FUTure PRopulsion and INTegration
towards a hybrid-electric 50-seat regional aircraft

Case Study on Hybrid-Electric Aircraft Designs Enabled by an Enhanced SUAVE Version

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Dominik Eisenhut, Jonas Mangold, Nicolas Moebs, Felix Brenner, Andreas Strohmayer
University of Stuttgart

FUTPRINT50

University of Stuttgart
Germany

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European Commission

Regional Aircraft – Top Level Aircraft Requirements

Top-Level Aircraft Requirements	Value
Entry into service	2035
No. of passengers	≤ 50
Maximum Range	800 km
Design Payload	5300 kg
Reduction of CO_2 emissions	≥ 75 % vs. ATR-42
Reduction of NO_x emisions	≥ 90 % vs. ATR-42
Reduction of Noise emissions	≥ 65 % vs. ATR-42

Conventional Aircraft

"unlimited" range

local emissions

Pure Battery-Electric Aircraft

severly limited range

no local emissions

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Regional Aircraft – Top Level Aircraft Requirements

Conventional Aircraft

"unlimited" range

local emissions

Pure Battery-Electric Aircraft

severly limited range

no local emissions

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Hybrid-Electric Aircraft

acceptable range

reduced local emissions

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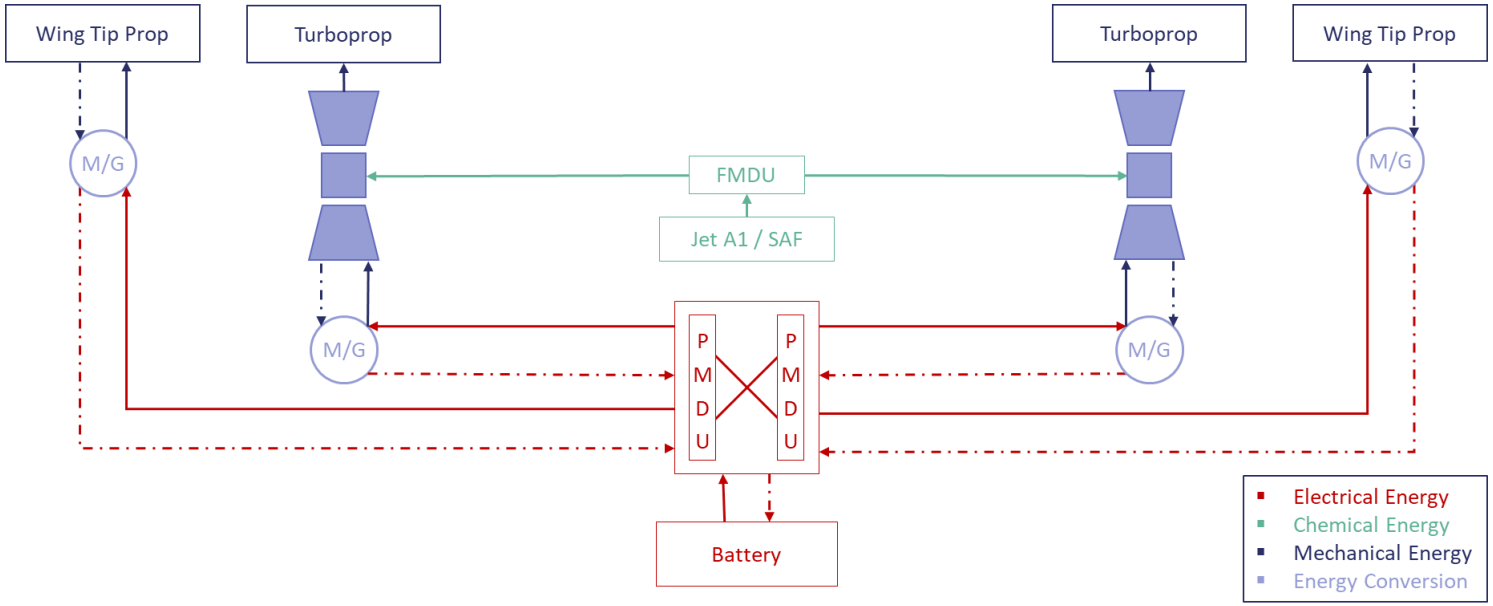
Hybrid-Electric Aircraft Architecture



EMS	Power	Energy Source
Variant 1	All electric motors at max. power during T/O, climb and cruise	Always powered by battery
Variant 2		T/O & Climb powered by battery Cruise powered by gas turbine
Variant 3		Always by gas turbine

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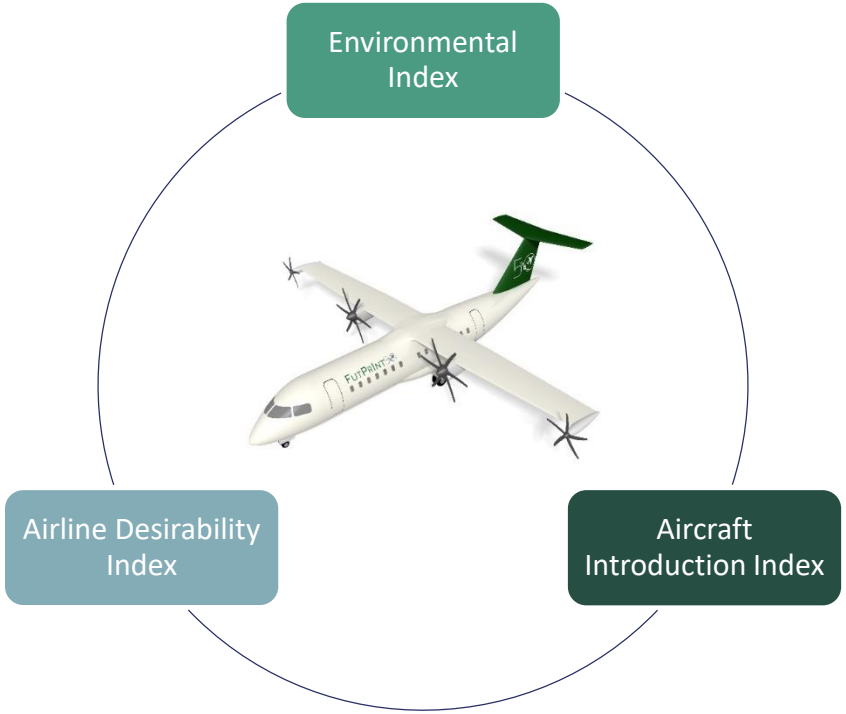
Case Study

Investigated Parameters:

- Hybridization of installed power
- Energy Management Strategies (EMS)
- Battery technology level
- Cruise speed and altitude

Figure(s) of Merit:

- Fulfillment of TLARs
- MTOM
- Performance: fuel consumption, emissions …



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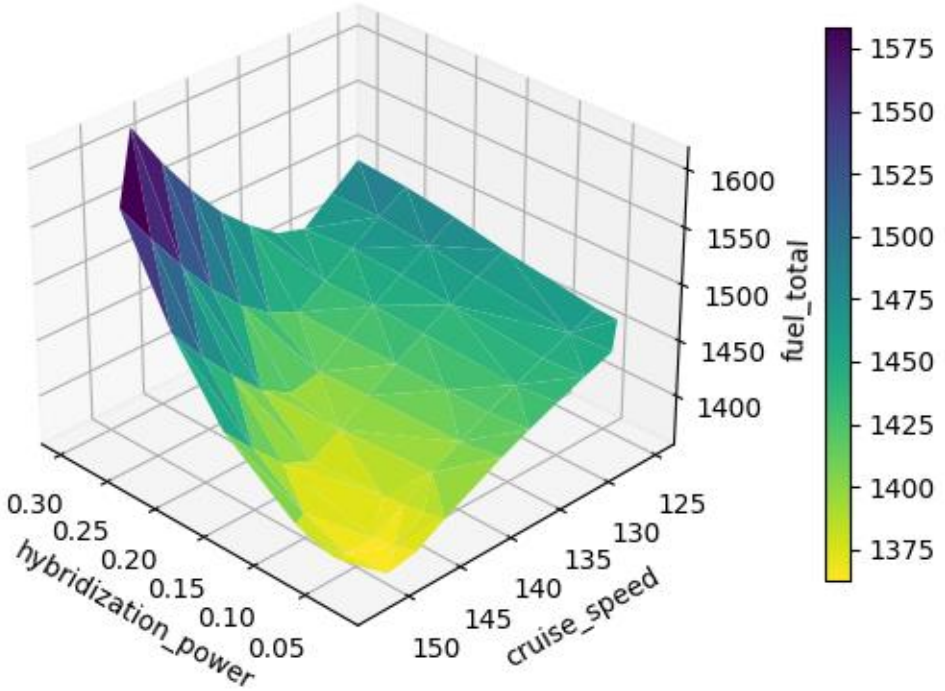
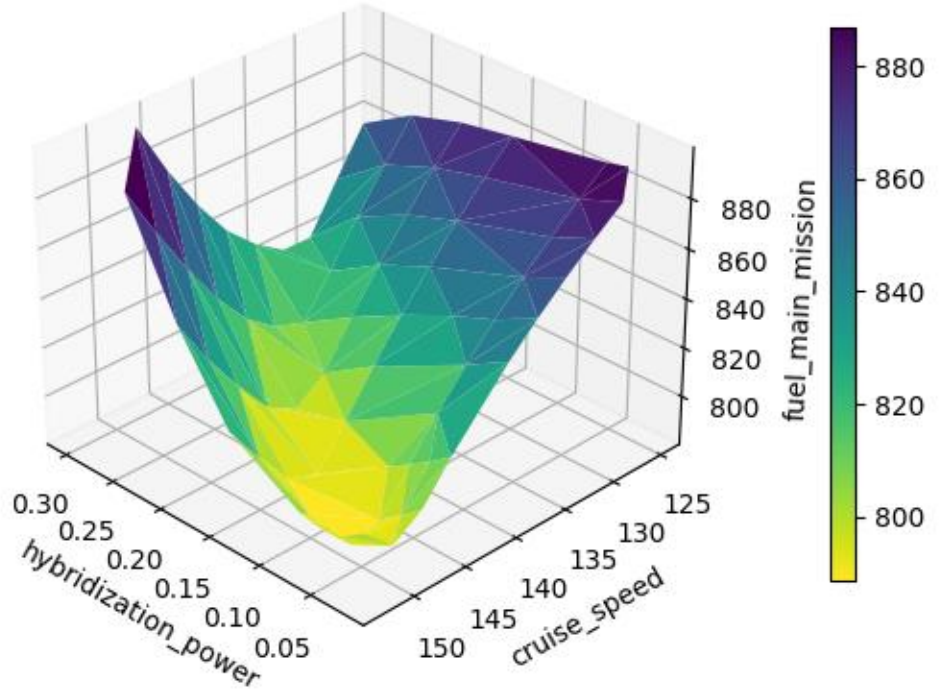
What mission to investigate?

Energy Management Strategy 2
Battery Technology + 100 %
FL 250

Total Fuel Burn



Fuel Burn Main Mission



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Results – Fuel Burn

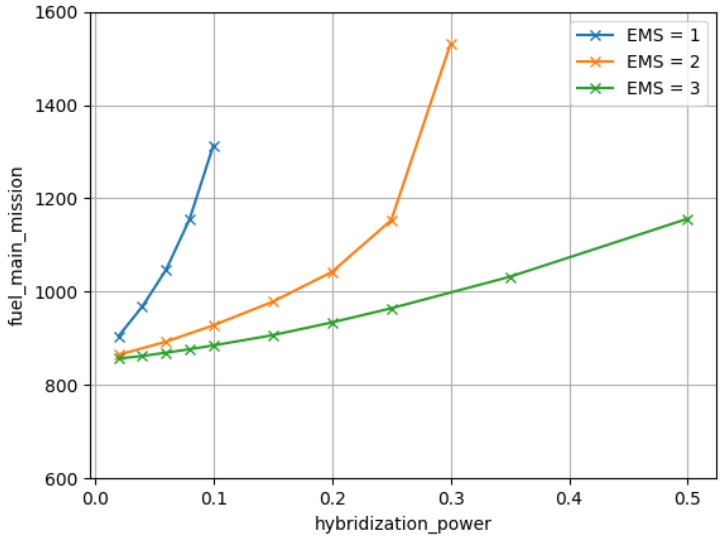
FL 250
500 km/h

Variations on:

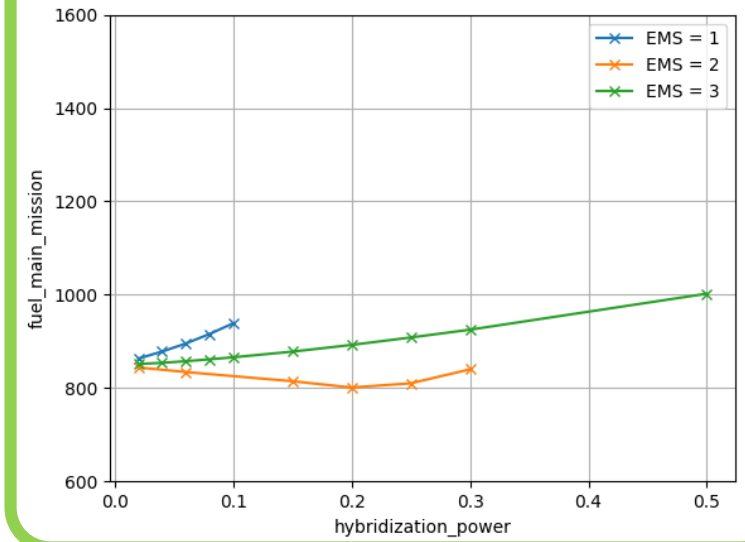
- Energy Managment Strategies (EMS)
- Hybridization of Power
- Battery Technology

EMS	Power	Energy Source
Variant 1		Always powered by battery
Variant 2	All electric motors at max. power during T/O, climb and cruise	Climb & T/O powered by battery Cruise powered by gas turbine
Variant 3		Always by gas turbine

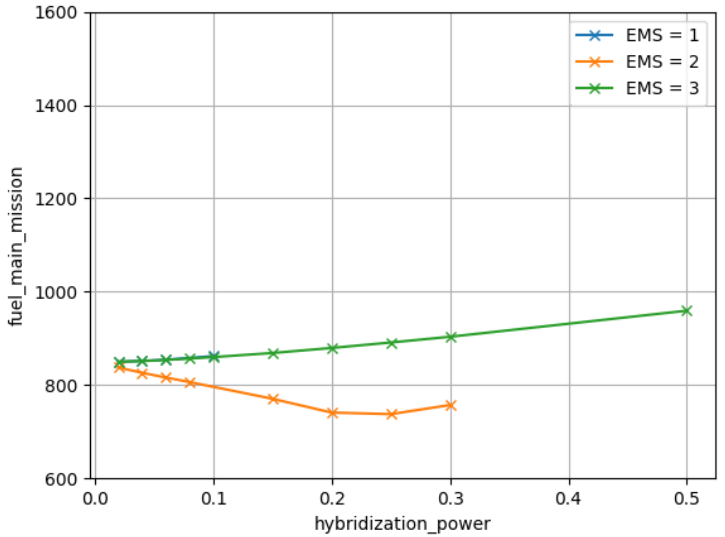
Today's Battery Technology



+ 100 % Improvement



+ 200 % Improvement



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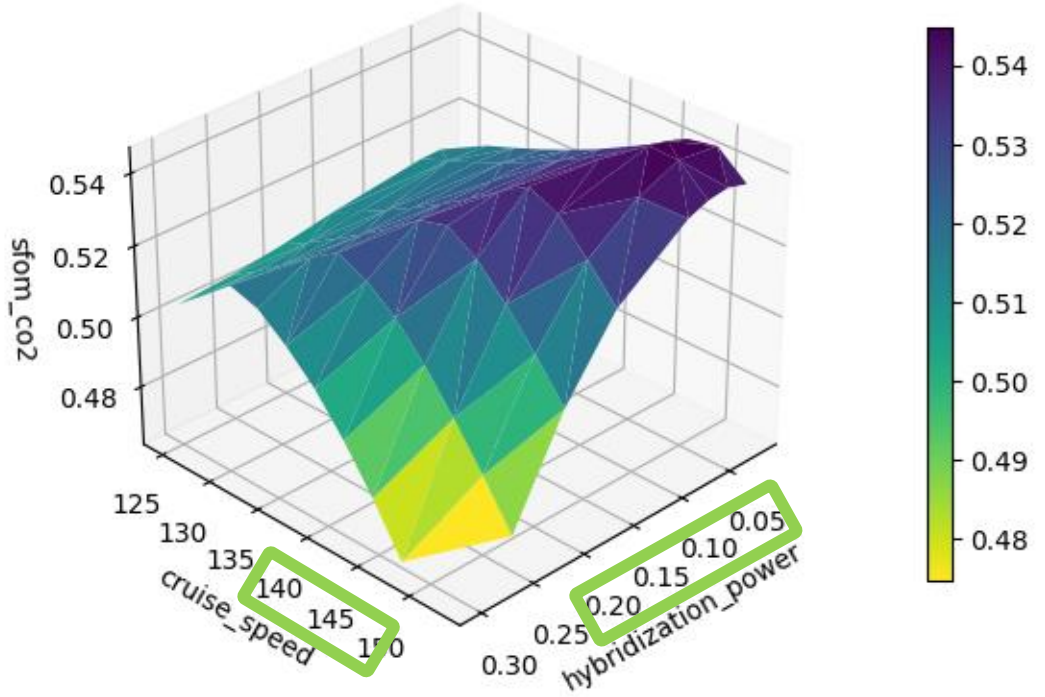
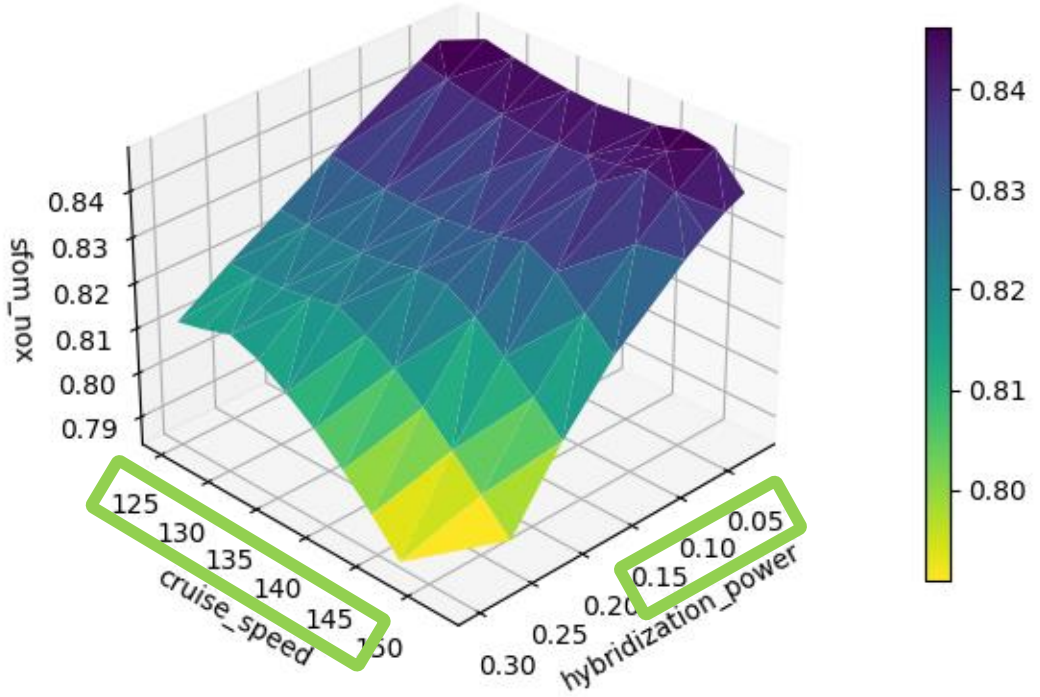
Results – Global Warming Potential

Energy Management Strategy 2
Battery Technology + 100 %
FL 250

CO_2 Global Warming Potential



NO_x Global Warming Potential



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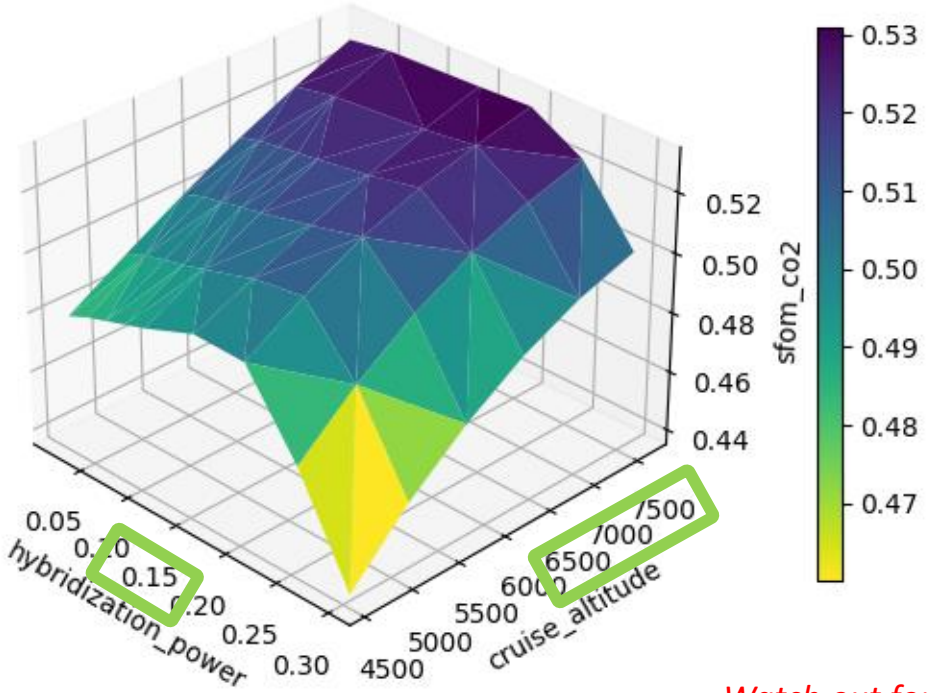
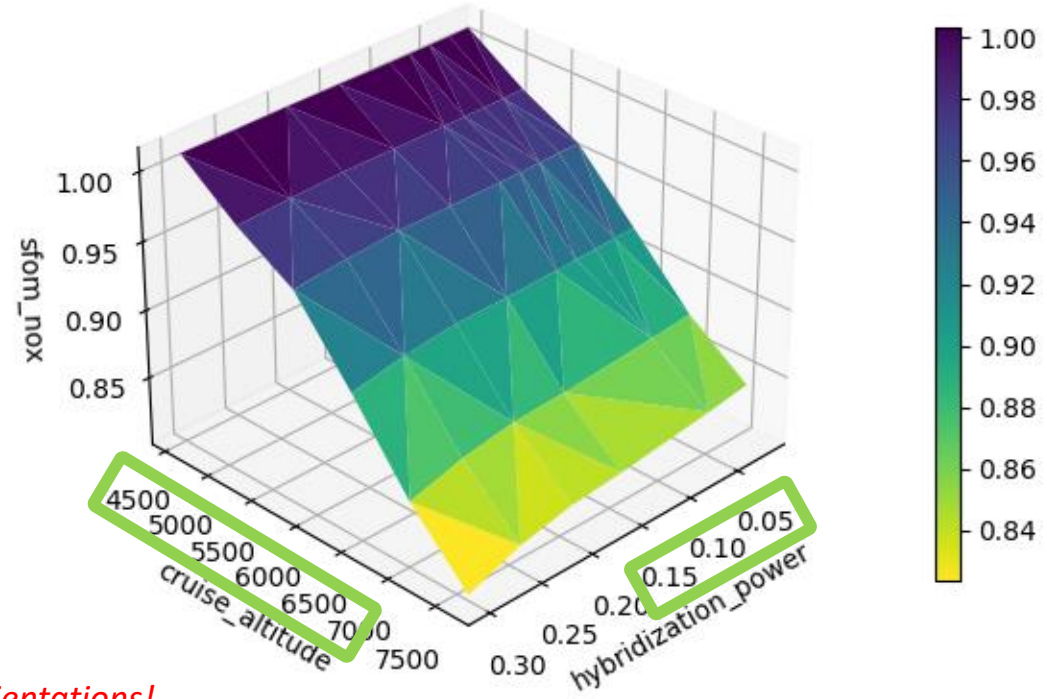
Results – Global Warming Potential

Energy Management Strategy 2
Battery Technology + 100 %
500 km/h

CO_2 Global Warming Potential



NO_x Global Warming Potential



Watch out for axis orientations!

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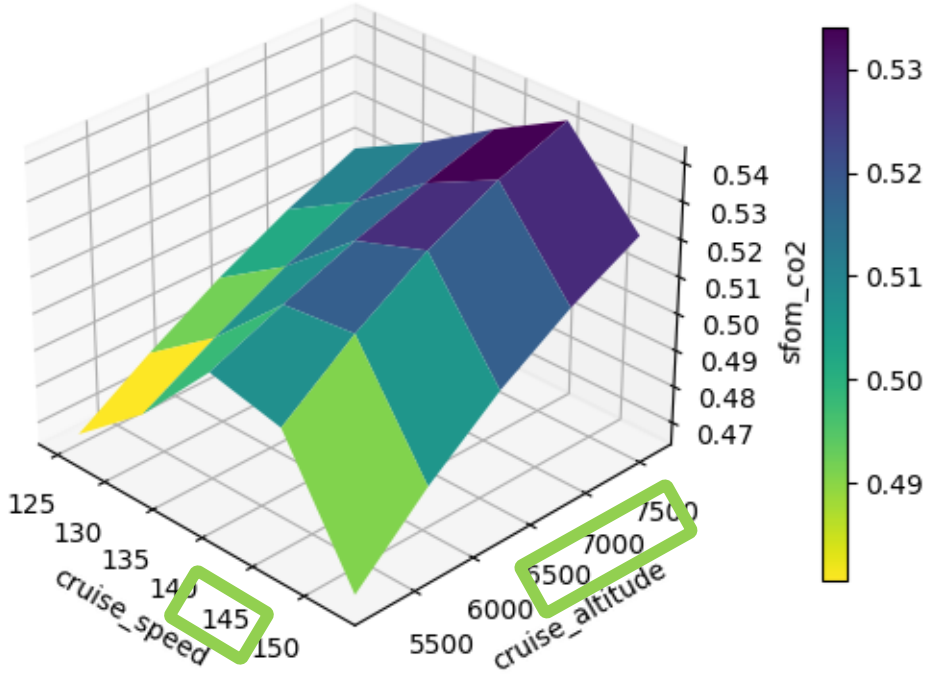
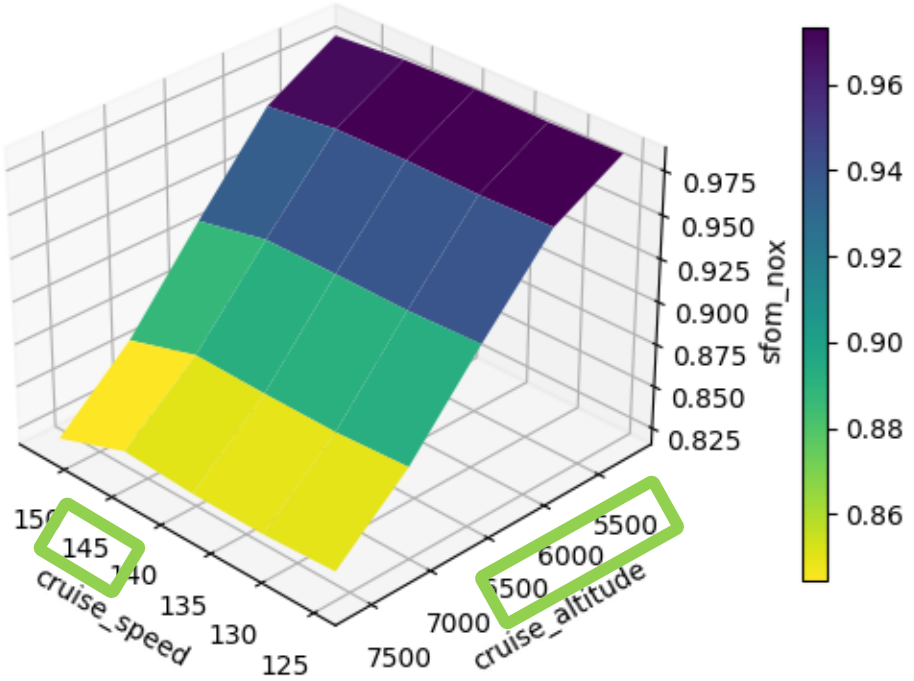
Results – Global Warming Potential

Energy Management Strategy 2
Battery Technology + 100 %
H_P 15 %

CO_2 Global Warming Potential



NO_x Global Warming Potential



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“Optimal Design”

Key Facts		
MTOM	22800	kg
Hybridization of power	15	%
Cruise speed	525	km/h
Cruise altitude	21000	ft
Overall installed power	4300	kW
Fuel burn main mission	830	kg
Battery mass	1600	kg
Specific energy	337	Wh/kg
Specific power	465	W/kg
Mean L/D in cruise	14.8	-

→ Additional EMS and/or change in aircraft architecture

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Next Steps …

- Implement enhanced analyses models to capture (sub-)system interactions
  - e.g. electric motor and thermal management system
  - e.g. battery SoH and influence on aircraft mass/emissions
  - e.g. flight trajectory and energy harvesting
- Improve convergence, figure of merit, …
- Perform additional case studies on different aircraft and subsystem parameters

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FUTPRINT50

Greening tomorrow's aviation

through disruptive aircraft electrification technologies & international collaboration

eisenhut@ifb.uni-stuttgart.de

www.ifb.uni-stuttgart.de

Pfaffenwaldring 31, 70569 Stuttgart, Germany

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