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Update for the project

„Plug and Play Energypack for inland and shortsea shipping“

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www.marigreen.eu

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TU/e Technische Universiteit Eindhoven University of Technology

Where innovation starts

TU/e:	11,000	BSc and MSc	Mech. Engng.:	1,500	BSc and MSc
	1,500	PhD		175	PhD
	2,000	faculty staff		100	faculty staff

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Maritieme Academie

Maritime education for ~200 students

3 instruction vessels

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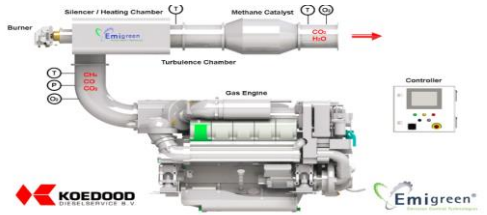
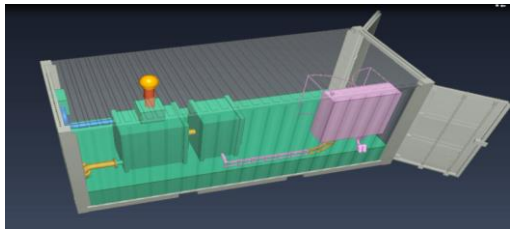
Plug&Play Energypack (Starting Point)

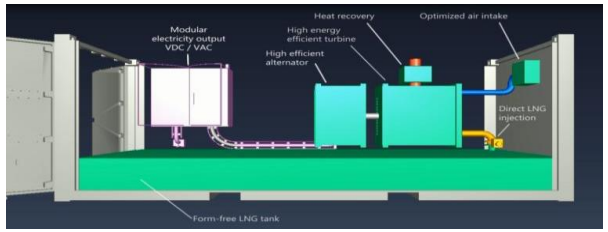
Goals

- Cost reduction for „small scale“ LNG-propulsion
- Improvement of emissions of LNG-propulsion
- Safe operation of LNG-propulsion through training
- 200-300 kW gas turbine
- Efficiency > 40%
- **Approach: advanced combustion modeling**



- Relevant gas turbines still in R&D phase, but highly promising
- Challenge: state-of-the-art, but proven technology
- **Solution: Innovative Hybrid Propulsion**





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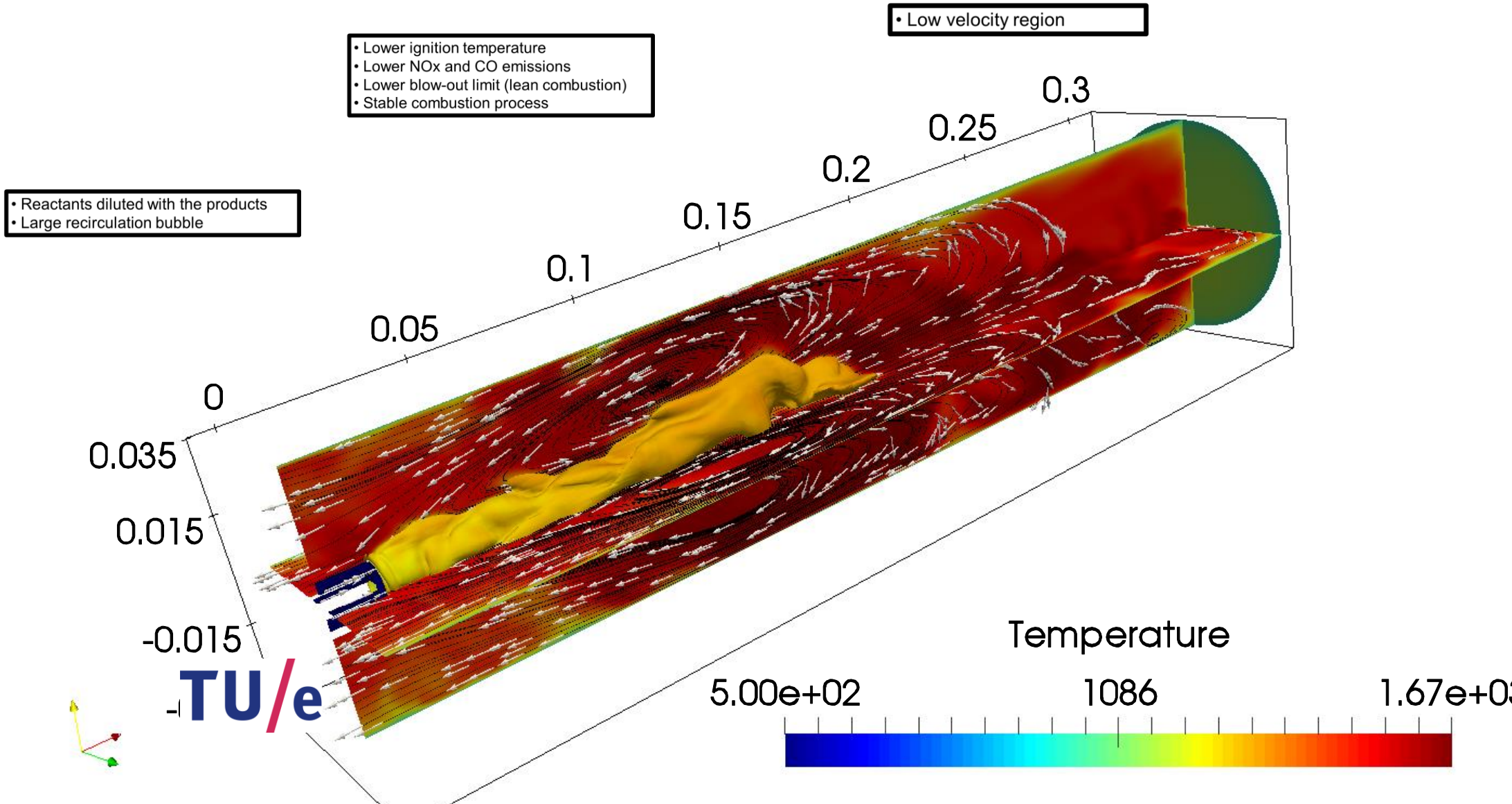
Modeling: Reverse Flow Combustor

Jeroen van Oijen, Bart Somers, Suleyman Karaca



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Emissions

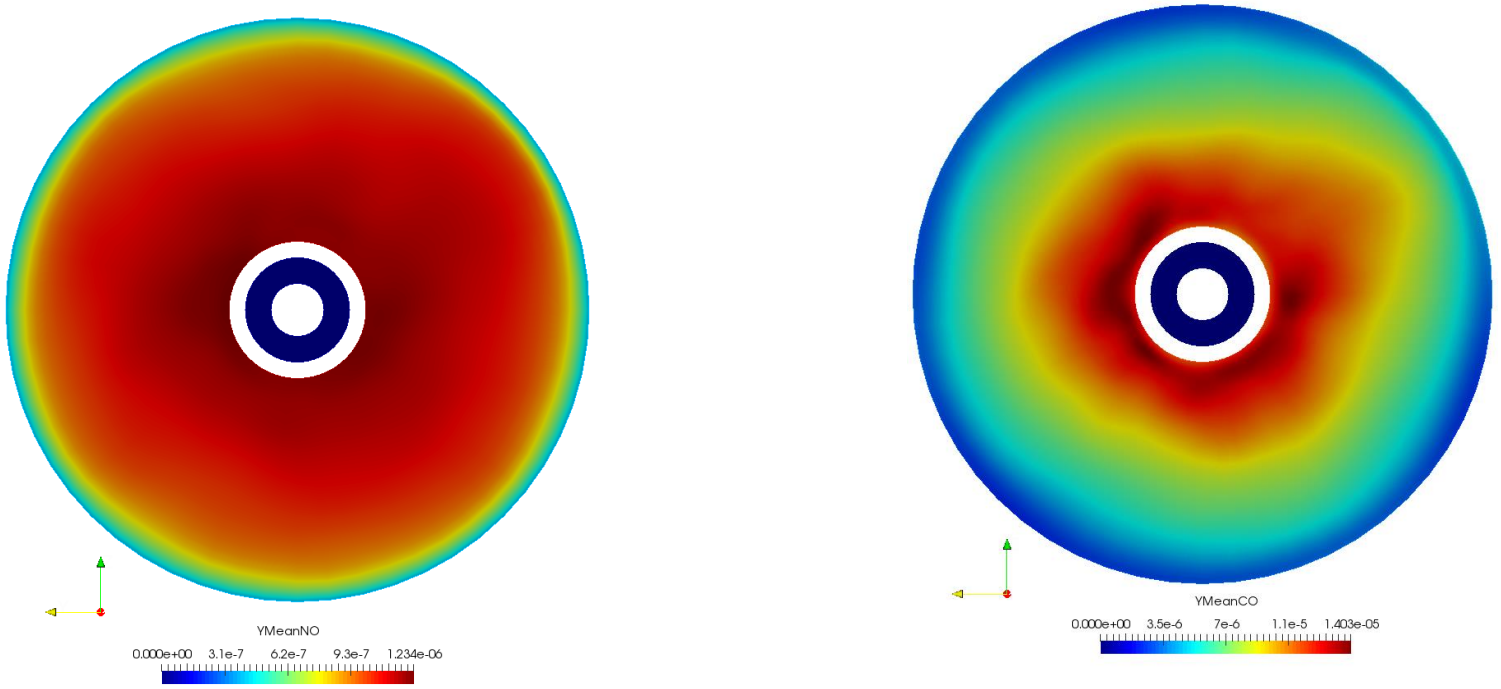


Figure : Mean NO and mean CO close to outflow

Calculated average NO and CO 2 ppm which matches well with experiments

Results

- methane/air combustion simulated with different conditions
- Flow field in good agreement with experiment
- Emissions are predicted accurately

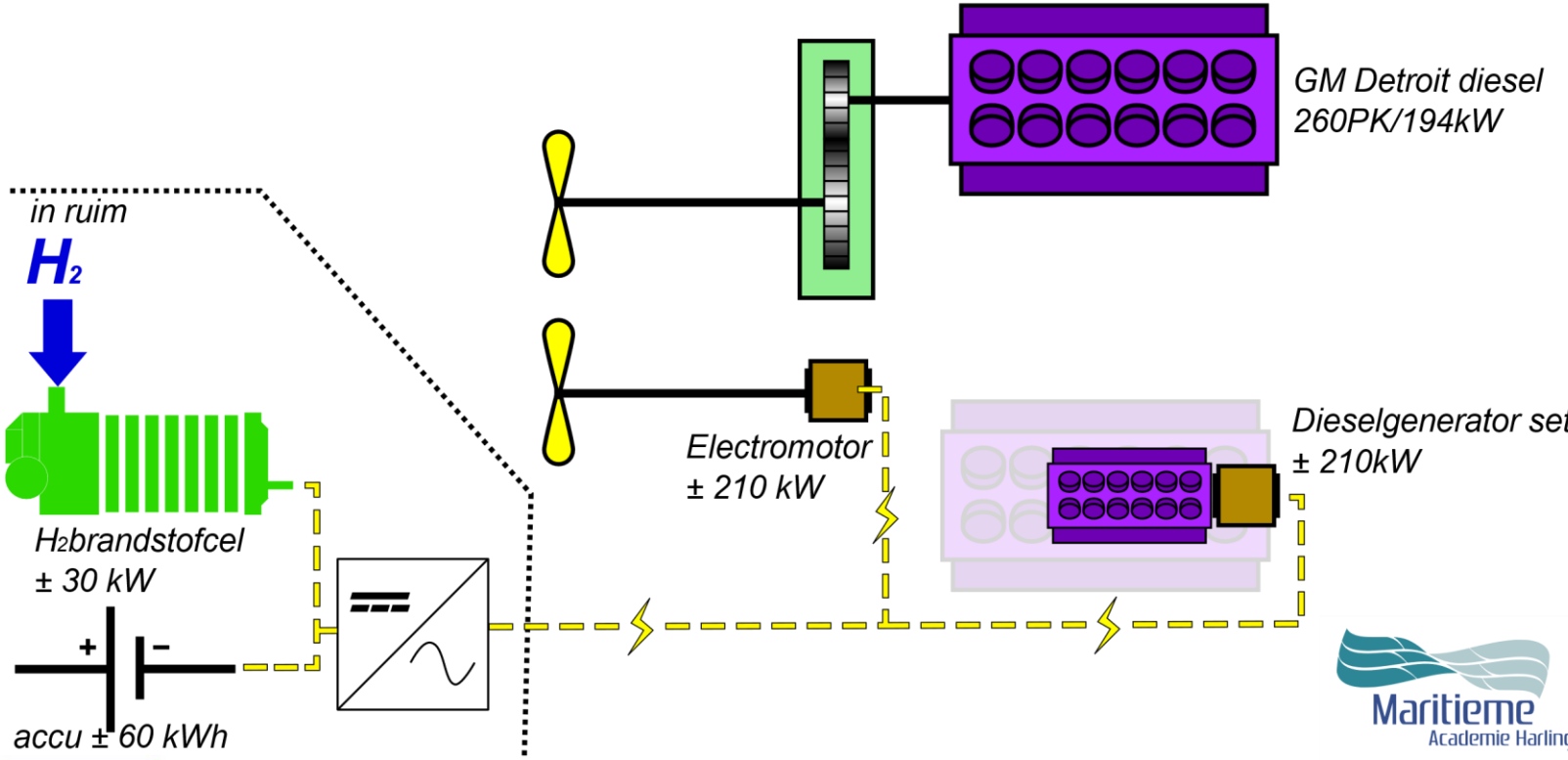
Current: extend to hydrogen combustion

Challenge: NOx

Hybrid Hydrogen Propulsion

EMELI ***Toekomstige situatie***

"Kempenaar"
55m x 7.2m 682T 1961



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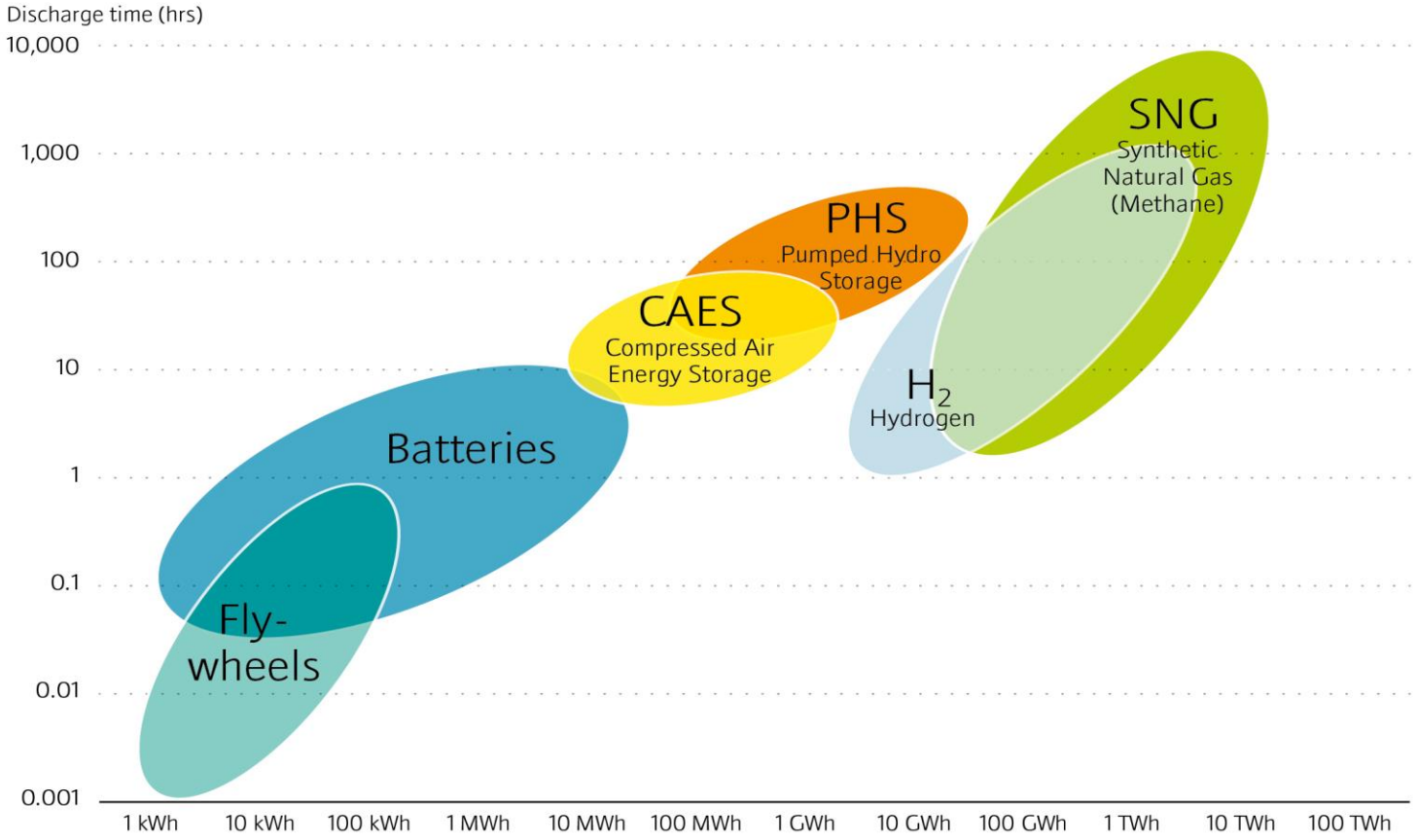
Why hydrogen?

Overview storage capacity of different energy storage systems

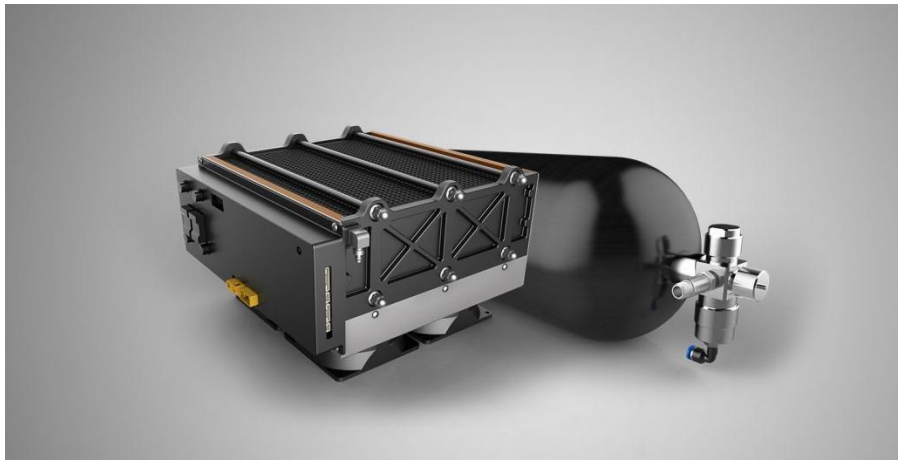


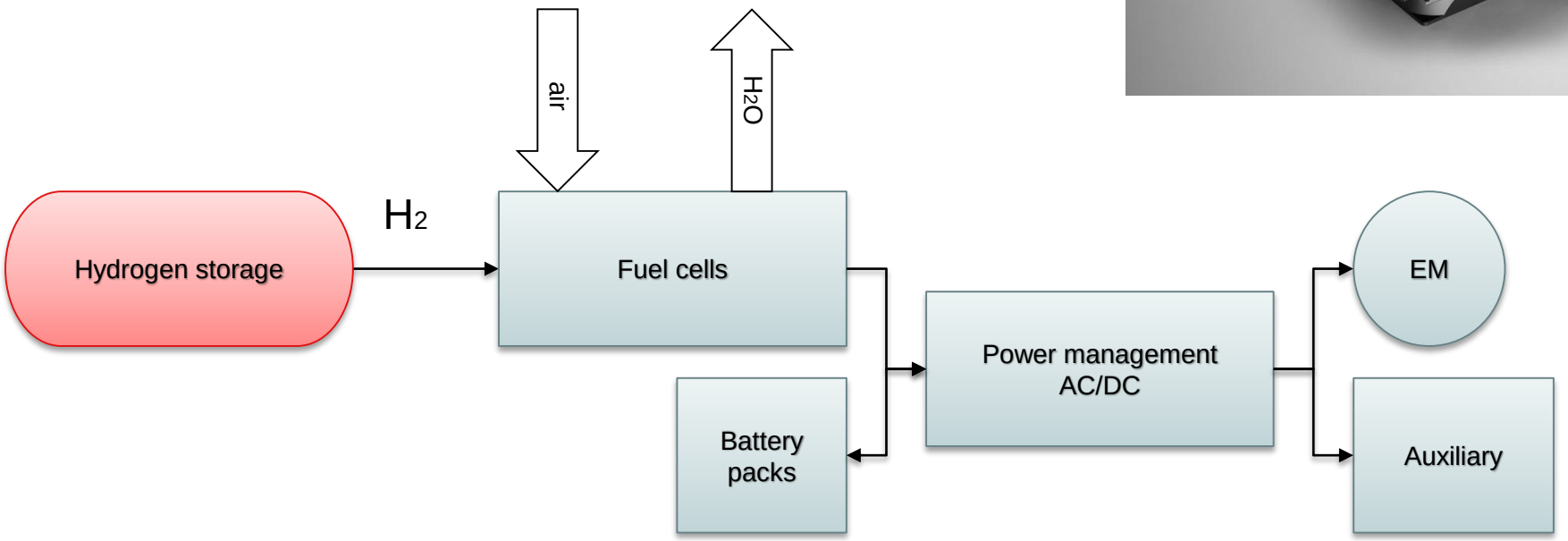
Renewables Global Futures Report Great debates towards 100 % renewable energy

REN21 Renewable Energy Policy Network for the 21st Century

Source: Fraunhofer Institute, Germany, 2014

Hydrogen configuration





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Fuel cells characteristics

	LT-PEMFC	HT-PEMFC	SOFC
Operating temperature (˚C)	40 - 80	150 - 180	500-1000
Electrical efficiency (LHV)	50-60	40-45	50-65
Fuel purity required	99.999% H2	CO<3%	Light hydrocarbons (S<20 ppm)
Gravimetric power density (W/kg)	250-1000	-	8.0-80
Volumetric power density (W/l)	300-1550	-	4.0-32
Life time	5 to 20k hours	10 to 60k hours	10 to 40k hours
Start-up time	<10 seconds	10 to 60 minutes	30 minutes to hours
Load transients (0 to 100%)	<5 seconds	2-5 minutes	<15 minutes
Capital cost today ($/kW)	>1000	4000-4500	3500-15000
Technology Readiness Level (TRL)	8	7-8	5-7
Cooling	Water cooling	Water cooling	Air cooling
Waste heat recovery	-	-/+	++

van Biert, L., Godjevac, M., Visser, K., & Aravind, P. V. (2016). A review of fuel cell systems for maritime applications. *Journal of Power Sources*, *327*(X), 345–364. https://doi.org/10.1016/j.jpowsour.2016.07.007

Steps to completion

- Project changes implemented (LNG to Hydrogen)
- We are currently finalizing the FC tendering
- Construction phase will commence in October 2018
- MV Emeli will serve as a test bed for the new propulsion installation and will gather data after the completion of the refit in “every day service” as a training vessel

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Hartelijk dank!
Dankeschön!
Thank you very much!

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