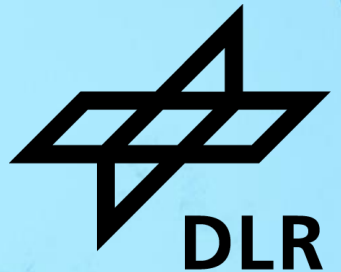


CHALLENGES FOR PEMFC FOR HIGH POWER APPLICATIONS: SCALING UP AND DURABILITY

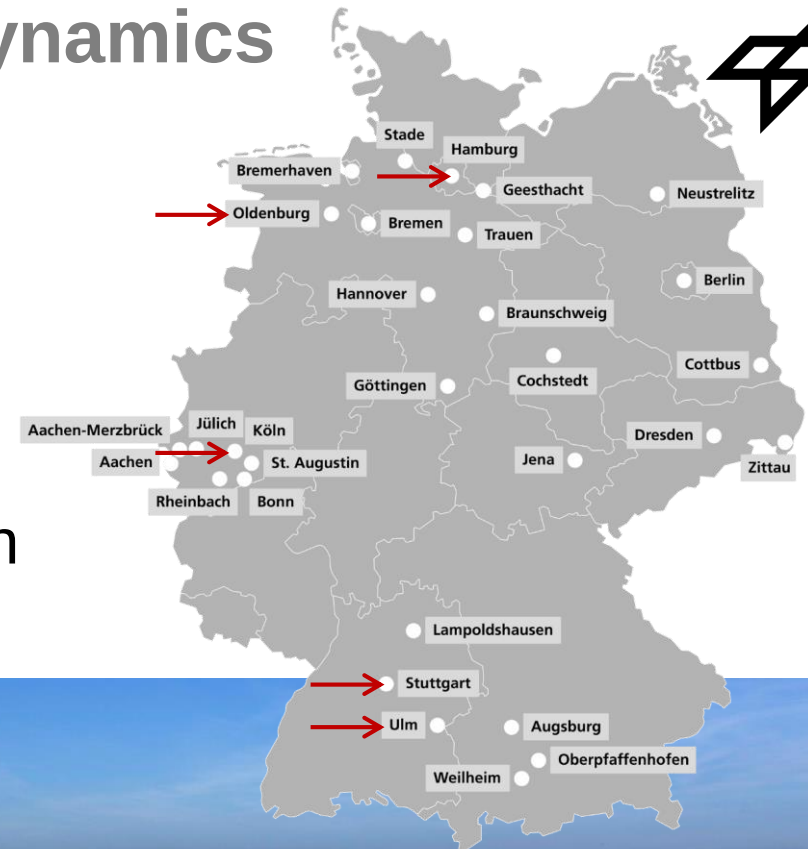
Dr. Pawel Gazdzicki, DLR

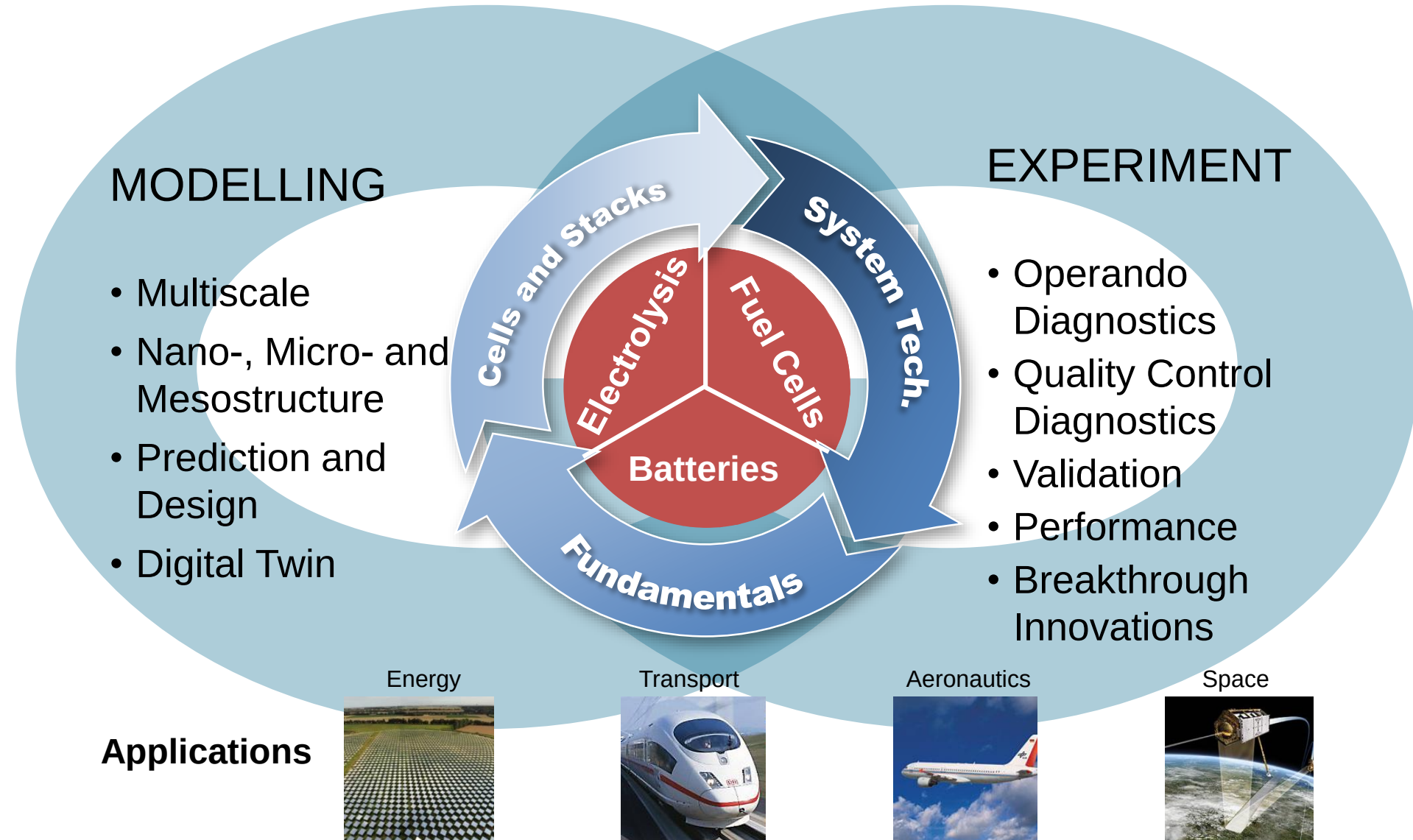


DLR – Institute of Engineering Thermodynamics

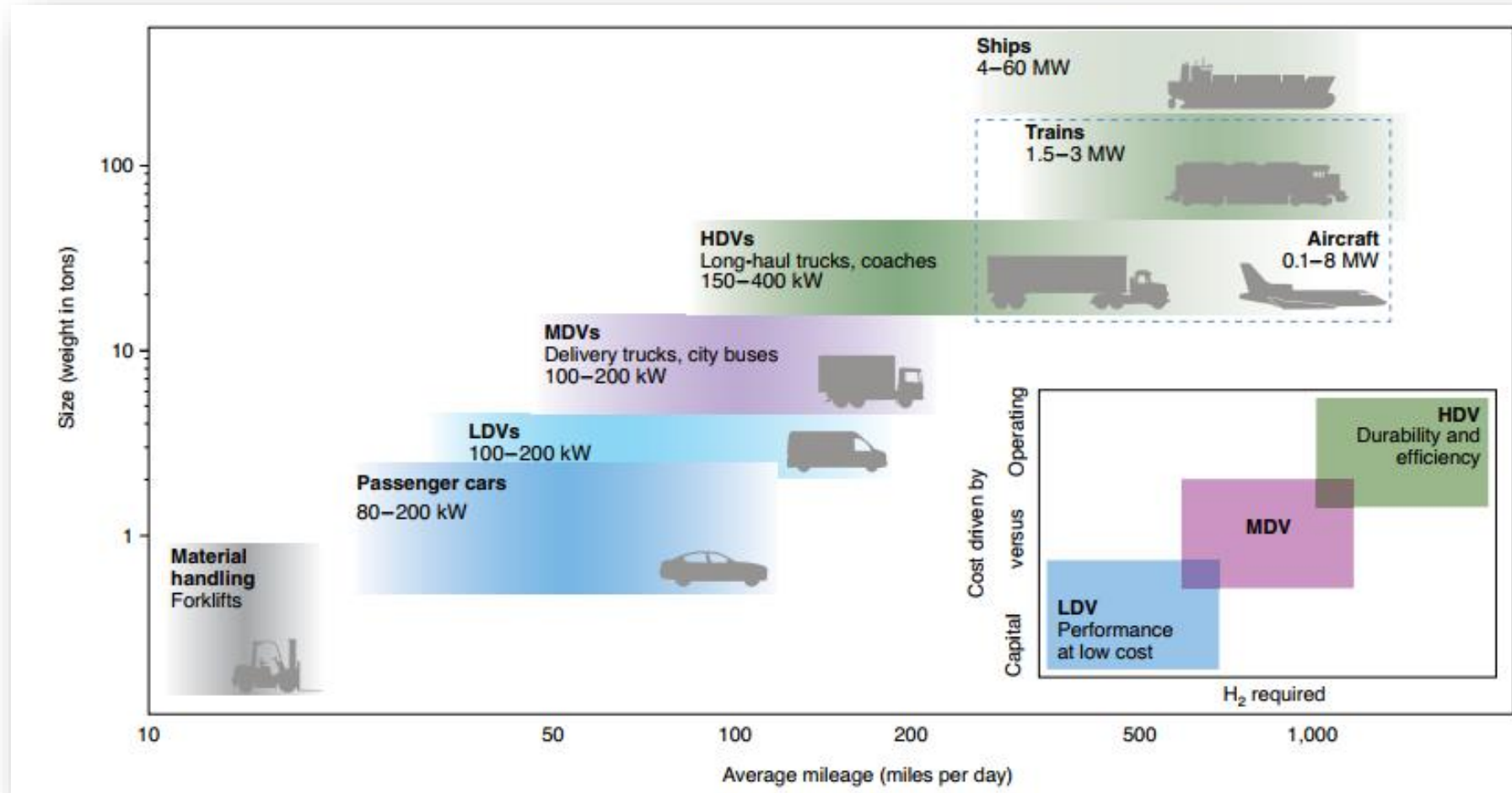


- Site in Stuttgart with focus on energy research
- Institute of Engineering Thermodynamics with sites in Stuttgart, Oldenburg, Ulm, Hamburg, Köln
- Director: Prof. André Thess
- Focus on energy storage and energy conversion based on renewable energies





Fuel Cells in heavy duty transport

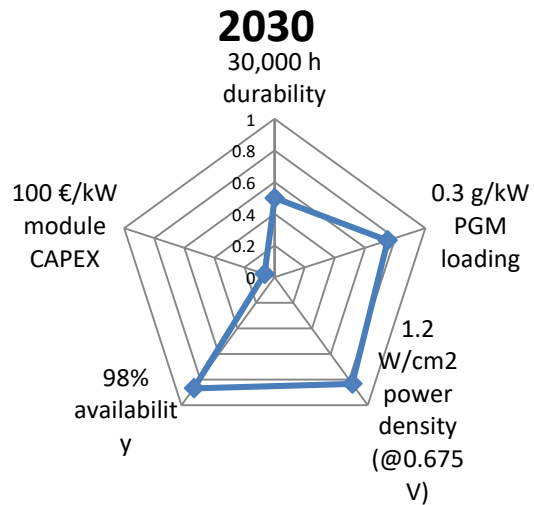


Cullen, D.A., Neyerlin, K.C., Ahluwalia, R.K. *et al.* New roads and challenges for fuel cells in heavy-duty transportation. *Nat Energy* **6**, 462–474 (2021). <https://doi.org/10.1038/s41560-021-00775-z>

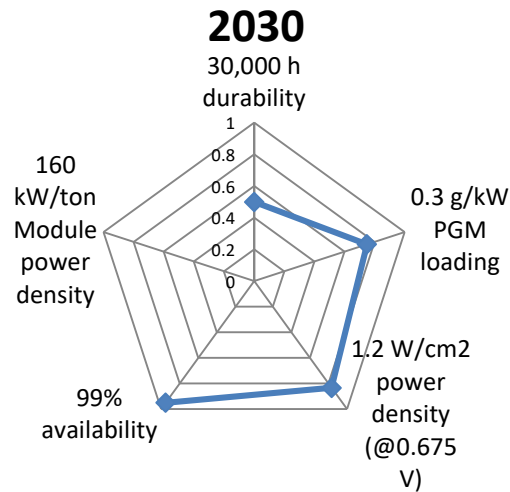
Current achievements and KPIs for PEMFC applications



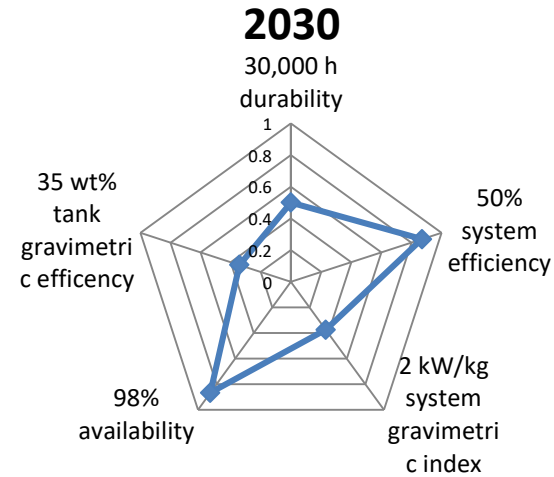
SoA vs HDV Targets



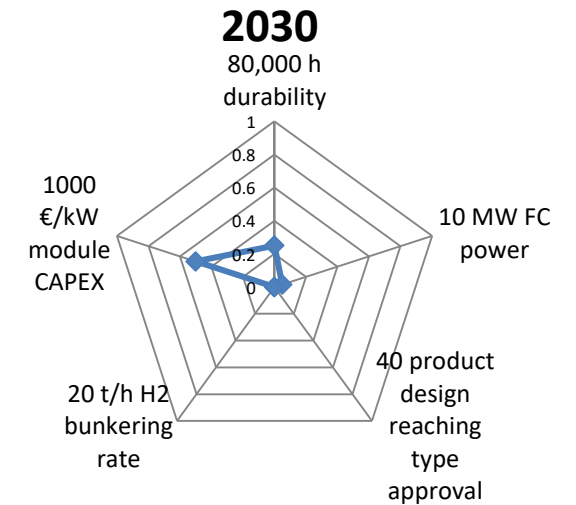
SoA vs Train Targets



SoA vs Aviation Targets



SoA vs Maritime Targets



PEMScale 1.5

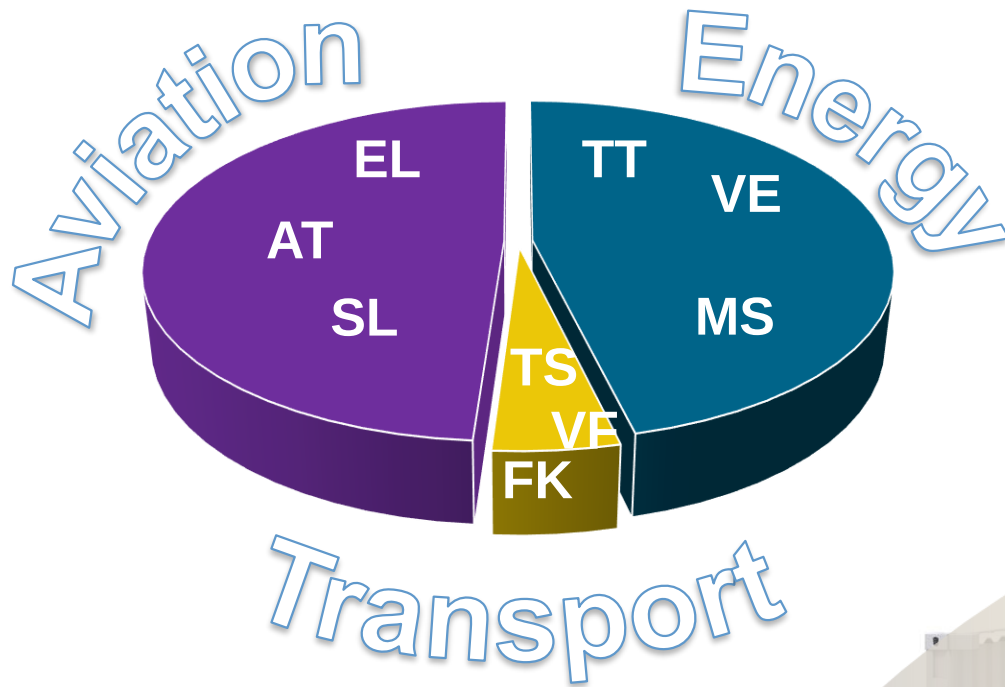


Sector Coupling

Hydrogen

Fuel Cells

System Analysis



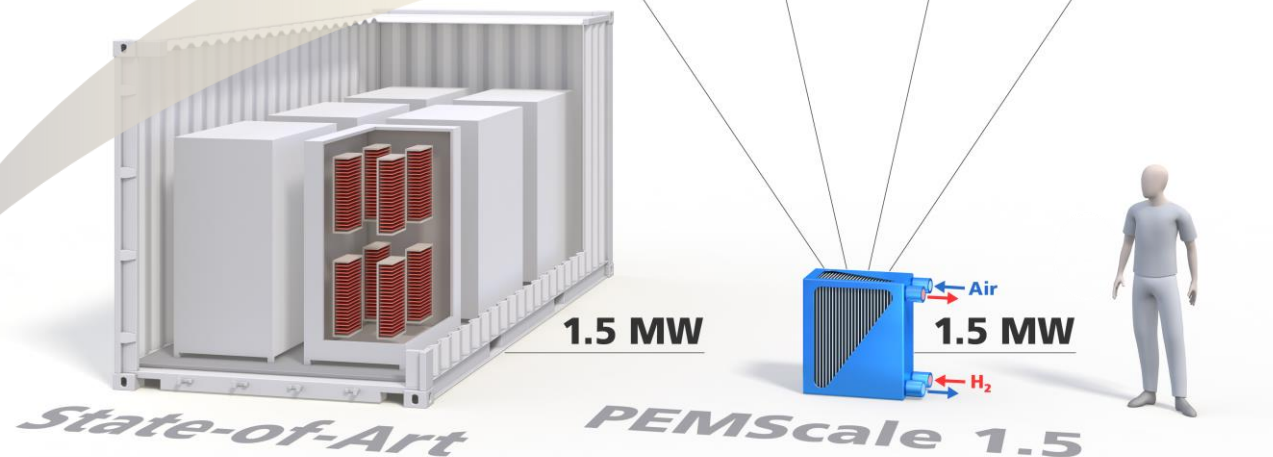
2022

2023

2024

2025

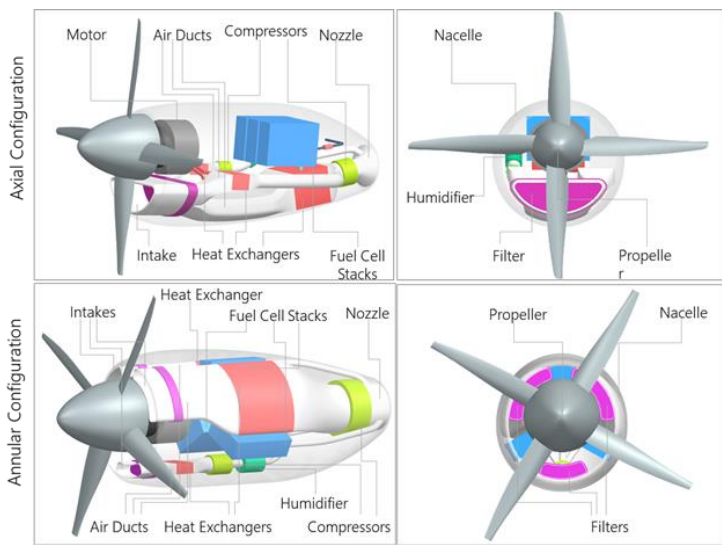
Advancing technology in terms of power density and adaptability



PEMScale – Examples

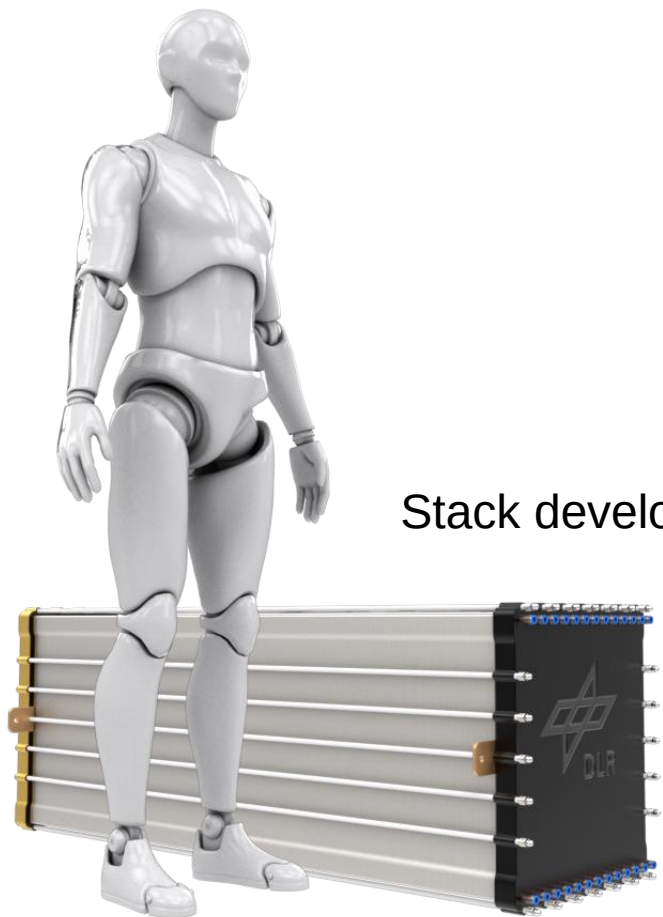


System integration concepts for aviation

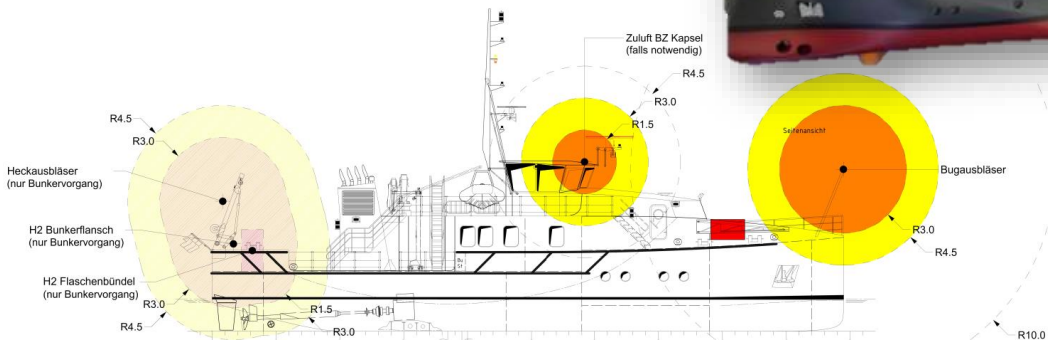


(DLR-EL)

Stack development

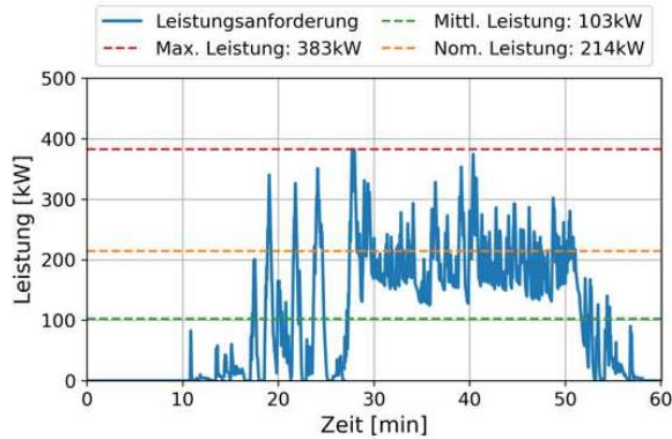


H2 safety concept for ships

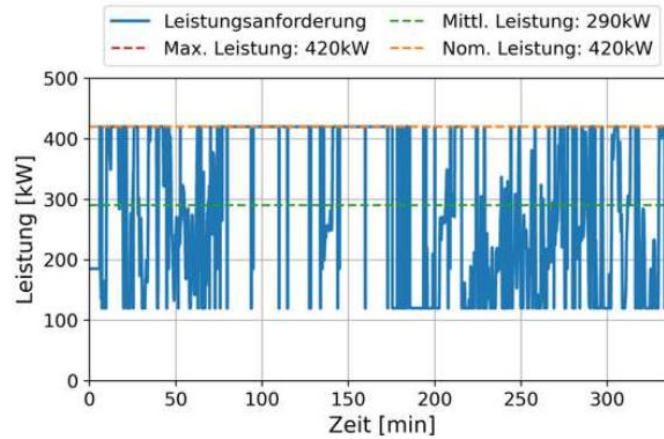


(DLR-MS)

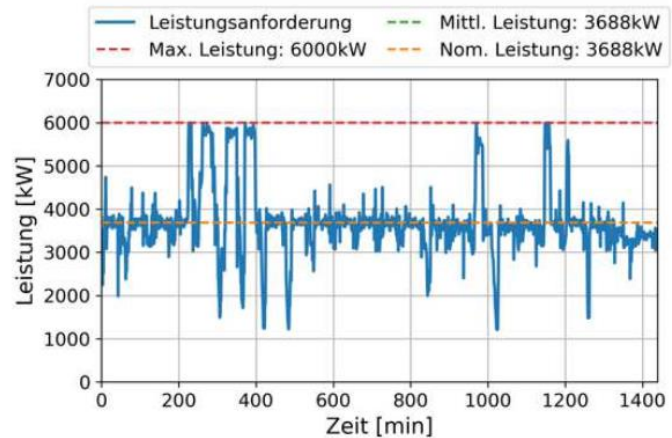
Requirements for HD applications – analysis of mission profiles



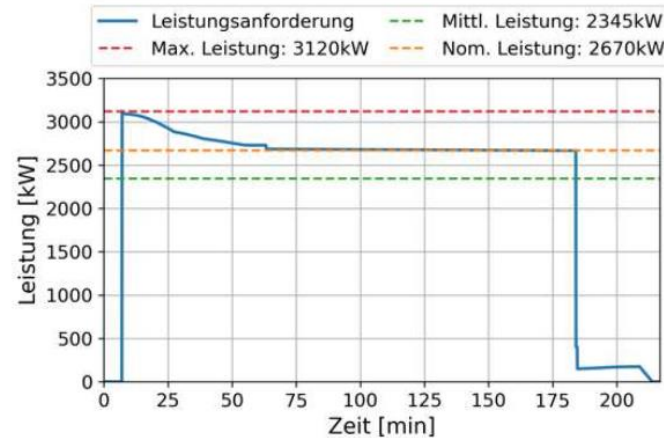
(a) LKW



(b) Zug



(c) Schiff



(d) Flugzeug

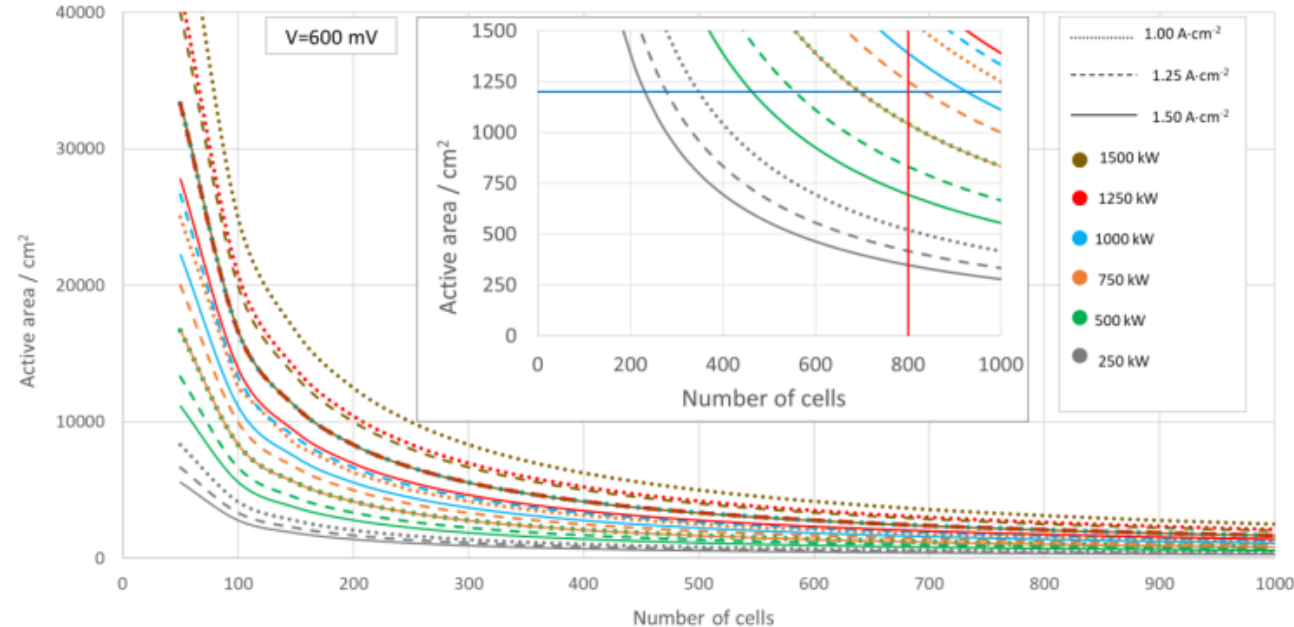
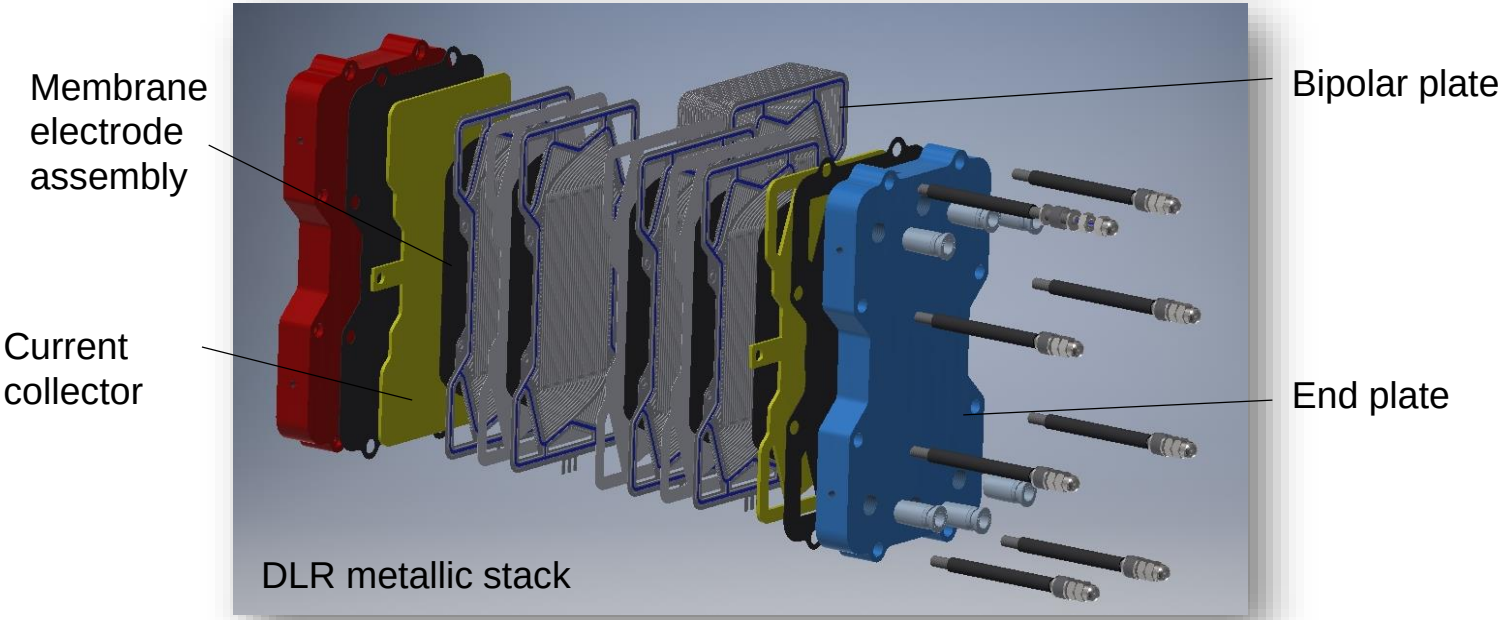
parameters		truck	train	ship	aircraft
power avg.	kW	104	290	3688	2345
power max.	kW	383	420	6000	3120



Parameter	Unit	Truck	Train	Ship	Aircraft
Min. Pressure	hPa	750	750	877	287
Max. Pressure	hPa	1080	1080	1080	1080
Min. Temp.	°C	-40	-40	-40	-47,4
Max. Temp.	°C	40	40	40	40
Min. rel. humidity	%	34% at 40°C	34% at 40°C	34% at 40°C	34% at 40°C
Max. rel. humidity	%	90% at 15°C	90% at 15°C	90% at 15°C	90% at 15°C

Development of concept for MW-Stack

Fuel stack parameter	Power output (kW)	Number of cells
	205	598
	120	400
	71	240
	140	309
	128	330
	130	-
	95*	440
	125	-
	160 (engine output)	400
	100**	455
	120	-

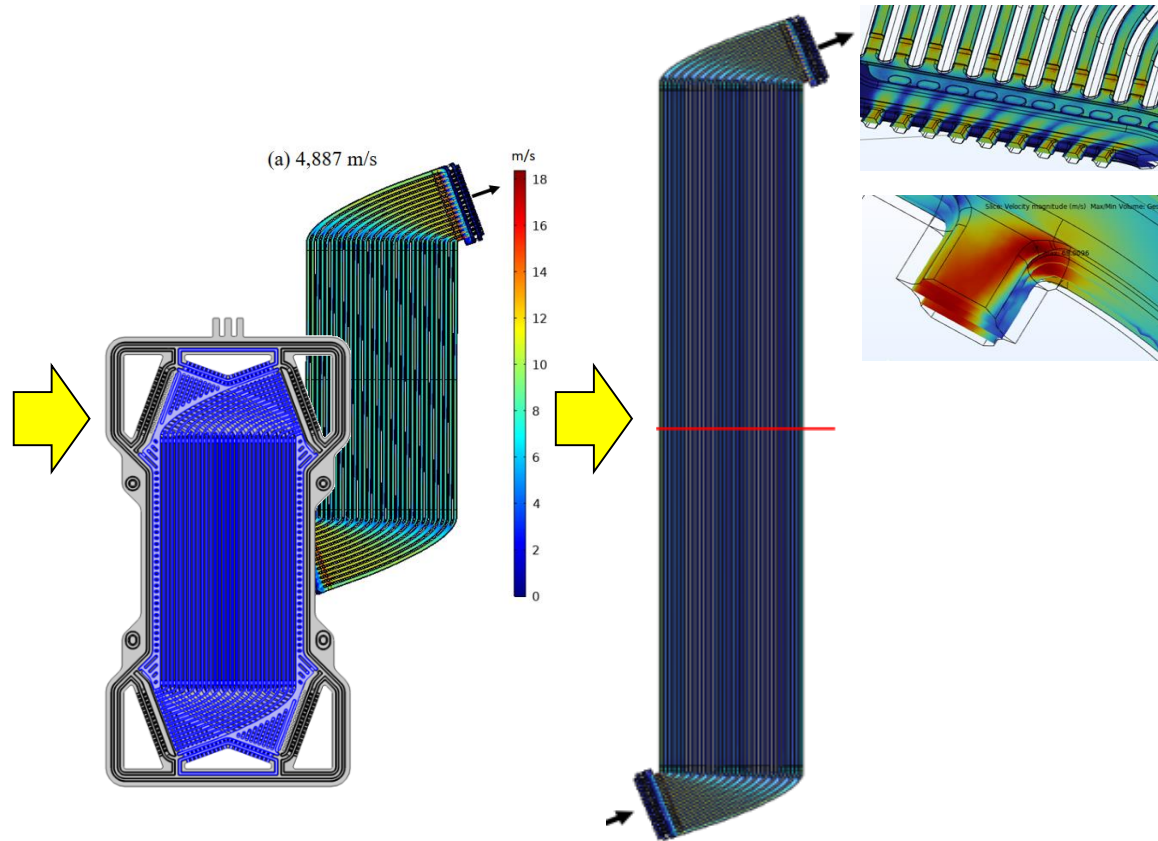


Fuel cell stacks from different companies (as of 2021)

Development of concept for MW-Stack

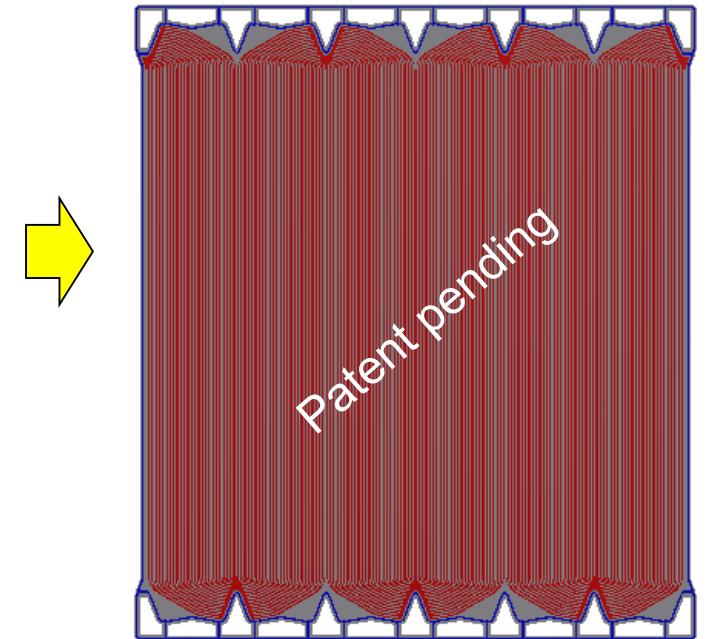


DLR lab scale stack



COMSOL model of
DLR Stack

Scaling up cell area



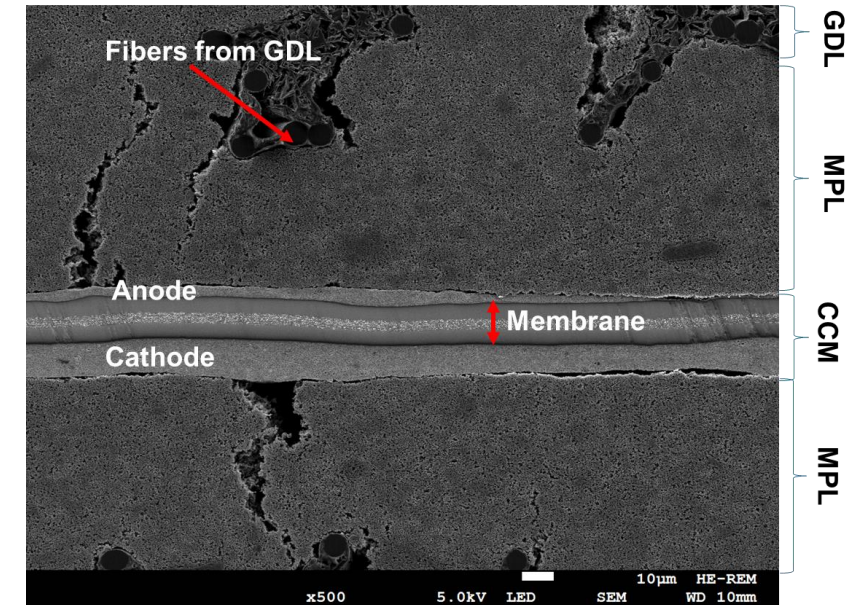
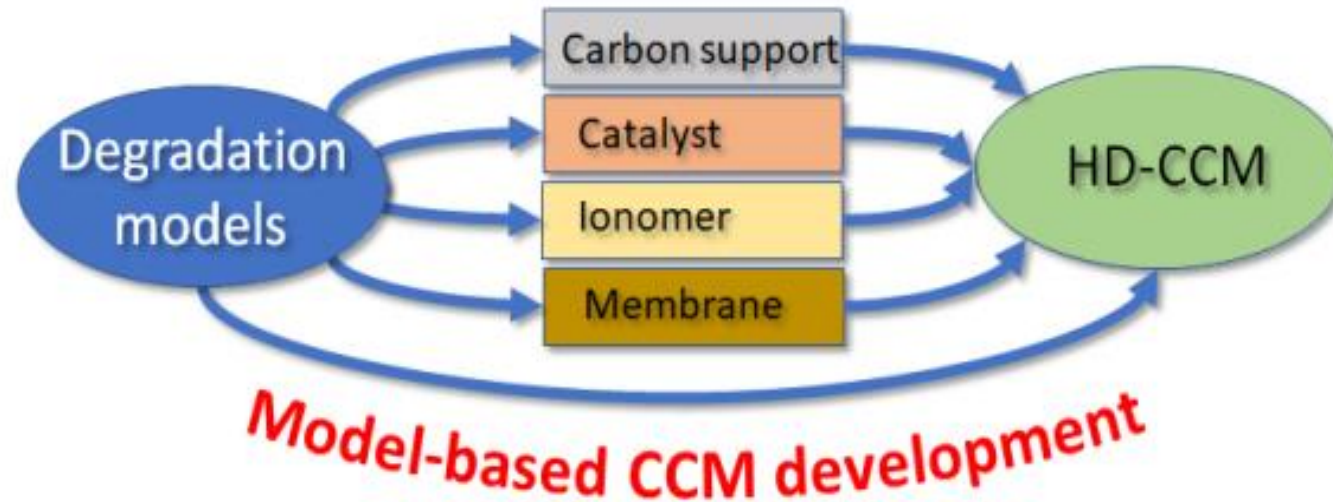
BPP with 1200 cm² with sub-
flow fields

PEMTASTIC

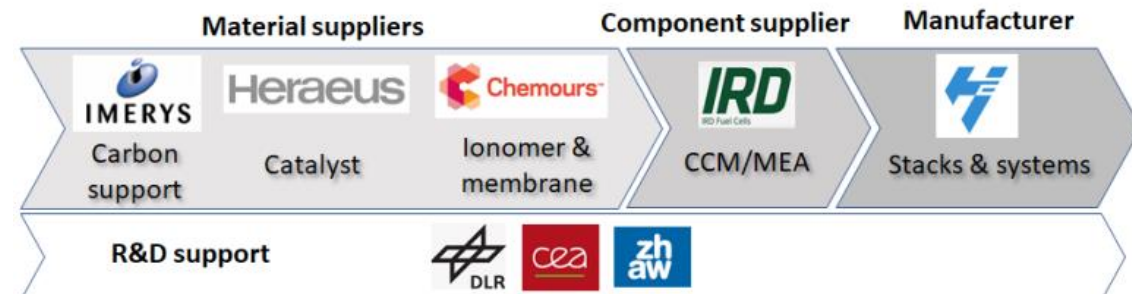
ROBUST PEMFC MEA DERIVED FROM MODEL-BASED UNDERSTANDING OF DURABILITY LIMITATIONS FOR HEAVY DUTY APPLICATIONS



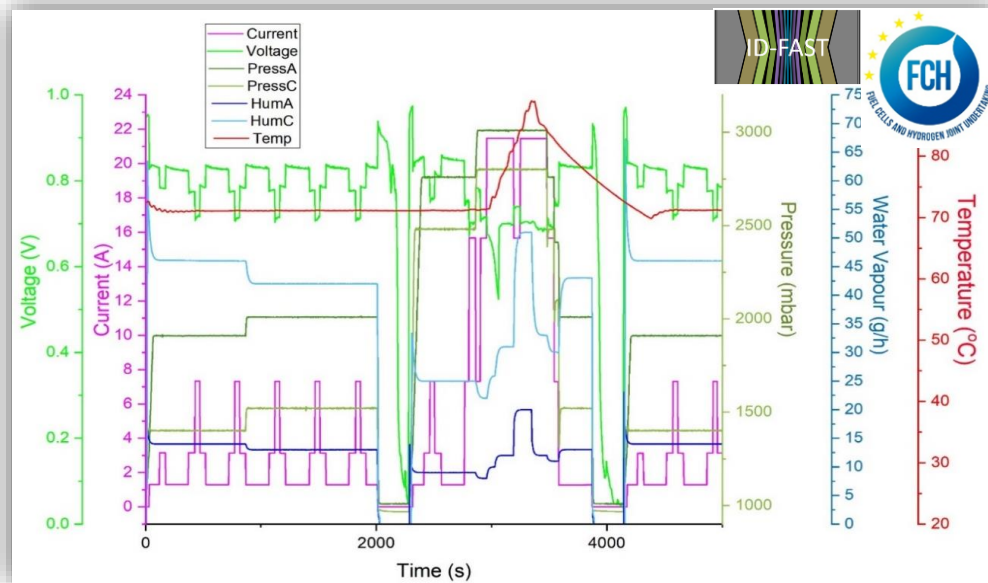
Co-funded by
the European Union



- **Call topic:** HORIZON-JTI-CLEANH2-2022-03-02 (RIA)
- **Duration:** 01.02.2023 – 31.01.2026
- **CleanH2 Funding:** 2.748 k€
- **Other funding:** 937 k€

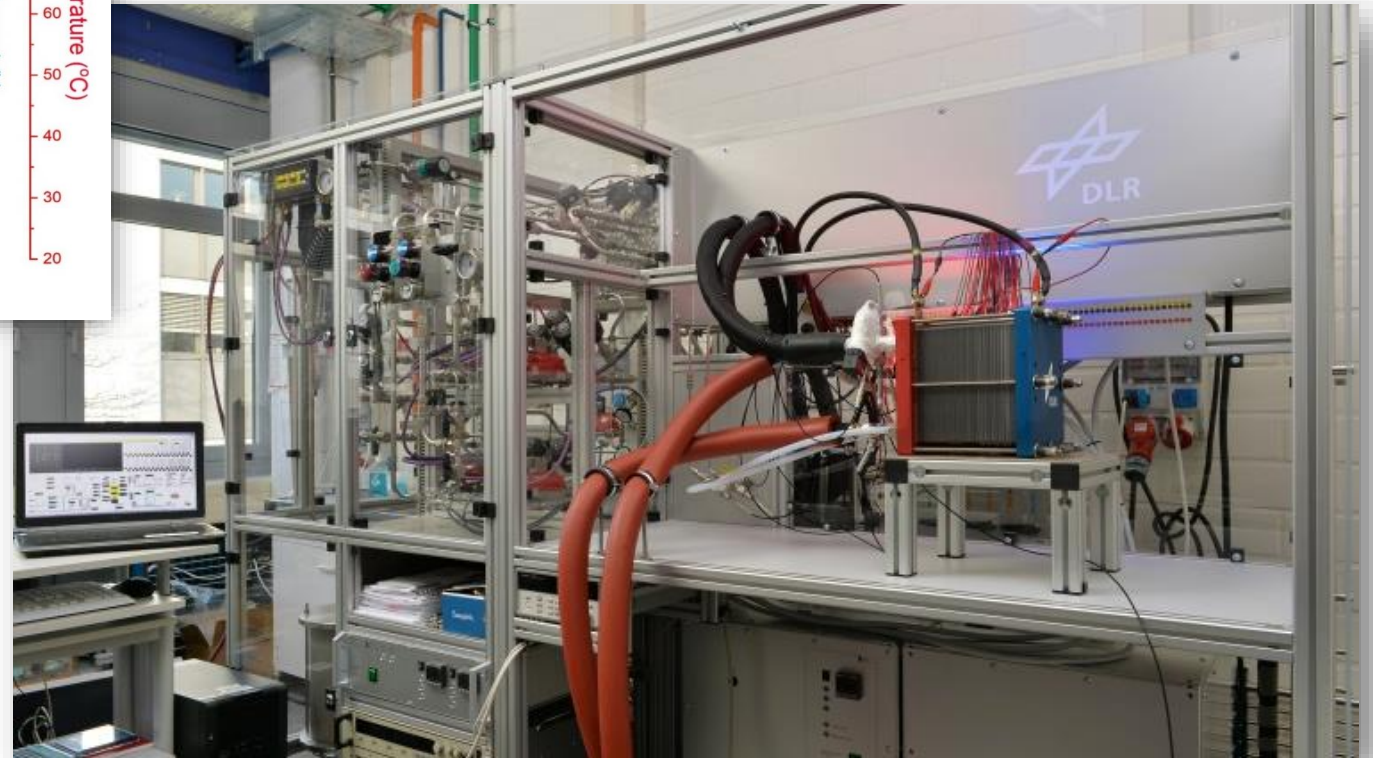


Investigation of durability – definition of FC testing protocols for heavy duty application



Control of

- Current density
- Temperature
- Humidity
- Pressure
- Gas concentration
- Gas flows, ...



Investigation of durability – definition of FC testing protocols for heavy duty application

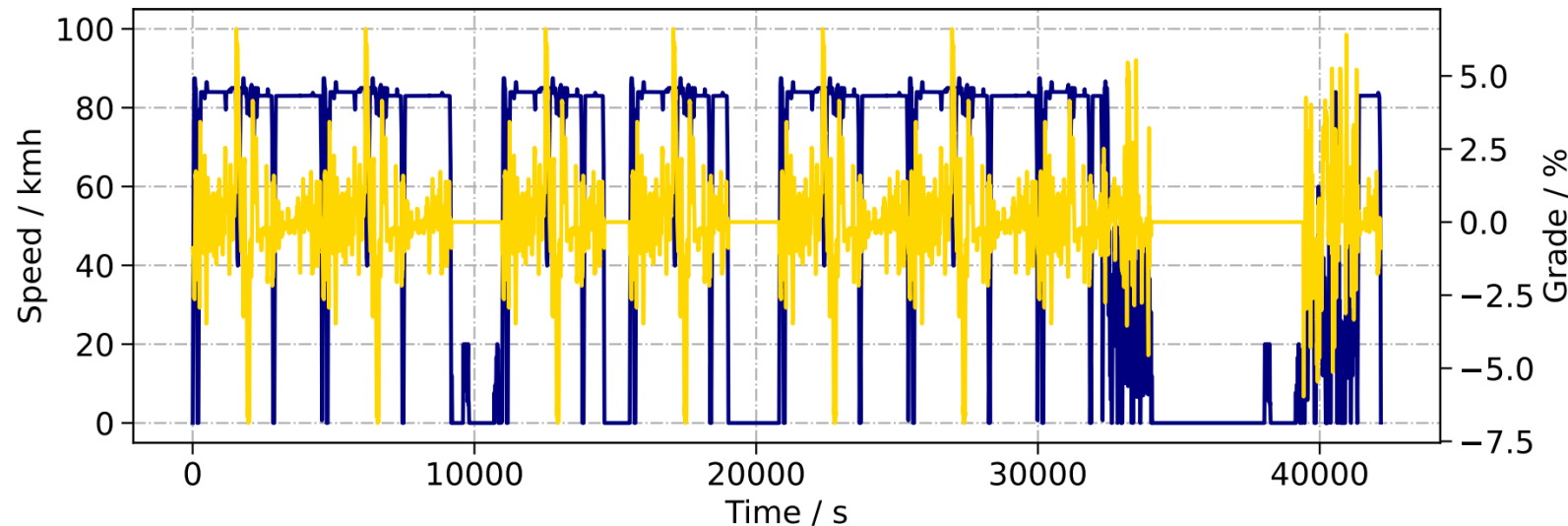
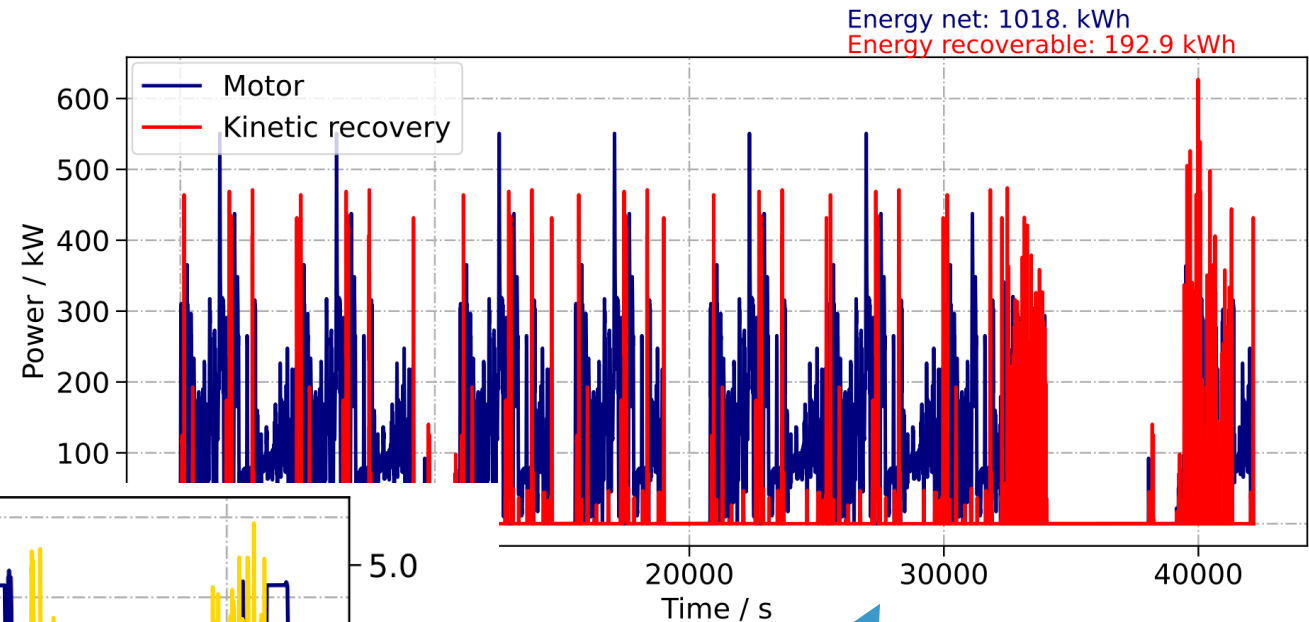
J. Sanchez-Monreal (DLR-TT)



Co-funded by
the European Union



GVW	35029 kg
Vehicle	15729 kg
Load	19300 kg
$A \times C_d$	5.3 m ²
C_r	0.006



Mechanical simulation

Investigation of durability – definition of FC testing protocols for heavy duty application

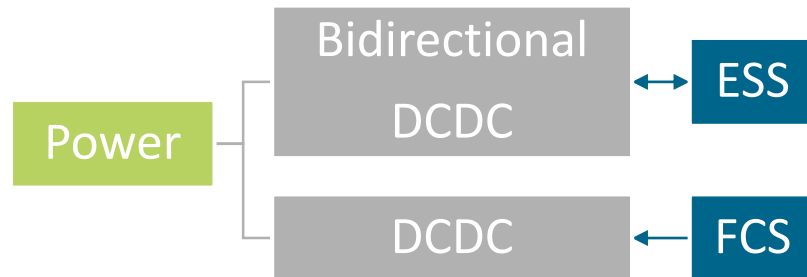
J. Sanchez-Monreal (DLR-TT)



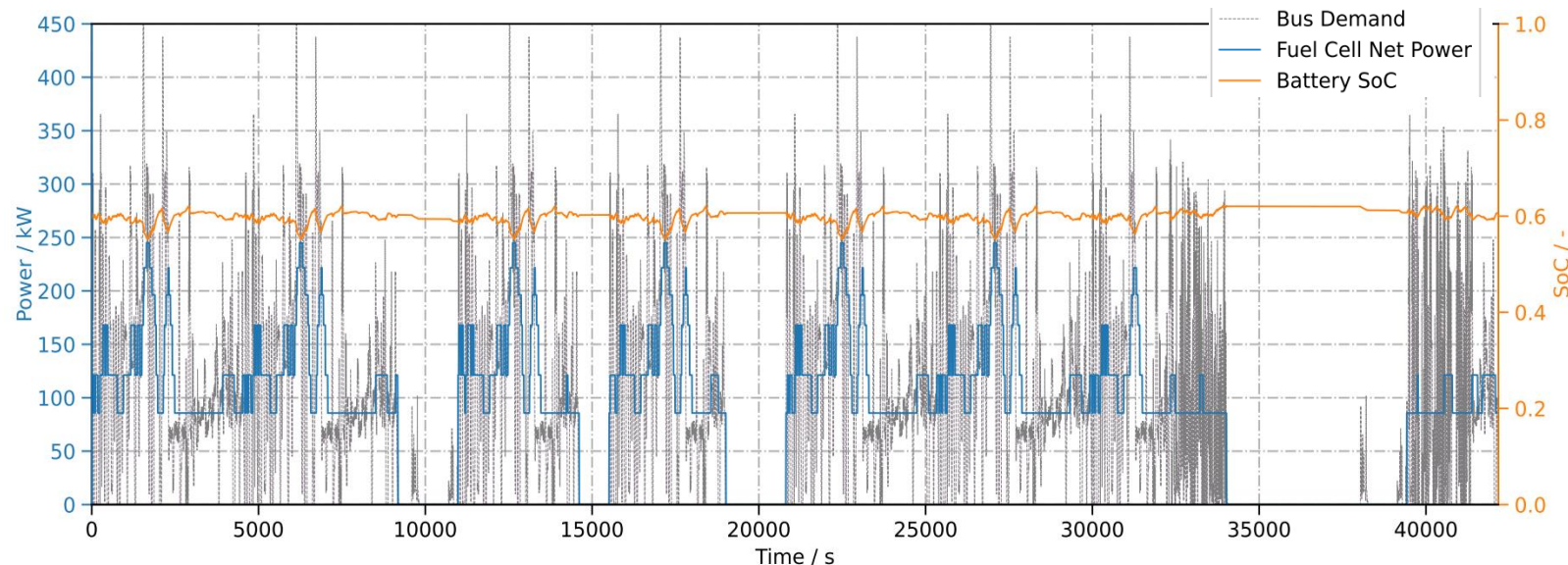
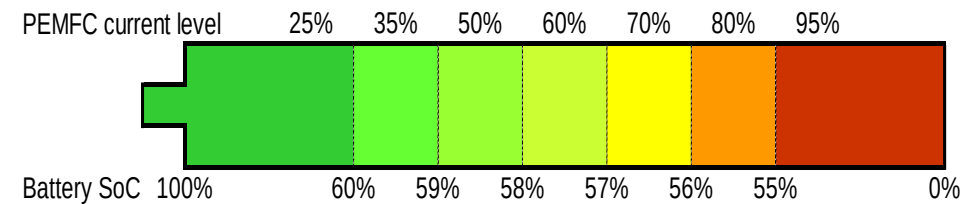
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Hybrid Architecture



Hybrid Strategy



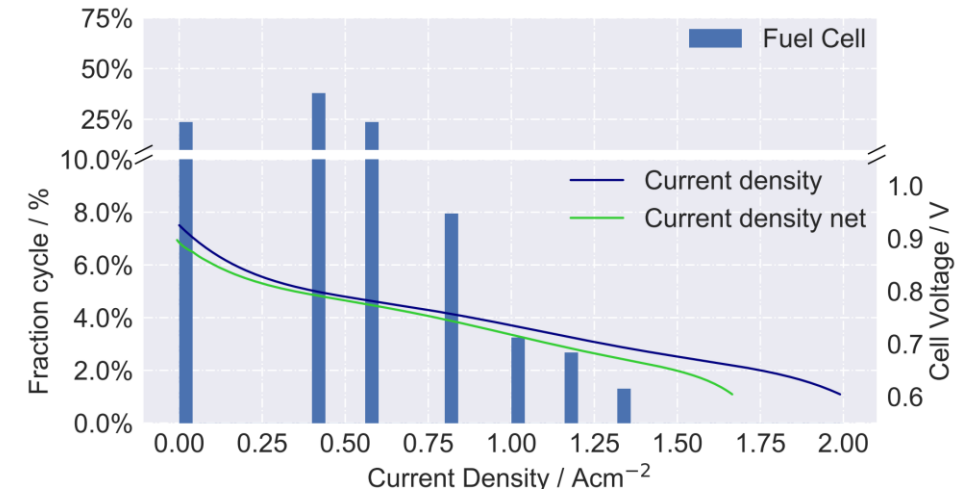
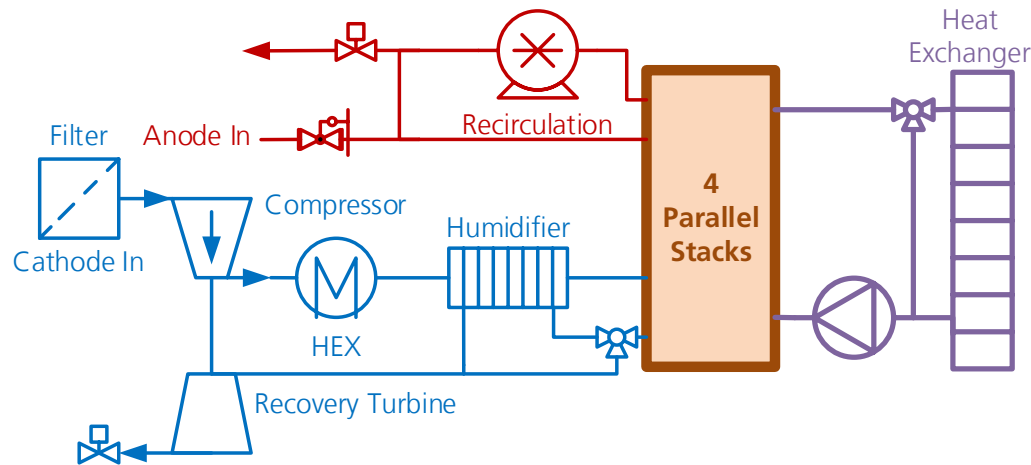
Project 101101433 — PENTASTIC

Investigation of durability – definition of FC testing protocols for heavy duty application

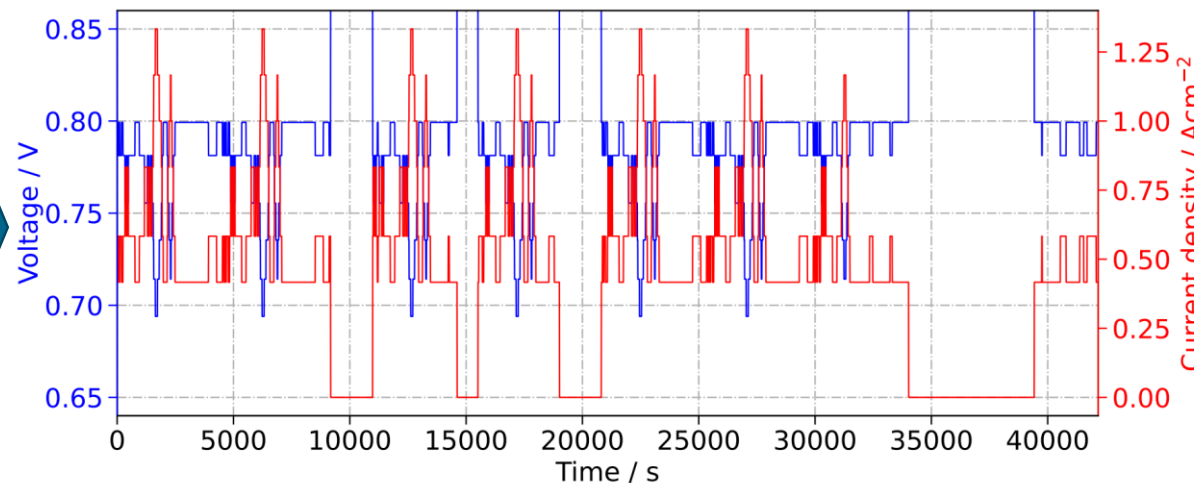
J. Sanchez-Monreal (DLR-TT)



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New fuel cell test
protocol representative
for heavy duty

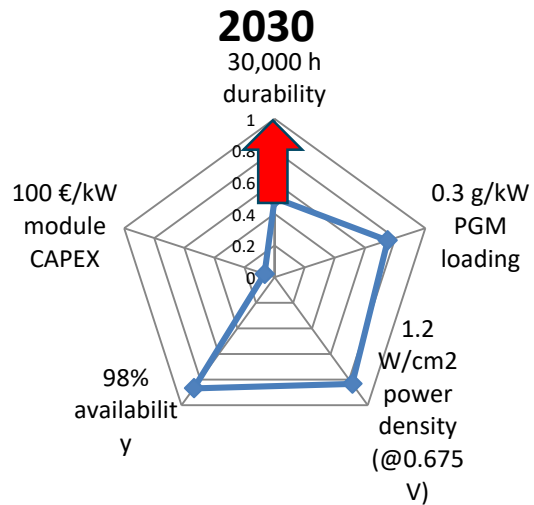


Next step define
accelerated stress test
specific for heavy duty

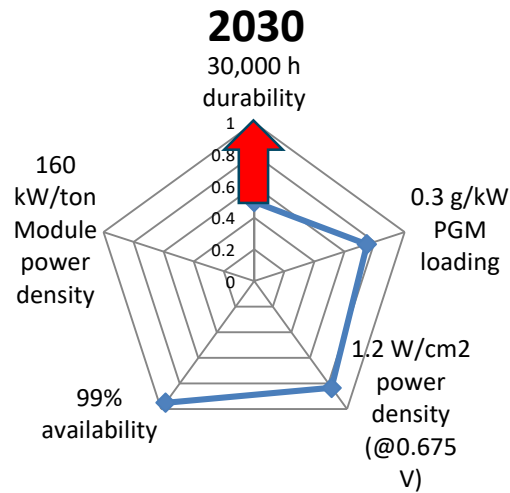
Current achievements and KPIs for PEMFC applications



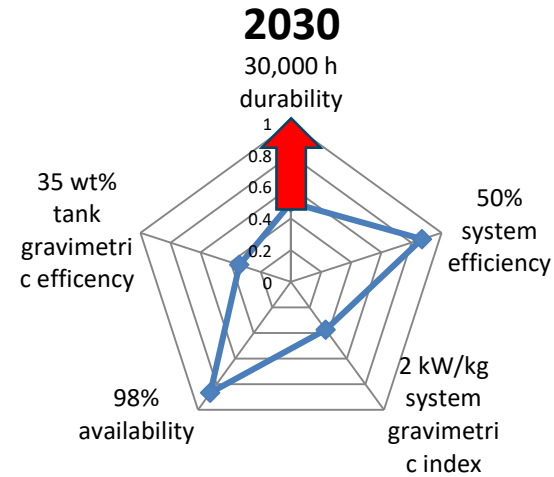
SoA vs HDV Targets



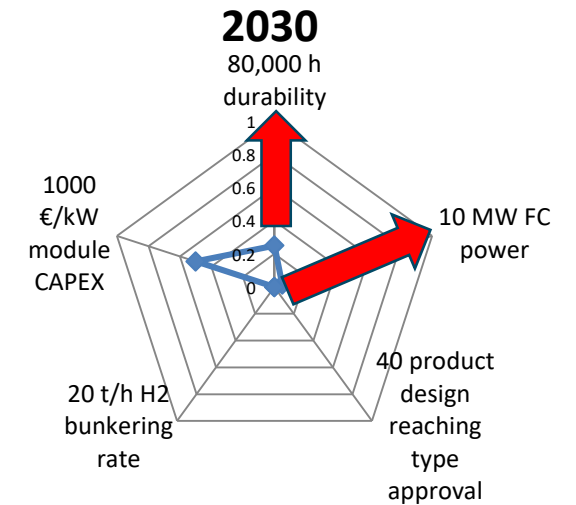
SoA vs Train Targets



SoA vs Aviation Targets



SoA vs Maritime Targets





**THANK YOU FOR YOUR
ATTENTION**

pawel.gazdzicki@dlr.de

