

Hydrogen and Electric Flight

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8 December 2021



Knowledge for Tomorrow

The German Aerospace Center DLR Deutsches Zentrum für Luft- und Raumfahrt

Germany's research centre for aeronautics and space.

- ca. 10000 employees
- ca. 55 institutes
- > 30 Locations
- International offices in Brussels, Paris, Tokyo and Washington D.C.
- Research Areas
 - Aeronautics
 - Space
 - Energy
 - Transport
 - Security
 - Digitalisation
- German Space Agency
- 2 agencies for
 - funding management
 - Knowledge transfer



Fuel Cell Electric Regional Aircraft



Comparison against ATR72-like aircraft

Energy demand		-20%
CO2 reduction		100%
Climate impact reduction		80-90%
Seat Mile Cost		-11%
Entry into service		2040
MTOW		+16%
Fleet size change		-3%

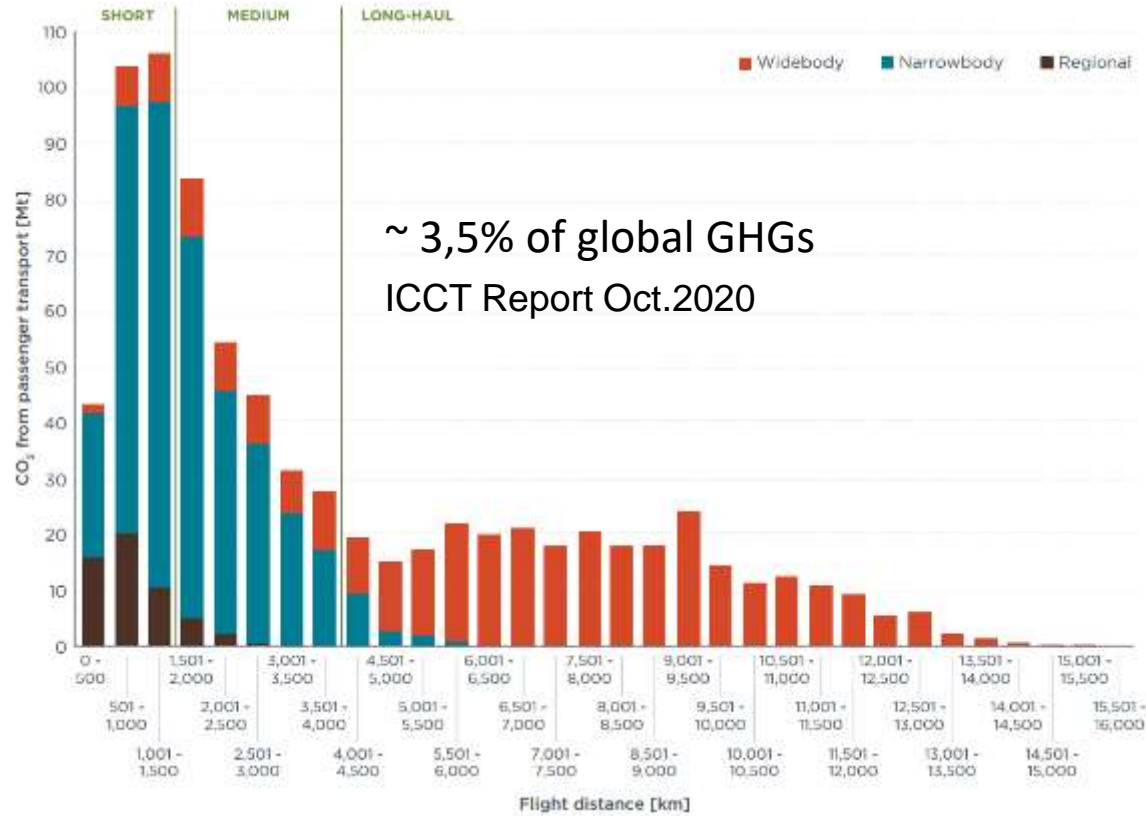
Design Mission

- 70PAX, in single class layout
- Mach 0.55; 1000nm range

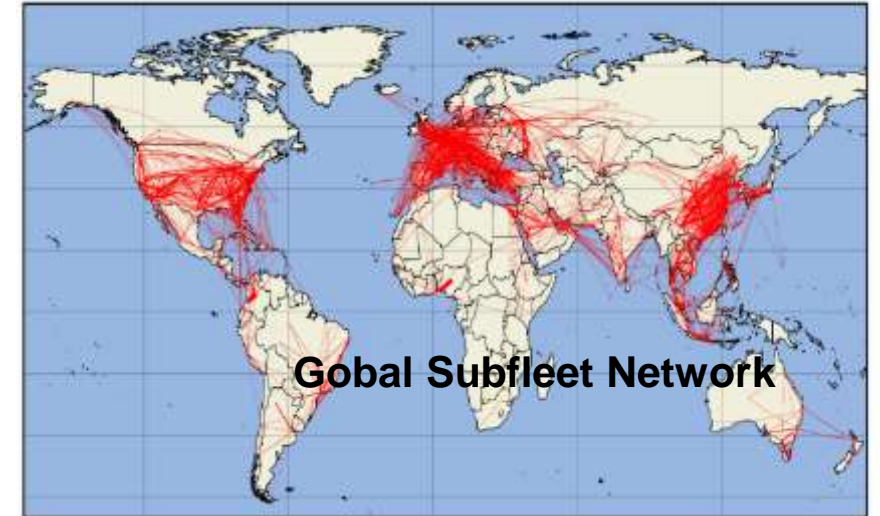
Features

- Distributed propulsion with 10 self-sufficient nacelle modules (FC, Inv, eMot, HX)
- Central tank architecture with 2 LH2 tank @ rear end in 5-abreast fuselage

Why Fuel Cell Systems and Hydrogen for E-aircraft?



~ 3,5% of global GHGs
ICCT Report Oct.2020



Global Subfleet Network

High share of CO₂-emissions from short and medium range travel

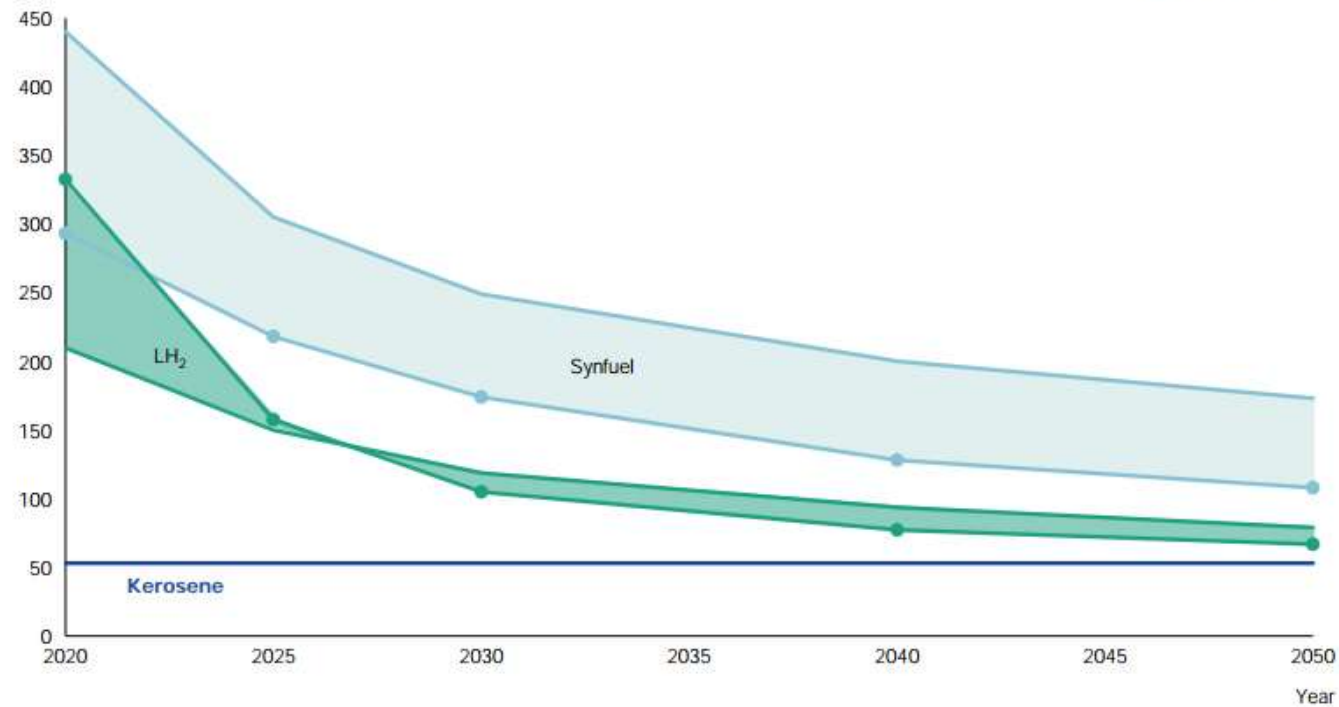


Why Hydrogen for E-Aircraft?

Exhibit 17

Cost projection of fuel prices in Europe

Cent per kg

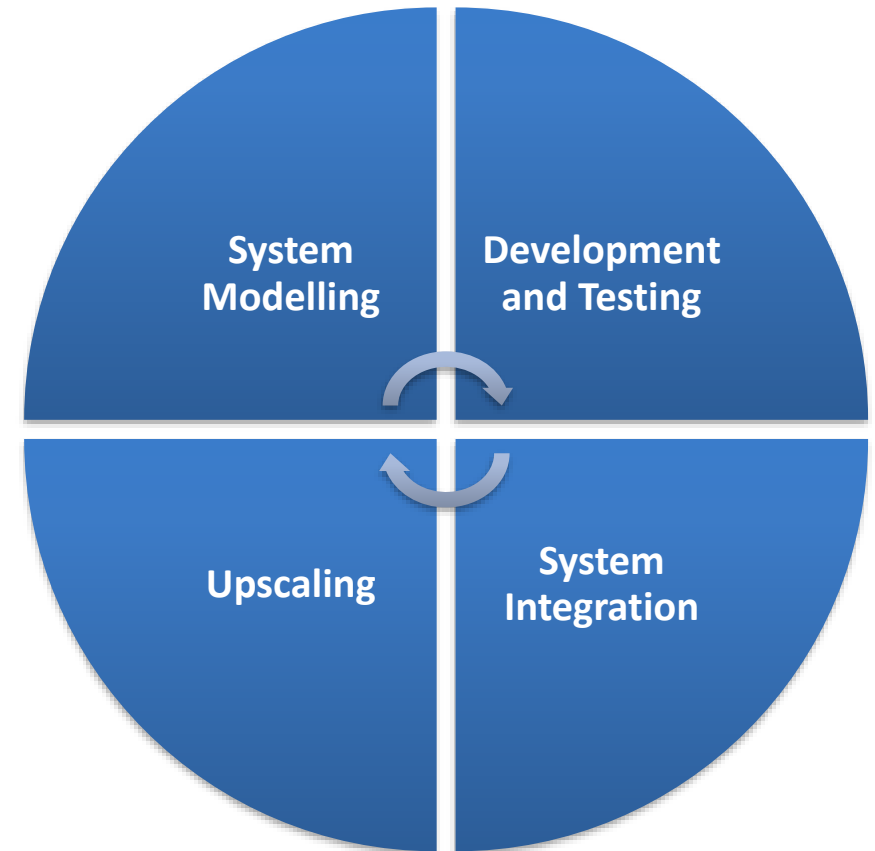


Projected cost of liquid hydrogen will be significantly lower than synthetic kerosene



Methodology of development of fuel cell based powertrains and energy systems for E-Aircraft at DLR

- System design and testing under critical conditions
- Development of optimized operation strategies
- Upscaling of fuel cell and hybrid powertrains for 100-1000 kW power
- Integration of electrochemical systems in flying platforms and demonstration tests

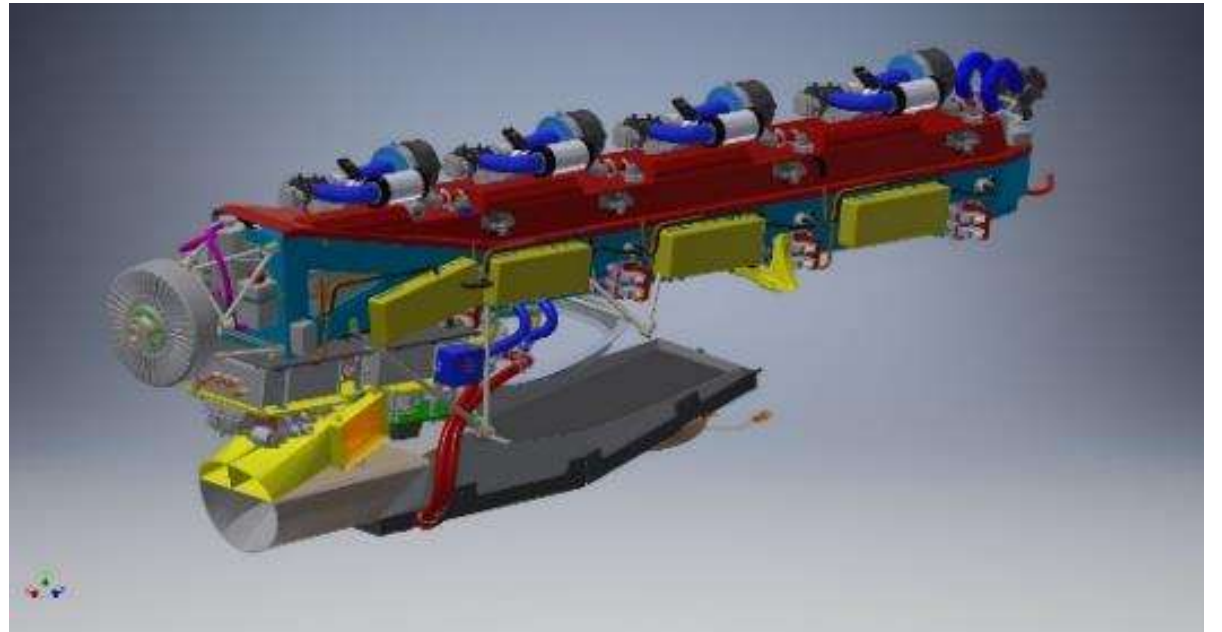


Fuel Cell Integration and Flying platform Hy4



Flying platform Hy4

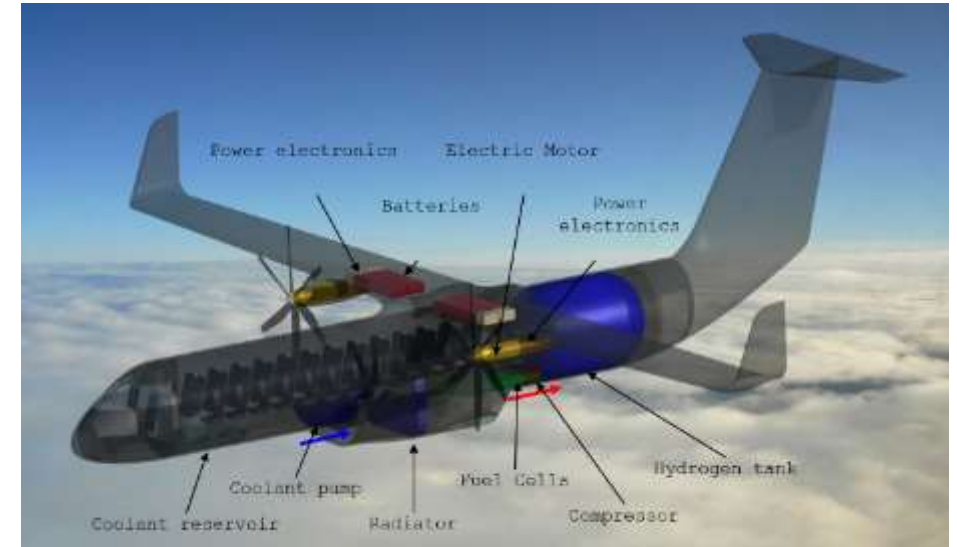
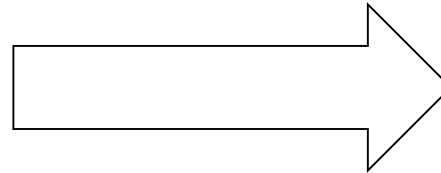
- Permit to fly from Airport Stuttgart
- 30 Take-offs and Landing



Upscaling of Fuel Cell Systems at DLR



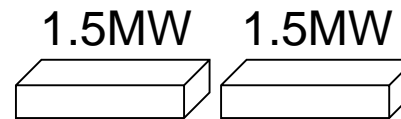
Now is the time
to scale-up



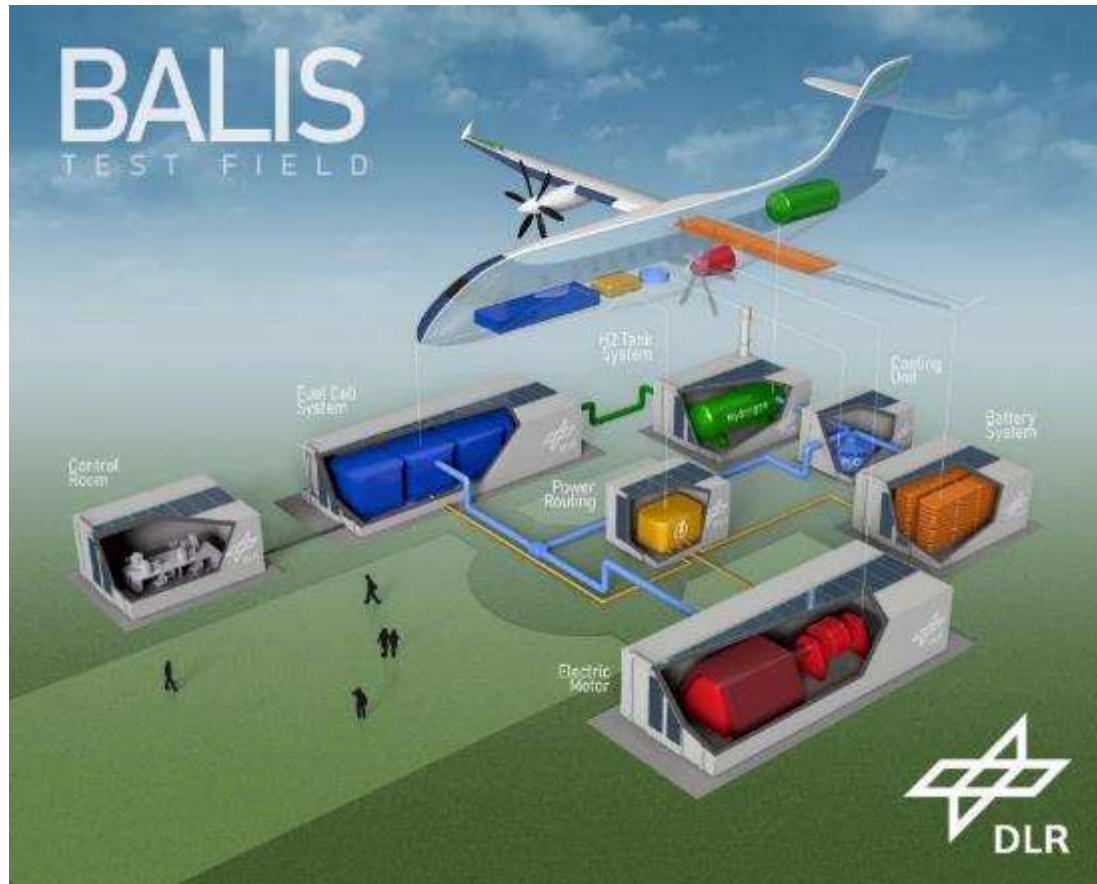
Today: 30 FC x 100kW



Future: 2 x 1,5MW



Fuel Cell System Upscaling and the BALIS test environment



- **Fuel Cell/battery hybrid powertrain with 1.5 MW power for aviation**
- Modular test environment: subsystem and powertrain testing
- Design, delivery and installation years 2020-2023
- Financial support 26 Million EUR from BMVI



Summary

- 20 years of experience in fuel cell systems development, testing and integration
- State of the art: comprehensive characterization from the cell to system level
- Challenge: upscaling fuel cell systems into the megawatt range
- Outlook: BALIS test infrastructure for fuel cell systems for aviation

