# Hydrogen-Electric Propulsion: Opportunities for Commercial Aviation

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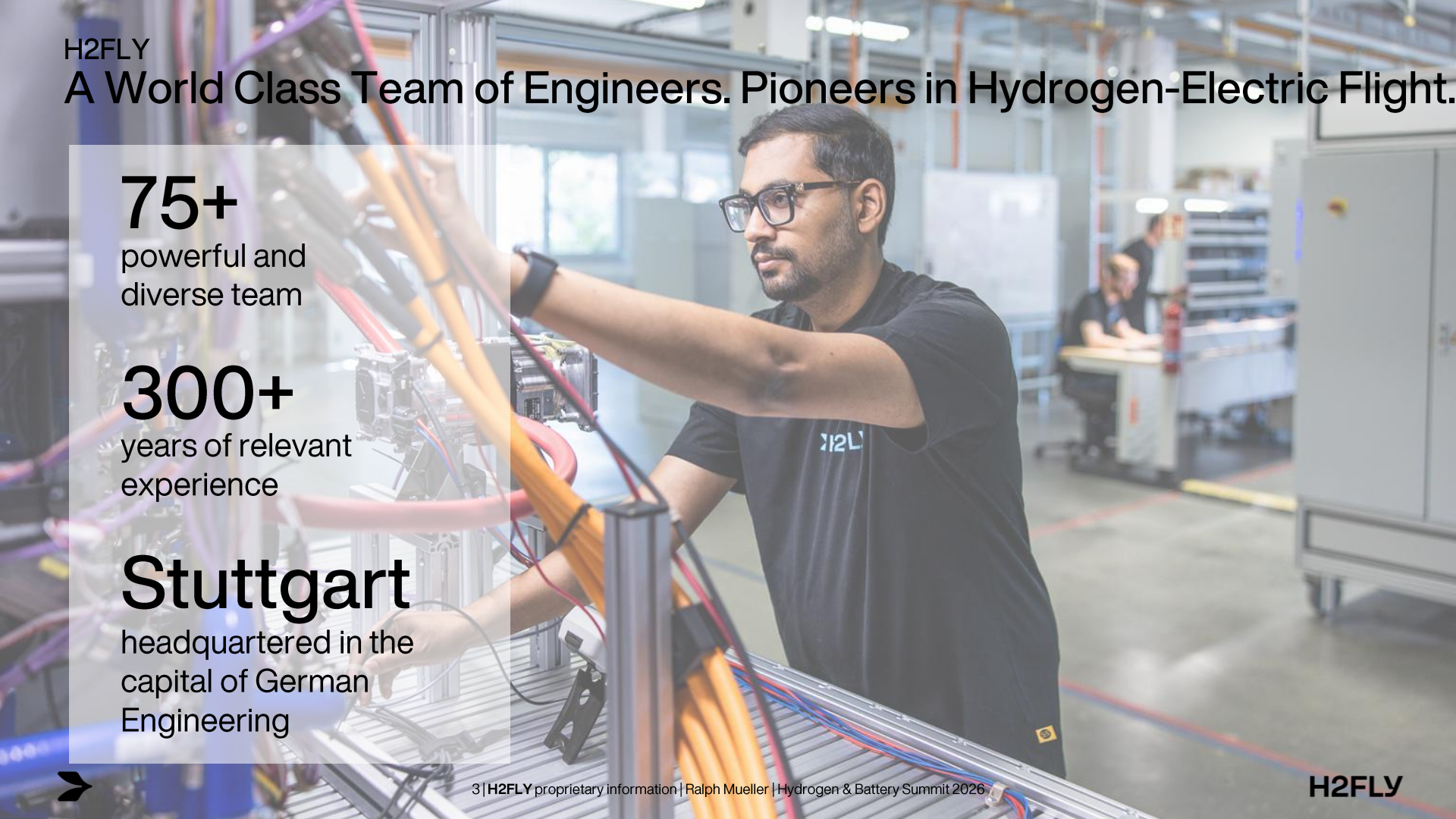
Hydrogen & Battery Summit
AERO 2026

# Introduction & recap

**H2FLY**

# A World Class Team of Engineers. Pioneers in Hydrogen-Electric Flight.



**75+**
powerful and diverse team

**300+**
years of relevant experience

**Stuttgart**
headquartered in the capital of German Engineering

H2FLY Roadmap

# Hydrogen-electric flight a reality and rapidly developing

## 2023

**World's first** piloted liquid hydrogen-electric flight

Foundation for long-range

Range: ~ 1,500 km

## 2024

**World's first** hydrogen-electric VTOL flights

Collab with Joby Aviation

Range: ~ 900 km

## 2025-2030+

- Fuel cell **specific power** and **efficiency**
- **Scale-up** systems covering 25-2000+ kW
- LH2 tanks 5-200 kg
- Integrated **prototypes**
- Ground and flight **testing**
- Certification-ready family of **components**
- **Certification process** CS-23 class aircraft

# The opportunity for commercial aviation -

- **Technology** for electrification is **ready**
- **LH2 Fuel cell** systems are **available** for testing
- Partners can **focus** on Airframes, Airports, Airspaces.

Best solution – Zero-emission aviation

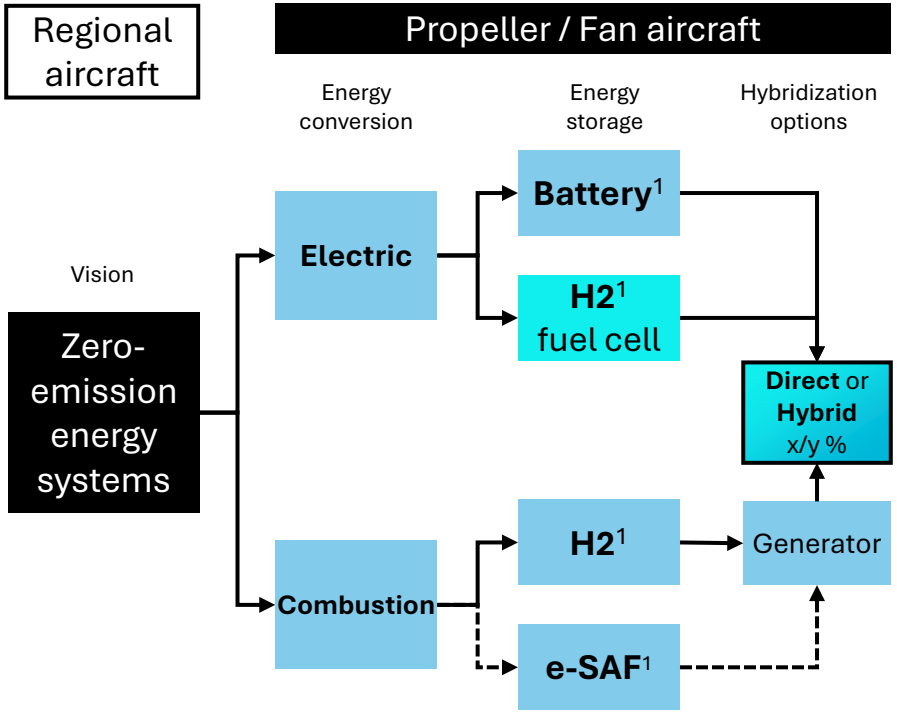
# Aircraft electrification with non-fossil fuel energy systems

**Various options** available to direct- and hybrid-electric powertrains:

- **Battery** electric
- H2 **fuel cell** electric
- H2 **combustion** with generator.

**Best solution** depend on:

- Mission
- Range
- Efficiency.



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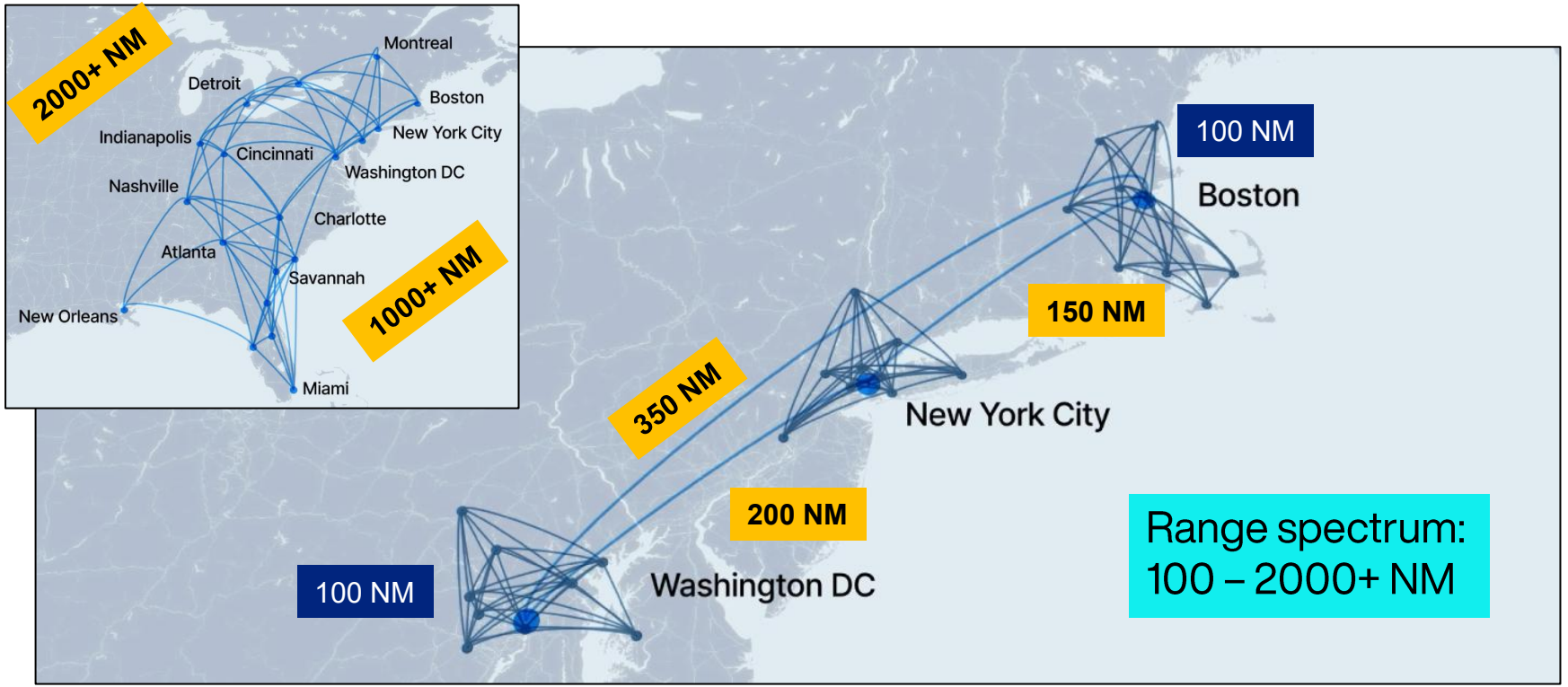
Best solution – Mission and Range

# Electric aircraft use cases have wide mission and range requirements



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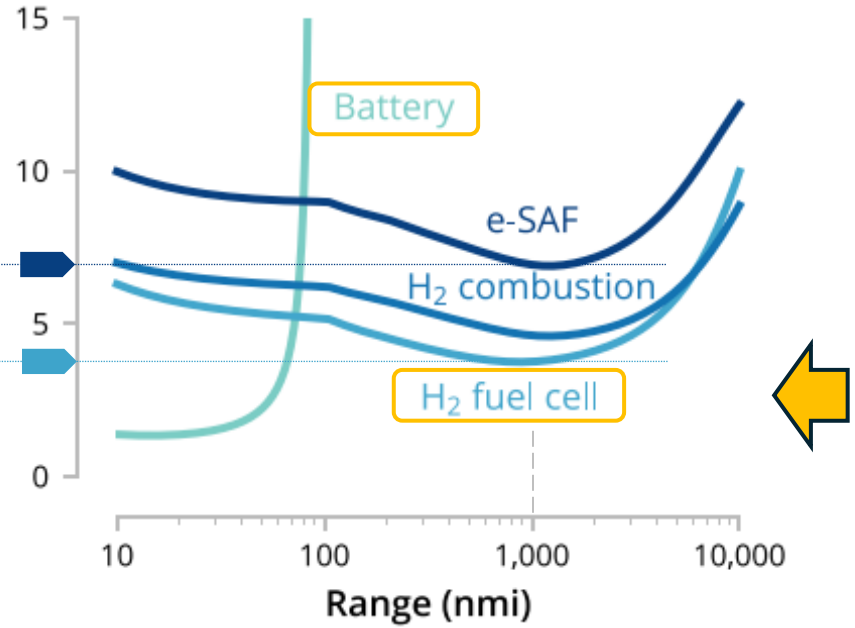
Best solution – Propulsion type

# LH2 allows higher aircraft propulsion efficiency above 100 NM range

**LH2 fuel cell** ~ **4-5 MJ** per passenger mile

**e-SAF** ~ **6-8 MJ** per passenger mile

**Propeller renewable electricity intensity at 250 kts** $\left(\frac{MJ}{pax - nmi}\right)$




**Data source:**
Eytan J. Adler and Joaquim R. R. A. Martins - Energy demand comparison for carbon-neutral flight.
*Progress in Aerospace Sciences*, 152(1):101051, January 2025; https://doi.org/10.1016/j.paerosci.2024.101051.



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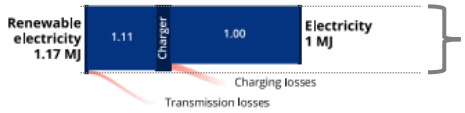
Best solution – Energy / fuel type

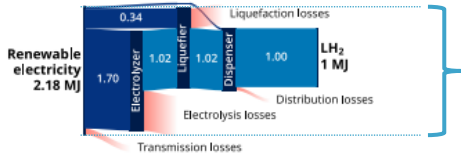
# LH2 fuel has production efficiency advantages over e-SAF




(a) Battery charging

**Li-Ion Battery**

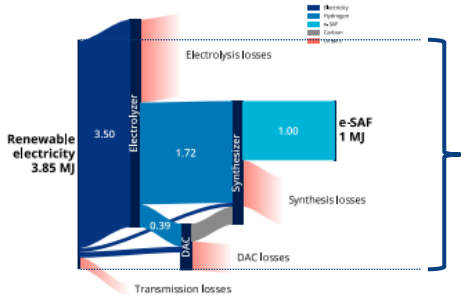
**= 85 %**
of energy to aircraft




(b) $LH_2$ production

**LH2 fuel cell**

**= 46 %**
of energy to aircraft




(c) e-SAF production

**e-SAF**

**= 26 %**
of energy to aircraft

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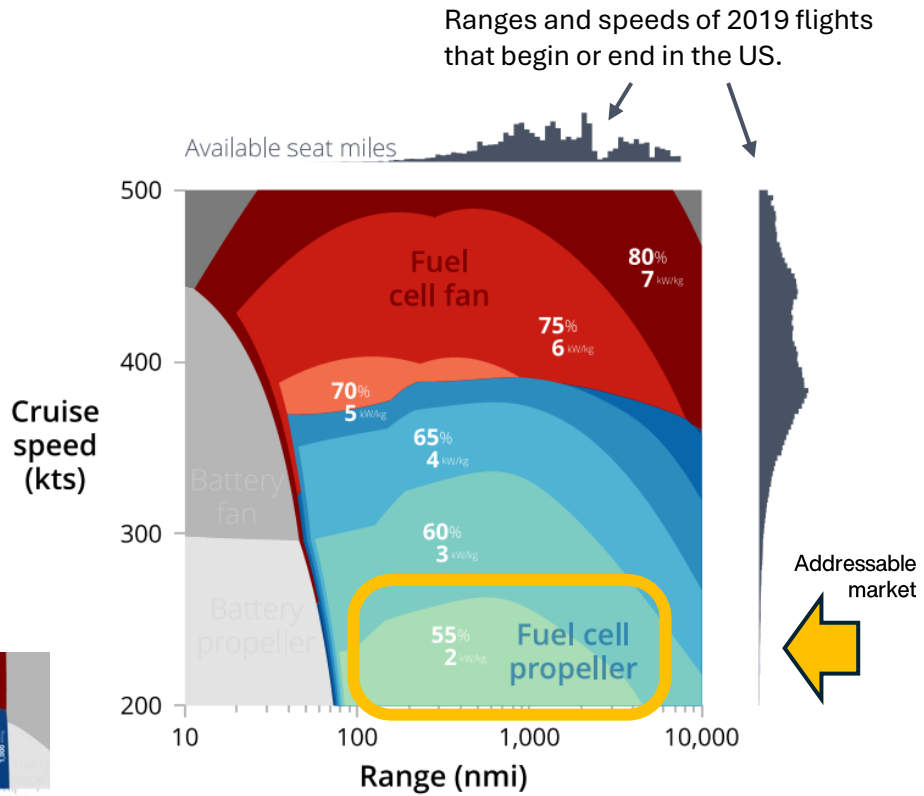
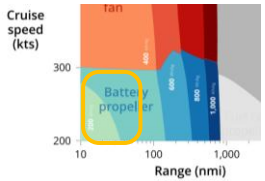
Best solution – Fuel cell tech specs

# LH2 fuel cell electric propeller aircraft capable to compete in the market

Fuel cell **specific power** and **efficiency key indicators** for market readiness:

- at **2-3 kW/kg** and **55%** capable to serve 100-2000+ NM **range**
- at **4-6 kW/kg** and **75%** efficiency above turbo fan combustion options
- Higher cruise speeds expect fuel cell **fan** propulsion.




Battery propulsion case:
400 – 1.000 Wh/kg

**Data source:**
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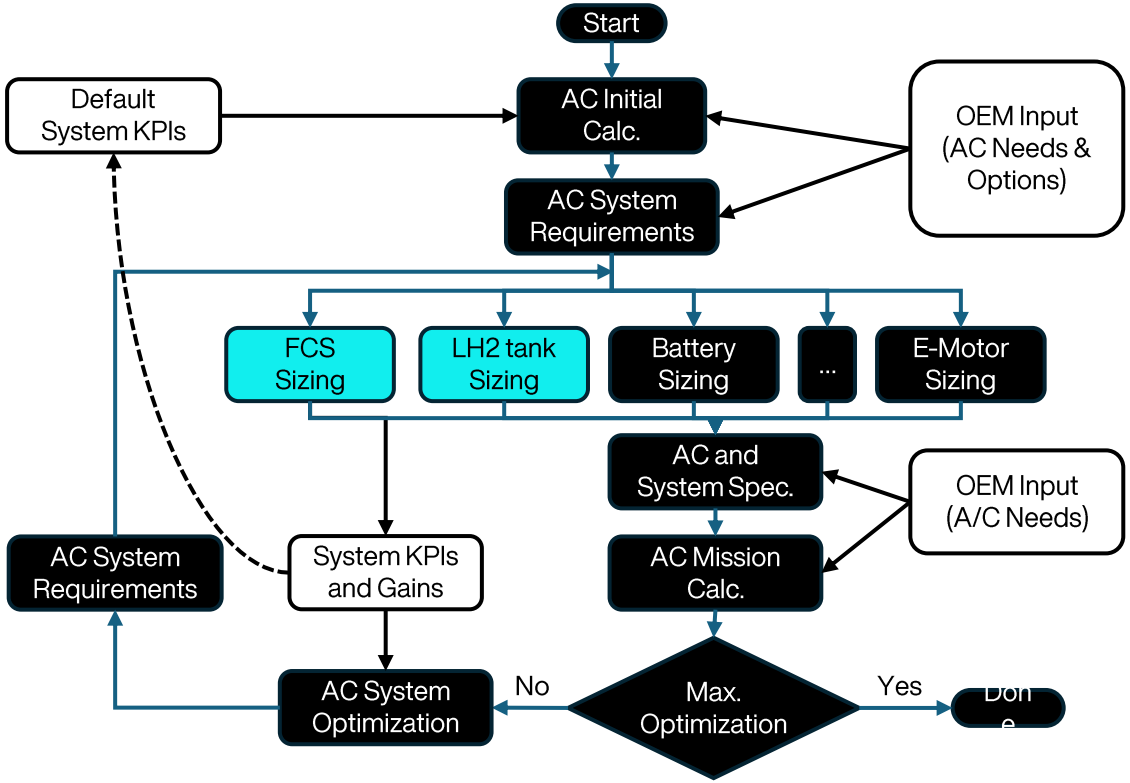
To achieve best overall performance -

# LH2 **fuel cell** energy systems need to be **tailored** to the **aircraft** & **mission**.

Best solution – LH2 HES concept development

# H2FLY aircraft level HES concept definition and design process

using H2FLY System Design Tools




- Nom. power
- nom. range
- nom. altitude
- Redundandcy,...

**OEM Input** & System Definition Level

- Detailed missions
- Emergency profiles
- A/C integration
- ConOps, ...



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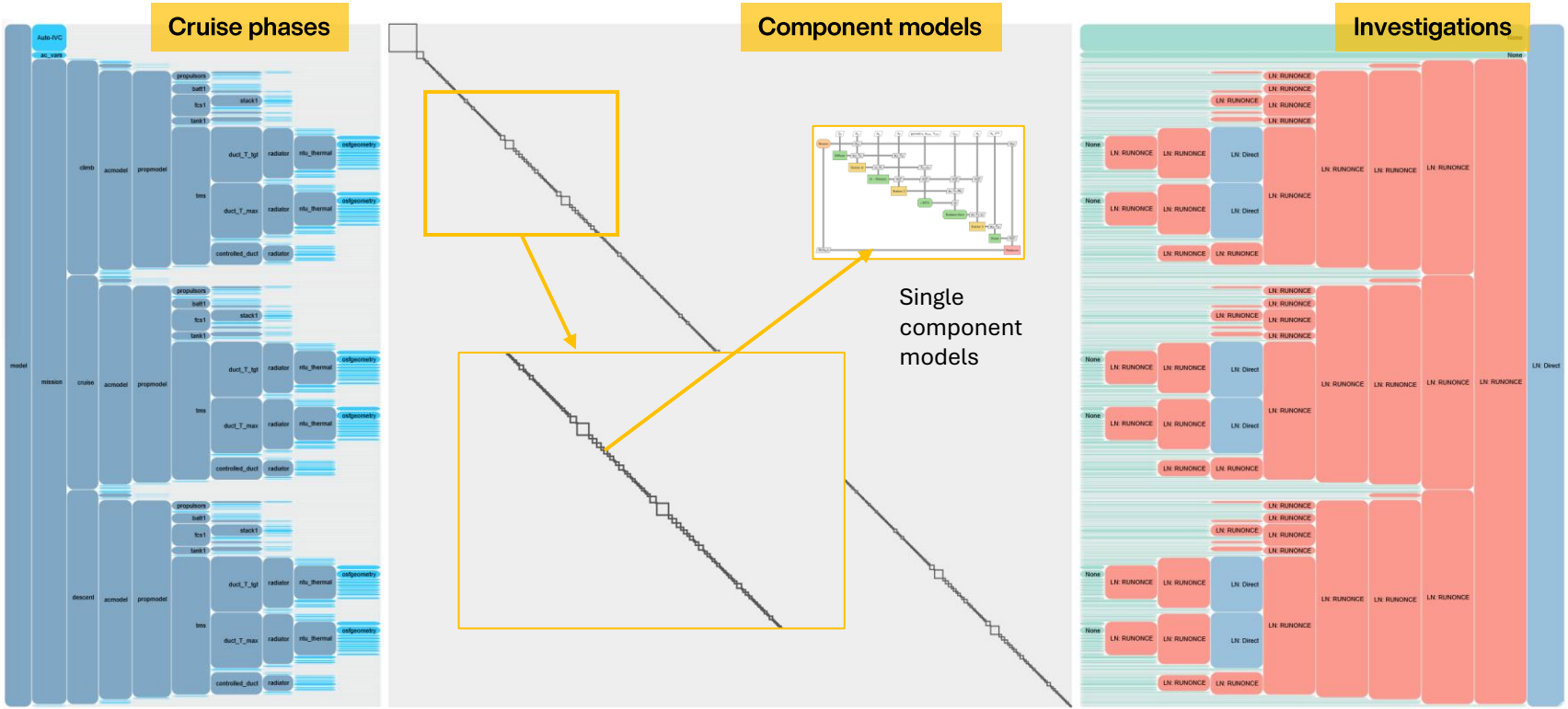
Best solution – LH2 HES concept development

# Multidisciplinary Design Analysis and Optimization of HES (HES-MDAO)

Based on real H2FLY test data validated simulation models



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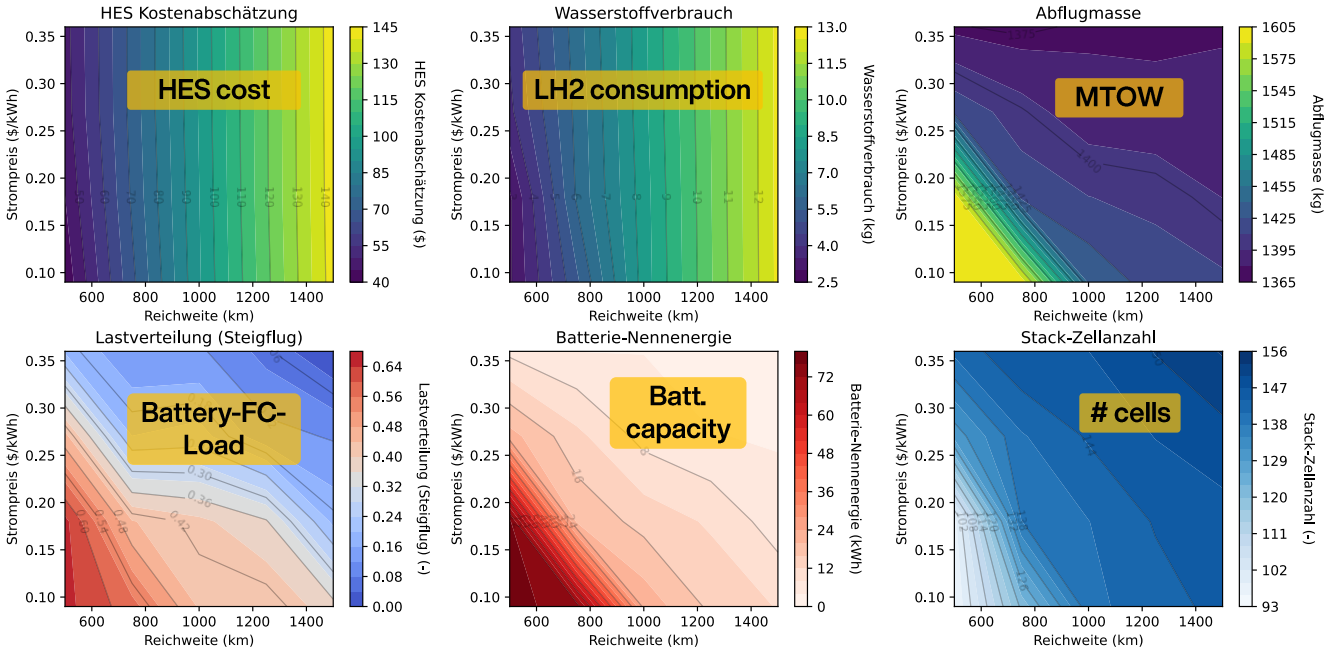
Best solution – LH2 HES concept development

# HES-MDAO: Sensitivity on Range & Electricity Cost

Based on real H2FLY test data validated simulation models




H2FLY offers specific quantification of KPIs subject to systematic optimization of HES design variables.

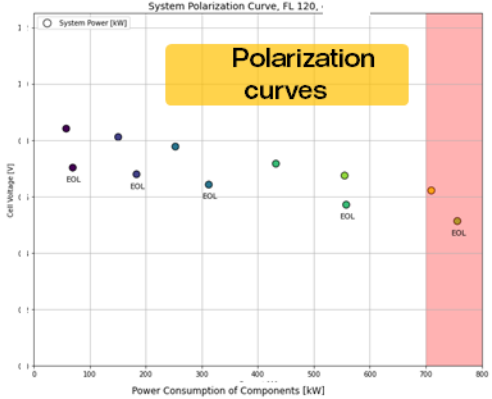


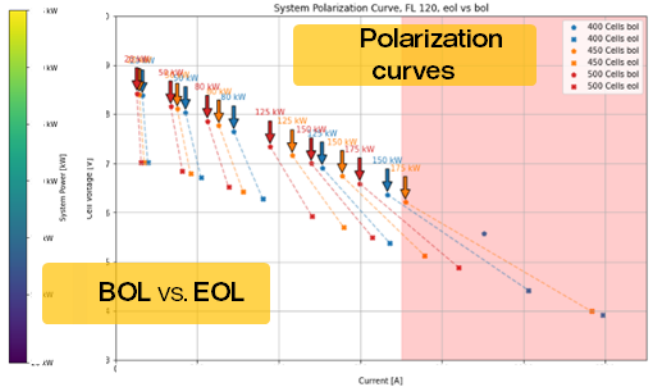
H2FLY

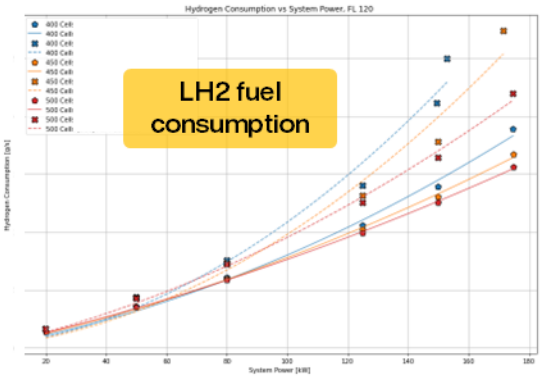
Best solution – LH2 HES concept development

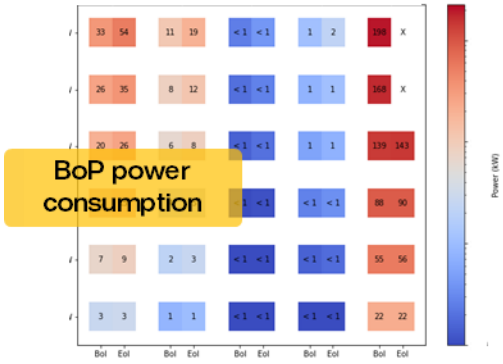
# HES-MDAO: Fuel cell & stack sizing trade-offs

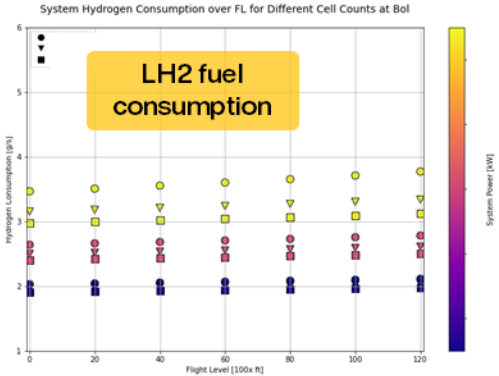
Based on real H2FLY test data validated simulation models

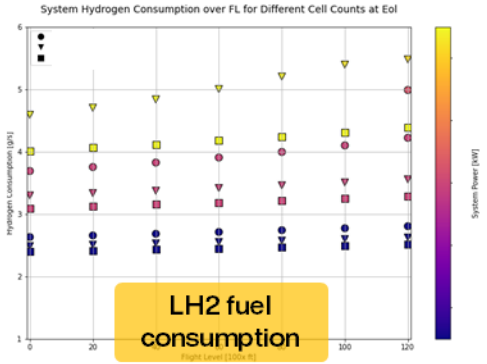


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Results

# HES-MDAO: Parameter study for eVTOL FCS design point

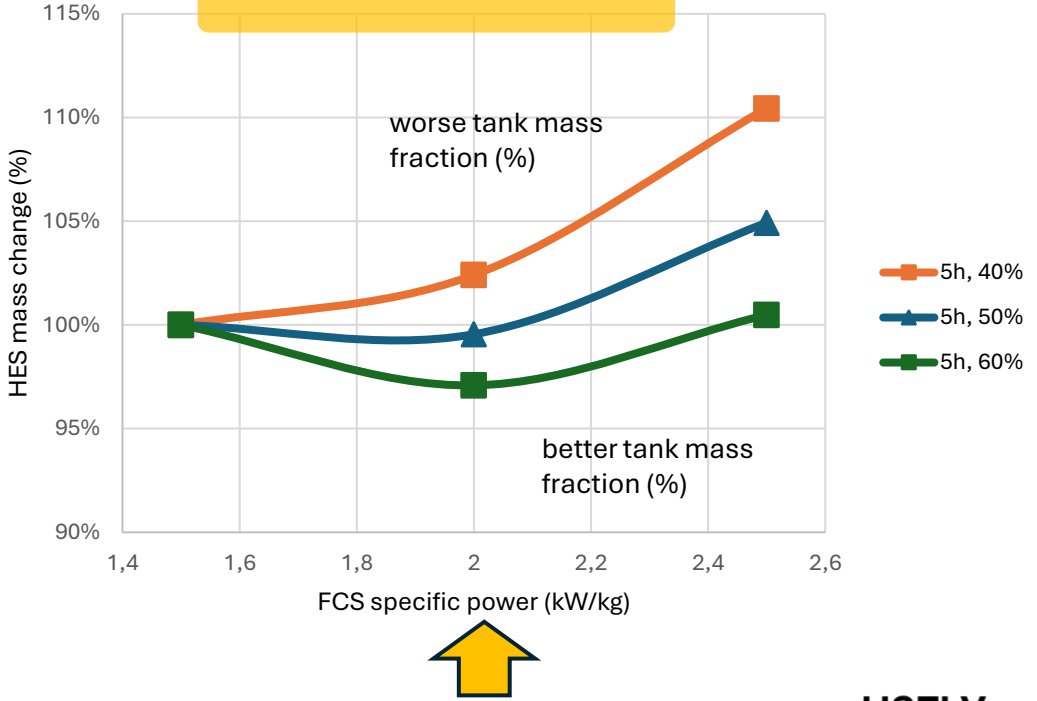
Based on real H2FLY test data validated simulation models

FCS options:

a) 2.5 kw/kg @ 35% efficiency
b) 2.0 kw/kg @ 45% efficiency
c) 1.5 kw/kg @ 55% efficiency

Sweet spot for
FCS specific energy **design point**
around ~ **2.0 kw/kg**.

**HES mass vs. FCS specific power**
for endurance and tank mass fraction



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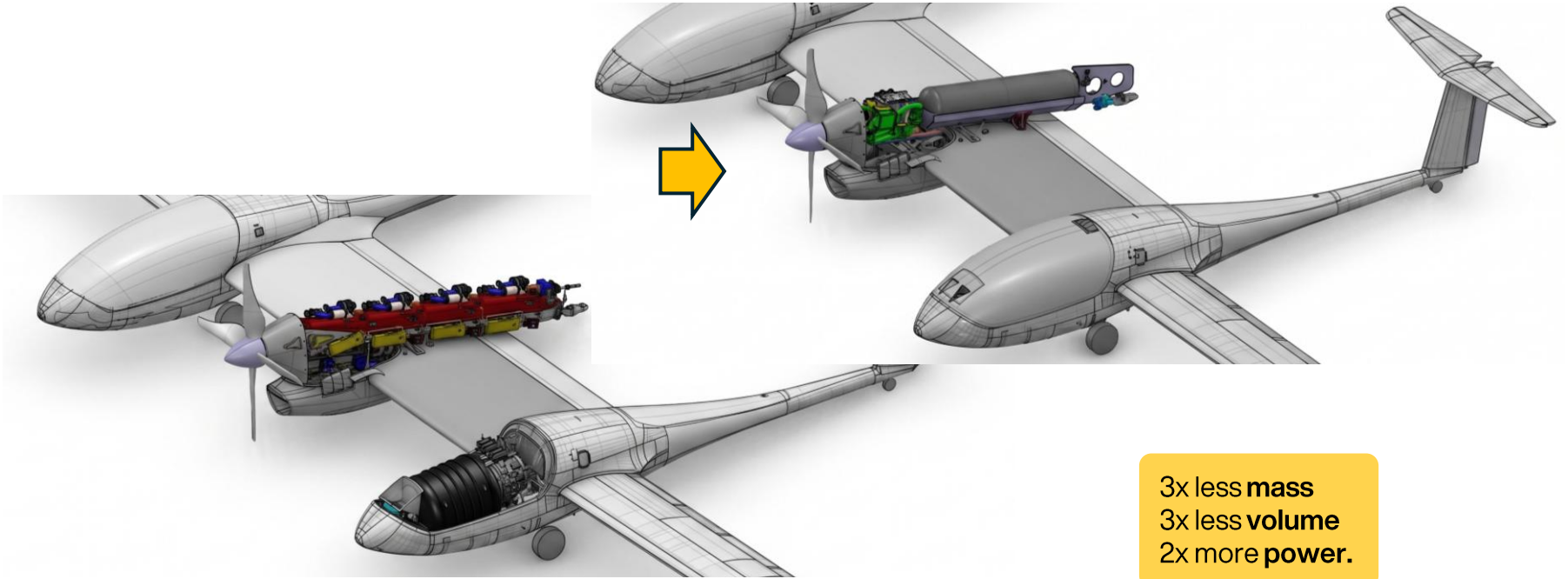
Results

# HY4 aircraft - New HES with significantly increased performance



3x less **mass**
3x less **volume**
2x more **power.**



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# Now is the opportunity for Commercial Aviation to start

- Technology for electrification is ready
- Players to focus: Airframes, Airports, Airspaces
- LH2 fuel cell systems available for testing


Electric
**Aircraft**
AAM / UAV / Regional

MRO

Verification

Production

Integration

Certification


Fuel cell systems

Prototyping

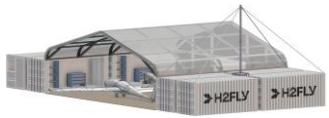
Flight Testing

Ground Testing

**Airport**
AAM / UAV / Regional

Component & HES Testing

GSE




25-2000+ kW
**Hydrogen-electric propulsion**
AAM / UAV / Regional

LH2 Supply Systems

Flight Operations

LH2 Refueling Systems

LH2 tank systems

**Airspace**
AAM / UAV / Regional



H2FLY

# Ralph Mueller
CEO

# H2FLY


For **Partners** in zero-emission aviation,

**H2FLY** supplies all it takes
to **build, integrate, test** and **operate**
hydrogen-electric aircraft.

**Contact us.**