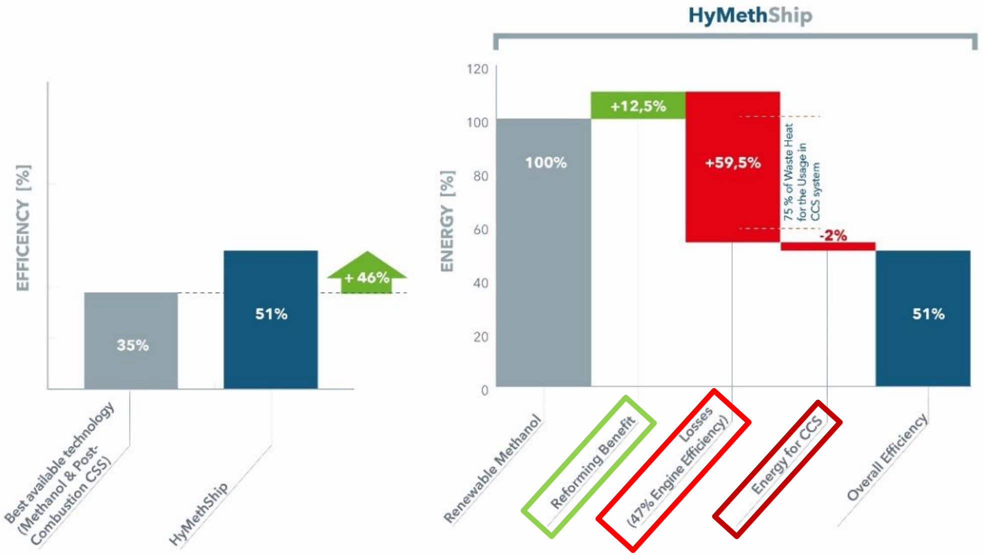
- 97% reduction in GHG emissions
- Elimination of SO_x and PM emissions
- Minimization of NO_x emissions



Goals and Objectives

Increase in efficiency

- 45% increase in efficiency compared to the technology with conventional CO_2 capturing



$CH_3OH + H_2O \rightarrow CO_2 + 3\,H_2$ - a higher energy gain from methanol than direct burning ($\Delta H_r \approx 50$ kJ/mol)!!

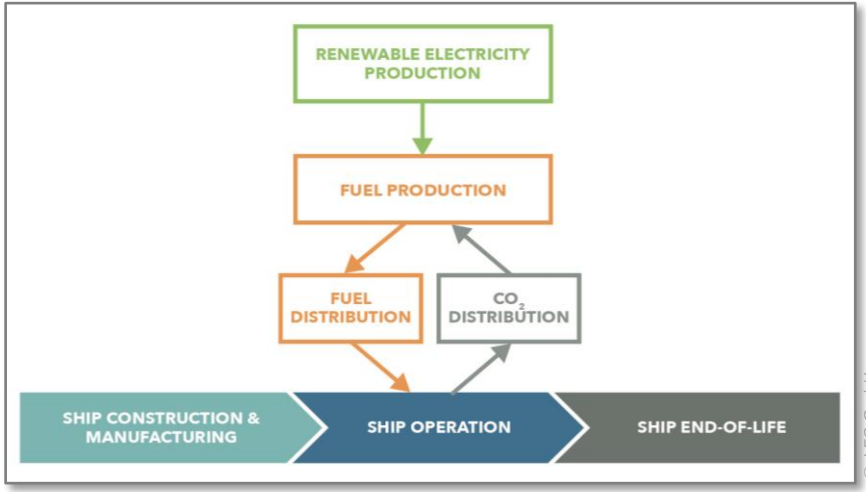
App. 75% of the waste heat is used for the methanol reforming and carbon capturing process

2% of the generated mechanical energy is used for the auxiliary devices

Goals and Objectives

Proof of environmental, economic, and safety performance

- Life Cycle Assessment (LCA)
- Life Cost Assessment (LCC)
- Hazard Identification (HAZID)
- Hazard and Operability Study (HAZOP)



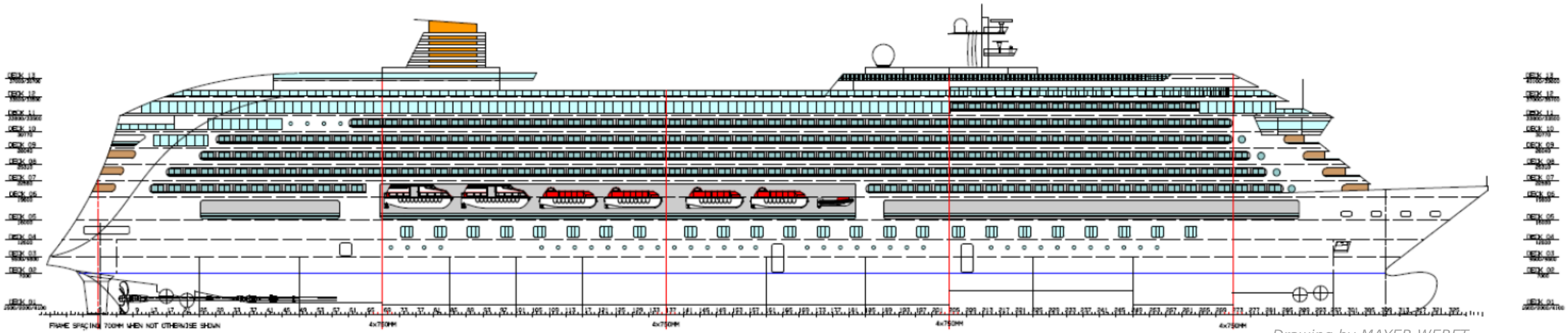
© LEC GmbH

Photo by EXMAR

Goals and Objectives

Detailed design for a case study ship

- The HyMethShip system is expected to be applicable to different vessel types (passenger vessels and ferries, roro cargo vessels, container vessels, tankers, bunkers, car carriers, and larger offshore support vessels) as it is based on a conventional reciprocating engine currently in use on the majority of ships.
- Detailed design for a case study ship that uses the HyMethShip system will provide a practical example of how the system can be integrated into and operated on a ship

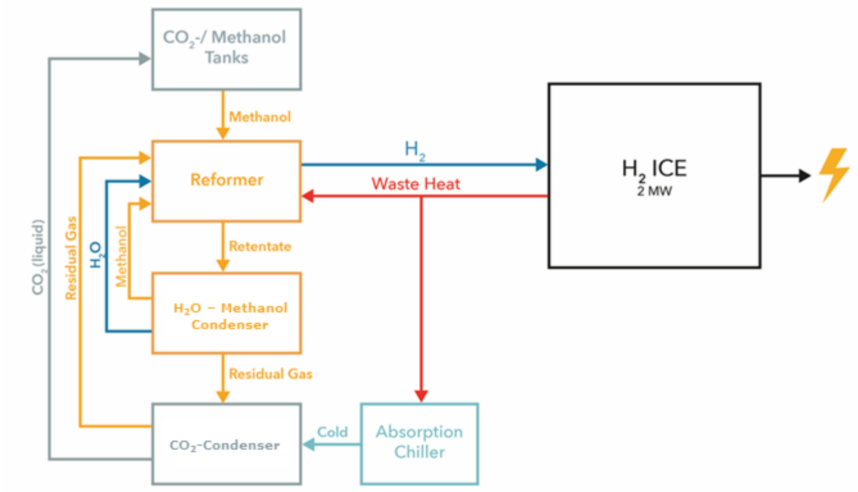


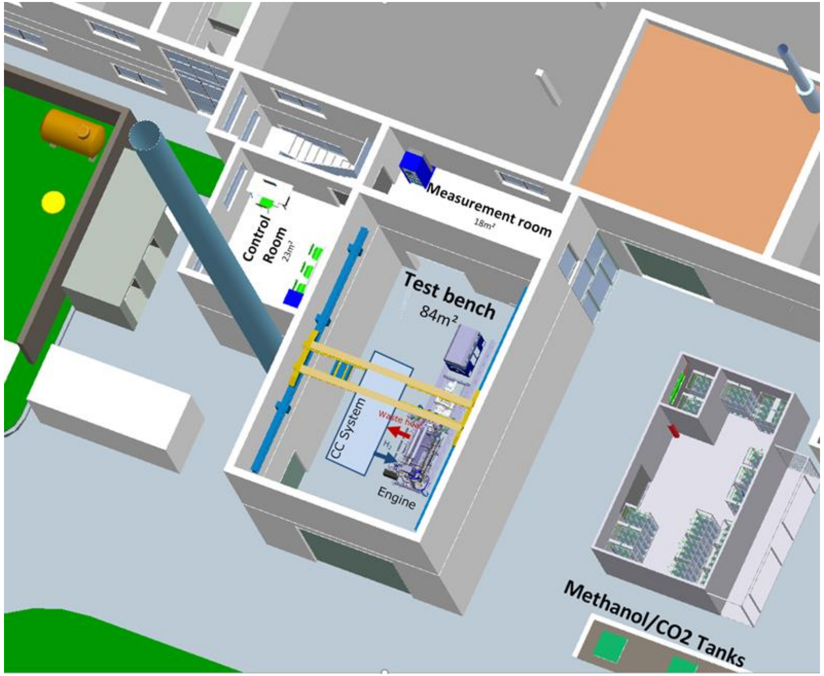
Drawing by MAYER WERFT

Goals and Objectives

System demonstrator

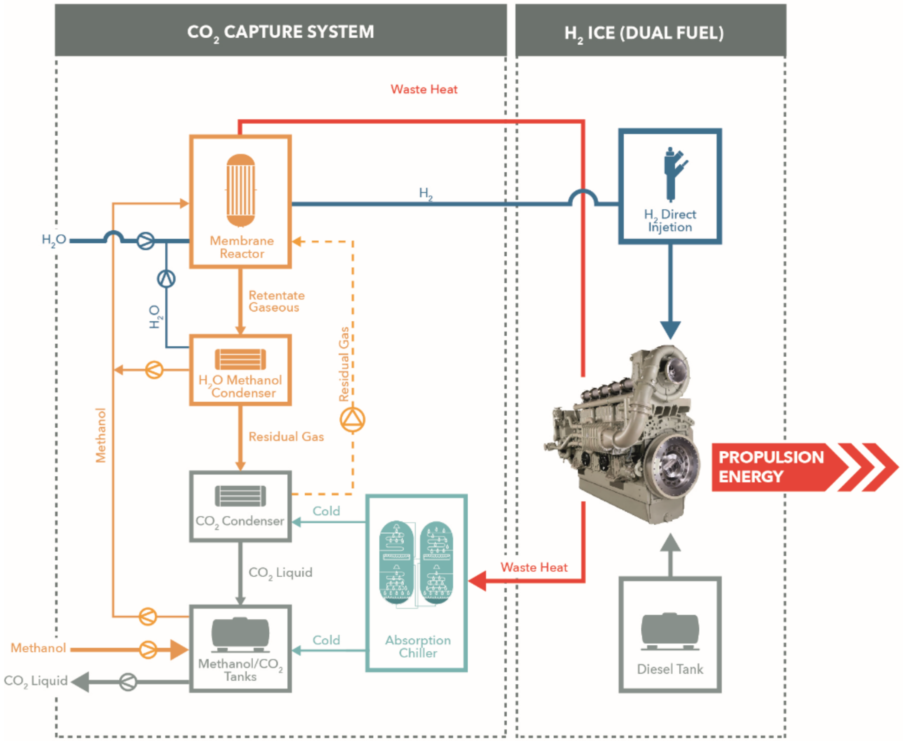
- The HyMethShip demonstrator is a full-scale onshore propulsion system with an engine power output of 1-2MW
- All relevant marine requirements will be considered in the designing phase of the system components





Project Introduction

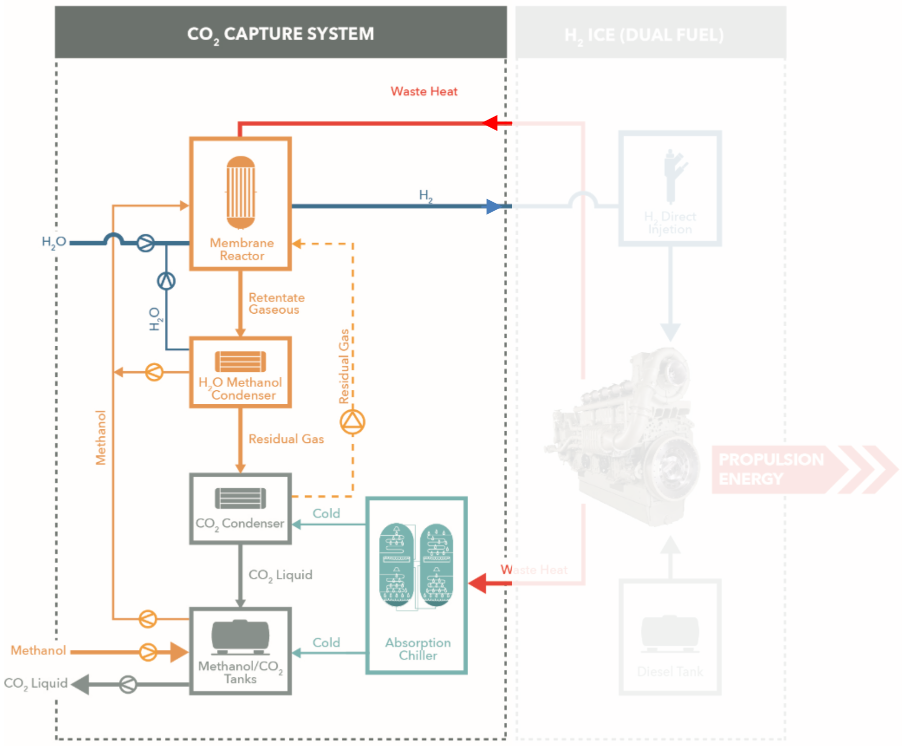
On-board setup



- Pre-combustion Carbon Capture System
- Dual fuel (diesel/methanol, H_2) ICE
- Control, monitoring and safety system

Project Introduction

Carbon Capture Process

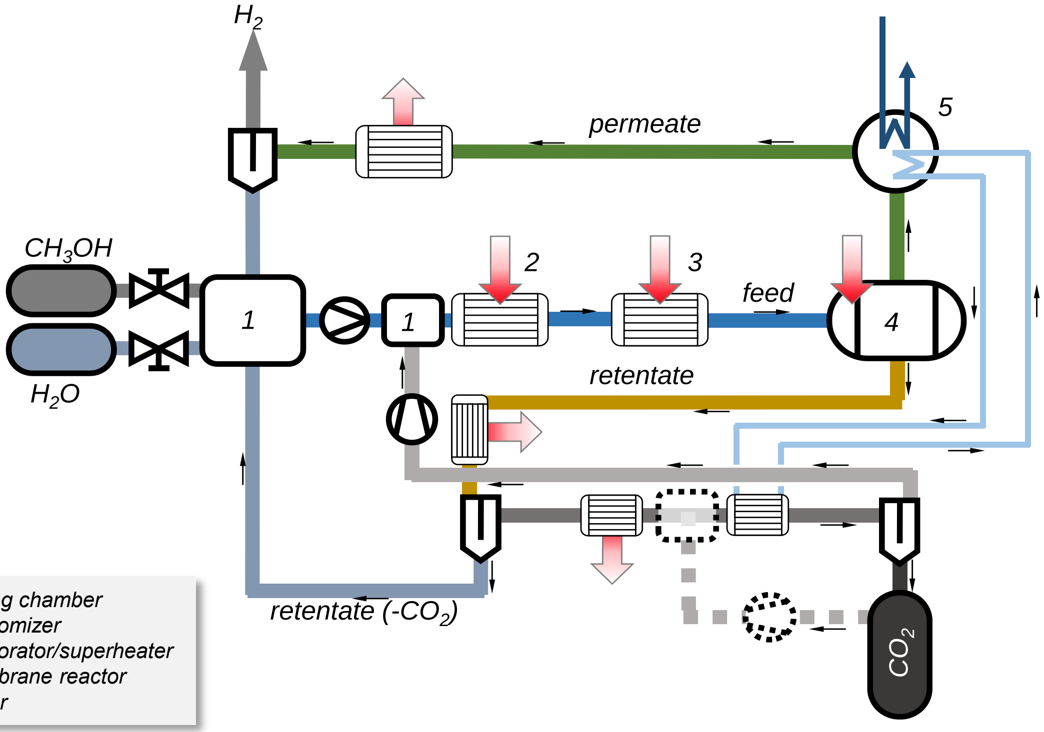


- Receiving liquid methanol from the tank system
- Supplying engine with fuel (H_2)
- Feeding liquid CO_2 back into the tank system

Project Introduction

Carbon Capture Process: Key technical challenges

- Providing the required heat transfer into the membrane reformer (heat input from the reaction and the permeate stream)
- Controlling the chemical and physical parameters of the streams (chemical composition, partial pressures, etc.)



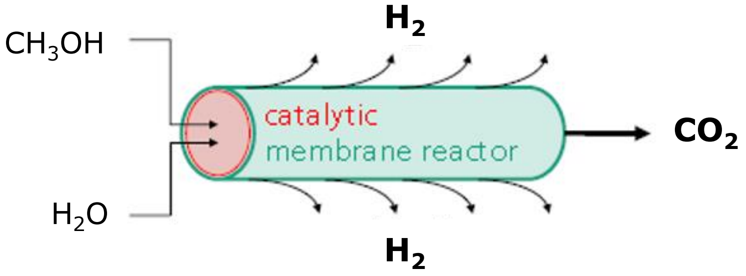
1…mixing chamber
2…economizer
3…evaporator/superheater
4…membrane reactor
5…chiller

Project Introduction

Methanol reformer

Two processes in the same reactor:

- Catalytic methanol reforming ($CH_3OH + H_2O \rightarrow CO_2 + 3H_2$)
- H_2 separation via membrane permeation



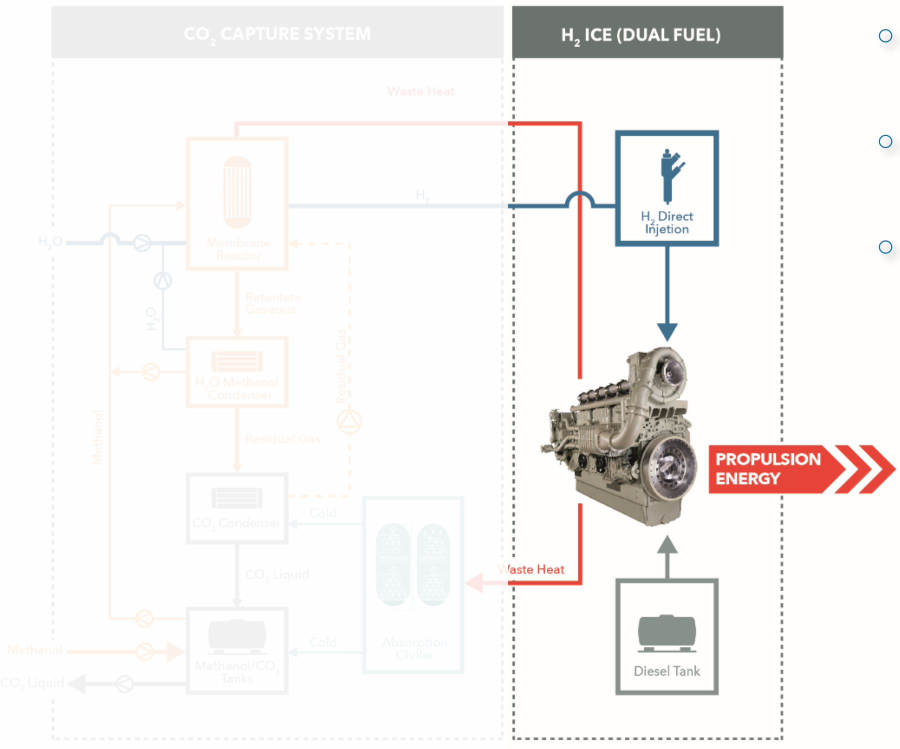
Ceramic-based carbon membrane technology:

- Free of precious metals
- Small to install (higher throughput)
- High H_2 pressure (10-20 bar)
- Low risk of poisoning (e.g. from CO or traces of sulfur)

Photo by Fraunhofer IKTS

Project Introduction

H2 internal combustion engine



- State-of-the-art engine upgraded to operate on multiple fuels
- Main fuel: H_2 (generated on-board by the methanol reformer)
- Backup and/or pilot fuel: diesel and/or methanol

Project Introduction

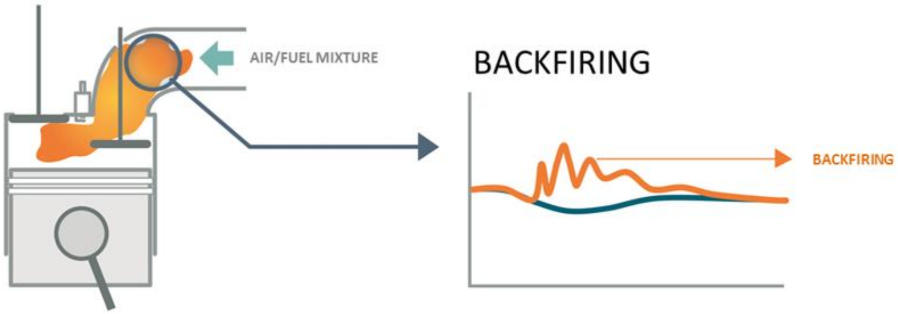
Dual-Fuel ICE

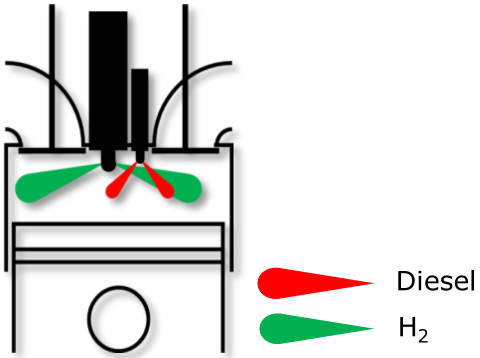
Hydrogen (main fuel)

- Hydrogen at medium pressure level of 10 to 20 bar is injected into the combustion chamber early in the compression stroke
- Spark ignited or ignition with diesel as pilot fuel (~1-3%) is considered.

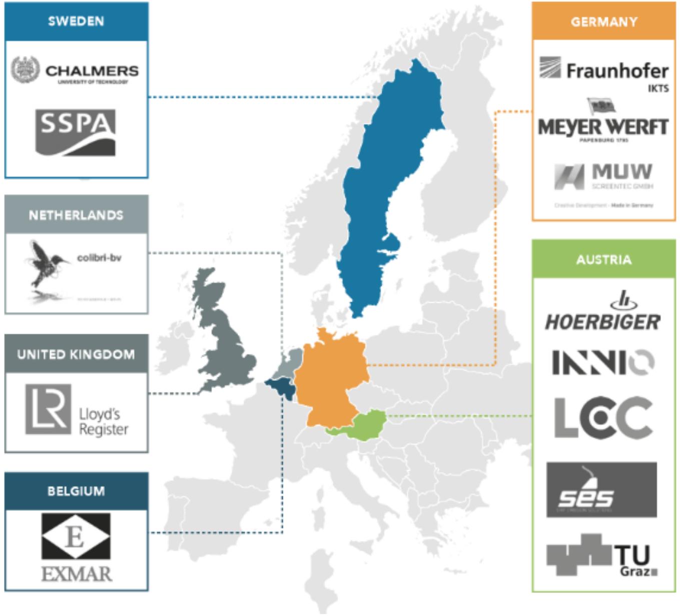
Redundancy

- Diesel combustion - the diesel injector is capable of providing maximum flexibility in terms of injected fuel mass to enable injection of diesel quantities ranging from 1% to 100% (full diesel backup) of the total fuel energy
- Methanol combustion - spark ignition system is used for hydrogen as well as for methanol combustion. Reduced emissions of NO_x, SO_x and PM, no bunkering of diesel required (reduced tank space).





Powerful Consortium



13 top-class partners

from 6 EU member states

represent the complete system

This powerfull consortium guarantees the transfer of innovation to the market

Project Team

Project Kick-Off: July 4. – 5., 2018

www.hymethship.com

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