



Hybrid-elektrische Antriebssysteme für Luftfahrzeuge und synthetischer Kraftstoff

Dr. Frank Anton, Siemens AG eAircraft
Brandenburger Energietag 2019, Cottbus, 24. Mai 2019

We develop hybrid electric propulsion systems for aircraft



Enabler to reduce total cost of ownership and environmental impact:

Hybrid electric propulsion



Useful range

Separation of power generation and thrust generation



Decreased fuel flow & emission



Silent propulsion

Distributed propulsion



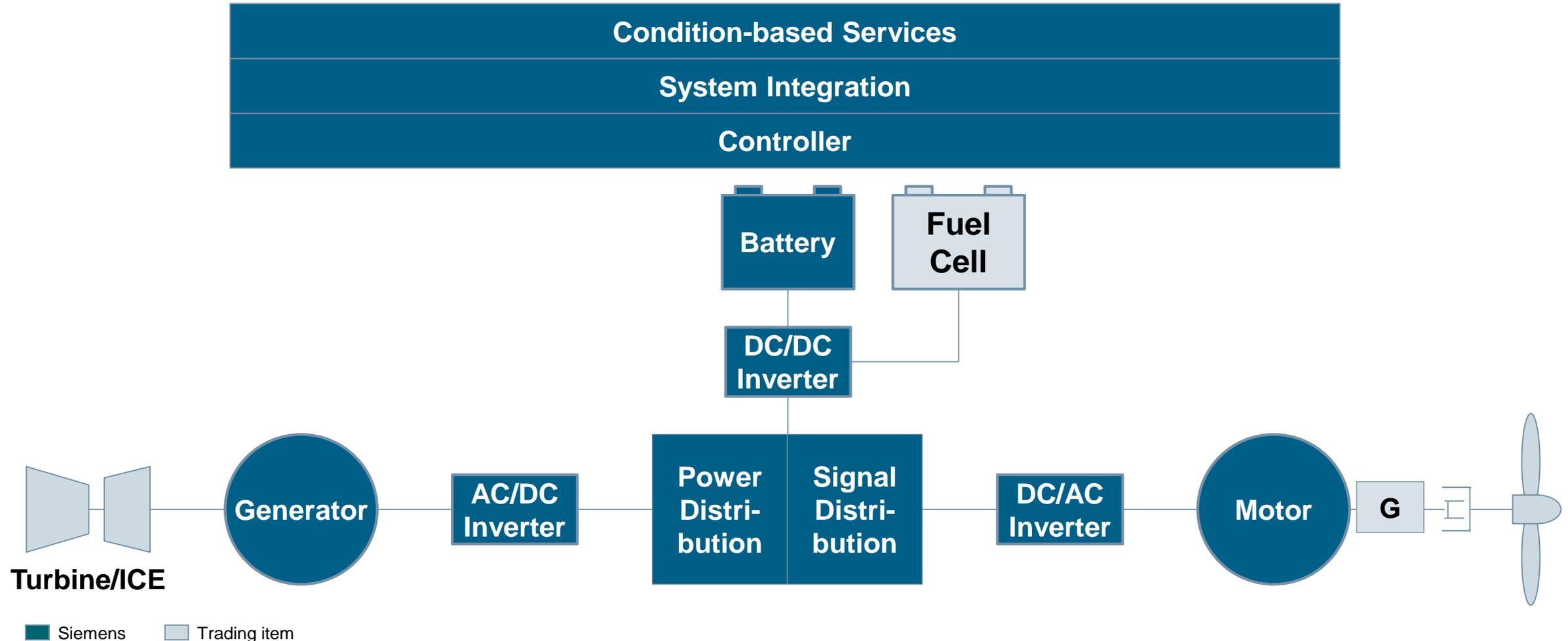
Increased aerodynamic efficiency

Vectorized thrust



eSTOL, eVTOL

Our core portfolio – electric propulsion units (EPU) for applications with high power/weight requirements



Extra 330LE

FAI Official World Record Flights at Dinslaken Schwarze Heide Airfield

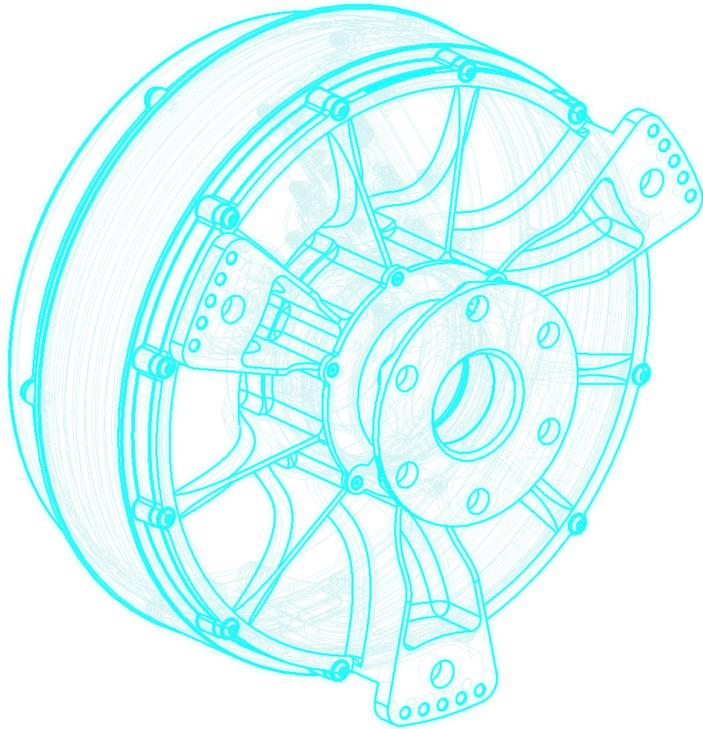
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**November 25th, 2016: FAI time to climb world record
eAircraft 500...1000 kg
3000 m in 4 min 22 sec
Pilot: Walter Extra**



**March 23rd, 2017: FAI speed world record
337.5 km/h (eAircraft <1000 kg)
Pilot: Walter Extra
342.8 km/h (eAircraft >1000 kg)
Pilot: Walter Kampsmann**

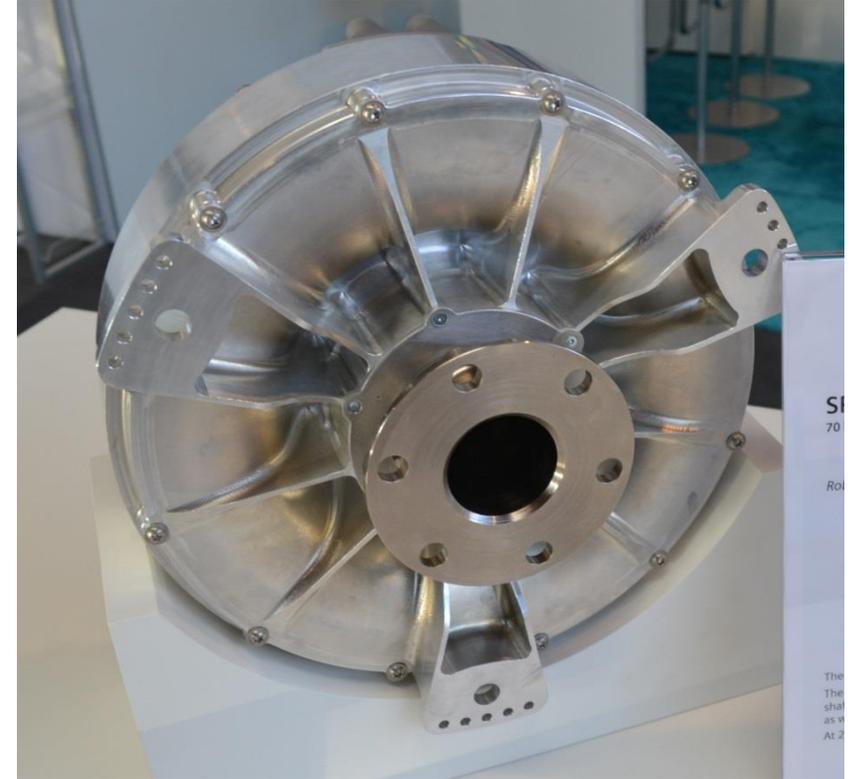
Digitl Twin: From concept to real-world object



Virtual concept



Virtual product



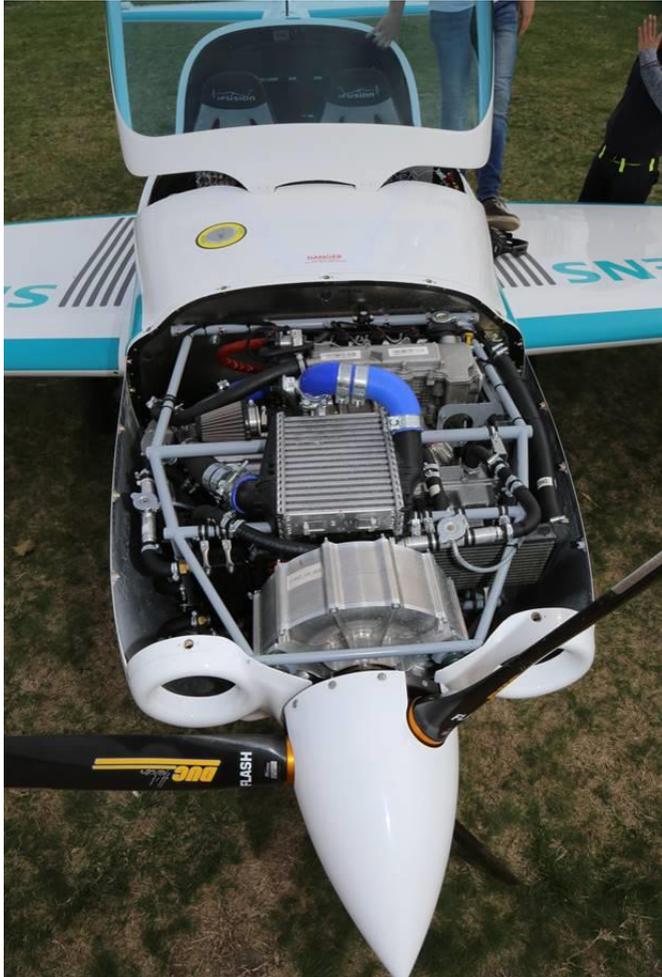
Real product

**eFusion - more than 300 emission free flight hours.
Diverse technologies on several test platforms in flight testing.**

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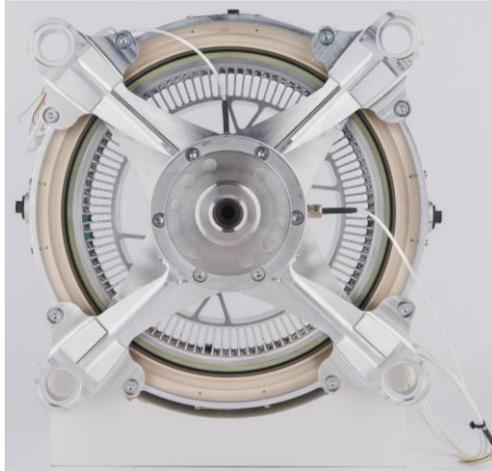


Maiden flight – hybrid-electric eFusion April 2018



SP260D & SP260D-A

Driving Power Density



SP260D-0

Direct Drive Permanent Magnet
MTOP 260 kW @ 2500 RPM
Torque 977 Nm
UDC 580 V
Oil cooled @ 90 °C
Efficiency 95%

50 kg
5.2 kW/kg

Weight
Power Density

SP260D-A

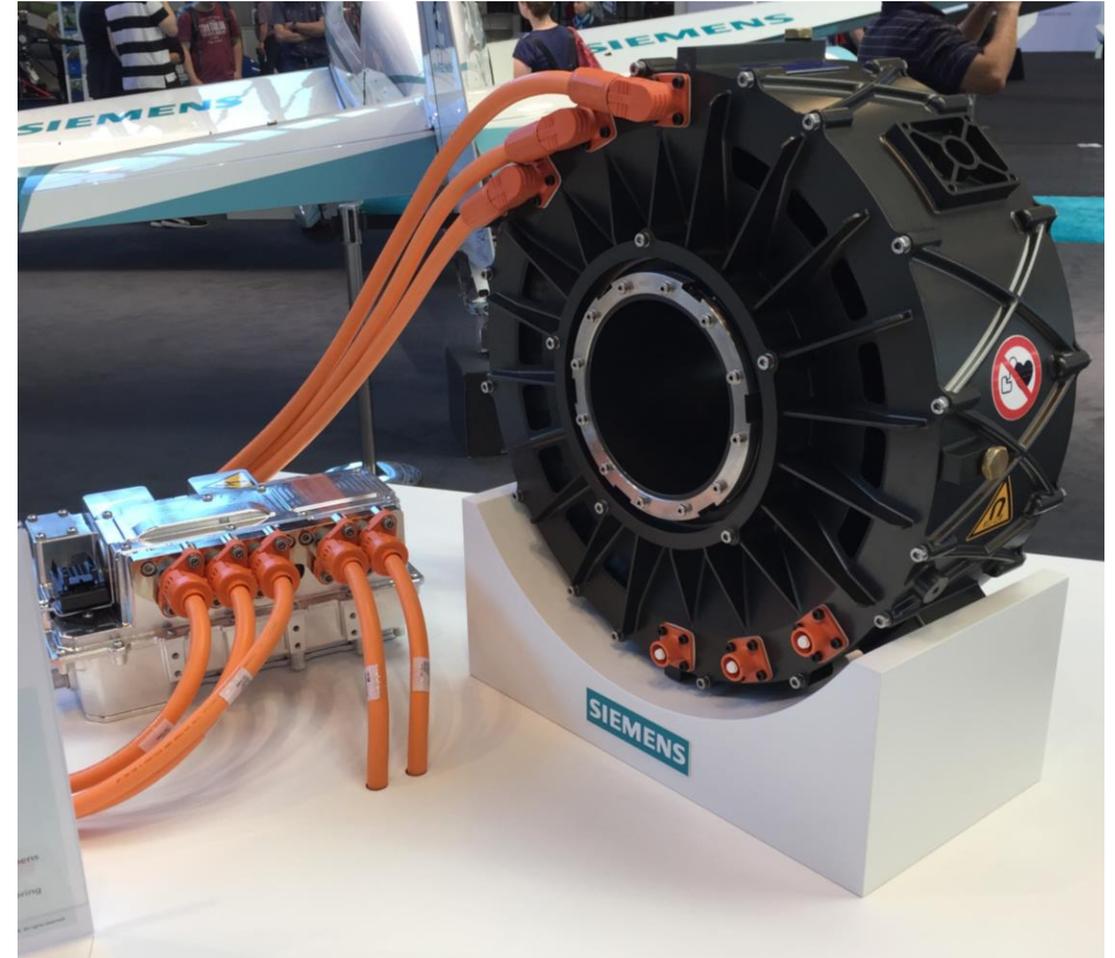
44kg
5.9 kW/kg

Developed for maximal Power Density
Redundant 3 Phase Windings

Implemented in Extra 330LE

Achievements:

- Electric Aircraft Speed Records
- Electric Aircraft Climbing Records
- First All-Electric Glider Towing



SP200D

Driving Torque Density



SP200D

Direct Drive Permanent Magnet

$P_{\max, \text{cont}} = P_{\max, 5\text{min}} = 204 \text{ kW}$

$N_{\text{cont}} = N_{\max} = 1300 \text{ RPM}$

$M_{\text{cont}} = M_{\max} = 1500 \text{ Nm}$

UDC 450 - 850 V

Oil cooled *Syltherm 800*

Weight 49 kg

Record Torque Density 30 Nm/kg

Designed for high-torque low-speed requirements.

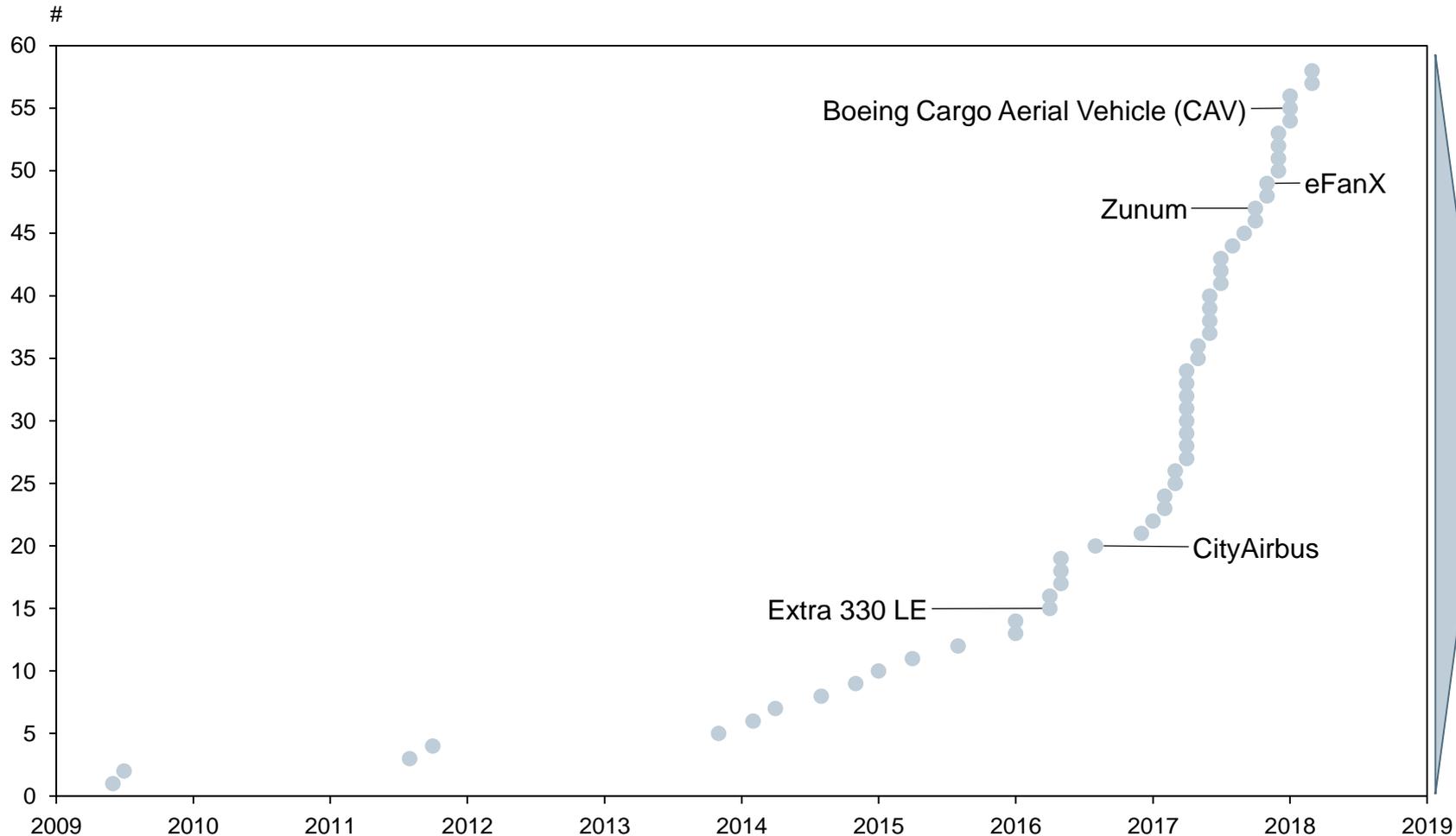
Allows for slow rotating propellers, hence low noise.

Currently under lab test



Industry activity in hybrid-electric aviation rapidly increasing

Number of (hybrid-)electric projects announced (cumulative)



Significant invests developing

- Explosion of announced projects in 2017
- Significant funding of startup companies, e.g.
 - Lilium (90' EUR, 2017)
 - Volocopter (31' EUR, 2017)
 - Joby Aviation (100' EUR, 2018)
- Growing investment activity of incumbents, e.g. Boeing (Aurora Flight Sciences and Zunum) or Geely (Terrafugia)



Diamond Aircraft and Siemens: Successful Maiden Flight of world's first Serial Hybrid-Electric Twin Engine Plane



- Distributed propulsion:
- Two electrically driven free-stream propellers
 - One electrical generator driven by a jet fuel piston engine
 - Battery



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Gefördert durch:



Bundesministerium
für Wirtschaft
und Energie

aufgrund eines Beschlusses
des Deutschen Bundestages

Diamond Aircraft and Siemens: Successful Maiden Flight of world's first Serial Hybrid-Electric Twin Engine Plane

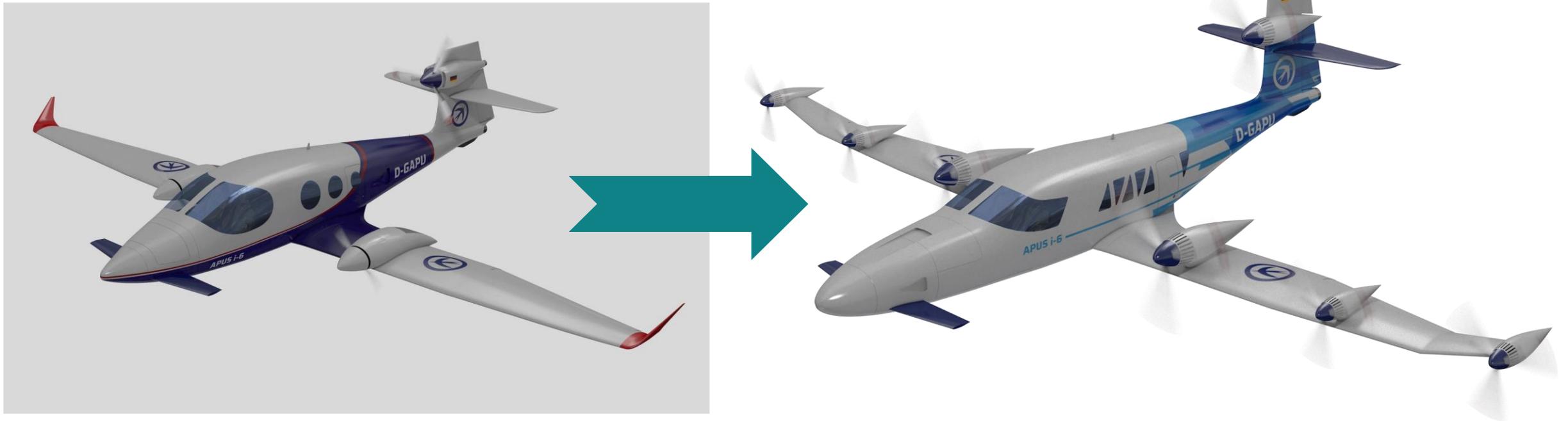


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 - Battery



Distributed Electric Propulsion: The IBEFA consortium is investigating the feasibility of a Seven-Propeller Hybrid-Electric Low-Noise General Aviation Plane.

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Specifications

Continuous Power	200 – 450	kW
MOTM	1990	Kg
Wingspan	10 – 18	m
Flight time	4 – 8	h
Range	1800 – 2300	km
Cruise Speed	400 – 450	Km/h



**Distributed Electric Propulsion:
The IBEFA consortium is investigating the feasibility of
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Distributed Electric Propulsion: The IBEFA consortium is investigating the feasibility of a Seven-Propeller Hybrid-Electric Low-Noise General Aviation Plane.



IBEFA „Innovationsbündnis für emissionsarme Flugzeugantriebe“,
im Rahmen der Antragstellung der Berlin-Brandenburg Aerospace Allianz
im Förderprogramm „Wandel durch Innovation in der Region“ (WIR!) des BMBF entstanden.



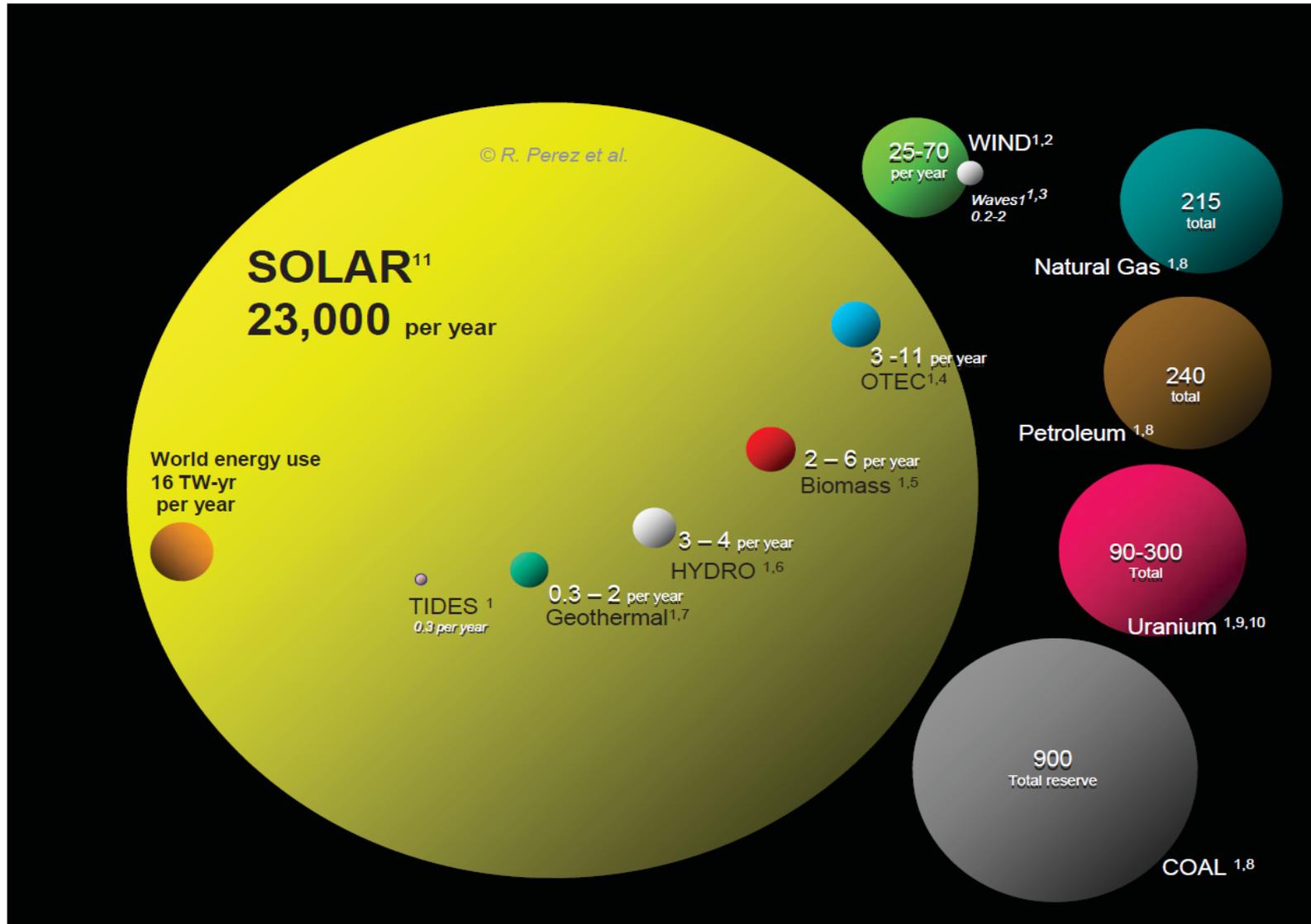
Partner:
Apus Aeronautical Engineering GmbH
Aquila Aviation International GmbH
Rolls-Royce Deutschland Ltd & Co KG
Siemens Aktiengesellschaft
Reiner Stemme Aero GmbH
Flugplatz Schönhagen GmbH
Flugplatz Strausberg GmbH
TU Berlin
BTU Cottbus
TH Wildau
Hasso Plattner Institut
LoI des DLR

Power – to – Green Fuel:

Renewable Energy

- **H₂ Electrolyzer**
- **CO Electrolyzer**
- **Green Fuels**

**Power to Green Fuel:
Renewable Energy → H2 Electrolyzer → CO Electrolyzer → Green Fuels**

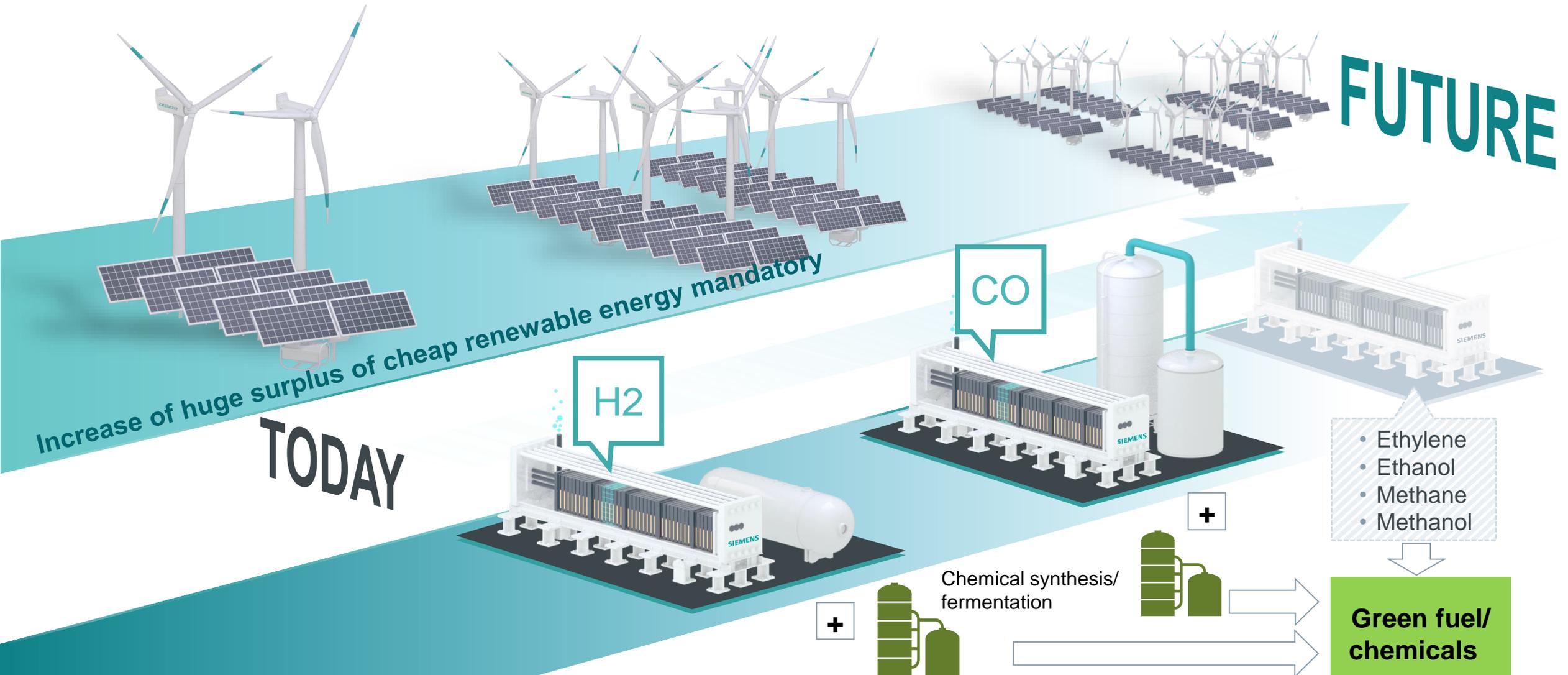


The Planetary
Use and Inflow [TeraWatt]
and
Reserves [TeraWatt-Years]
of Energy

Source: <http://asrc.albany.edu/people/faculty/perez/Kit/pdf/a-fundamental-look-at%20the-planetary-energy-reserves.pdf>

Power to Green Fuel: Renewable Energy → H2 Electrolyzer → CO Electrolyzer → Green Fuels

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Single step synthesis concept: Siemens PEM electrolyzer Silyzer 200 – facts and figures

5 MW

World's largest operating
PEM electrolysis system in
Hamburg, Germany

60 kWh

Specific energy
consumption for 1 kg
hydrogen

20 kg

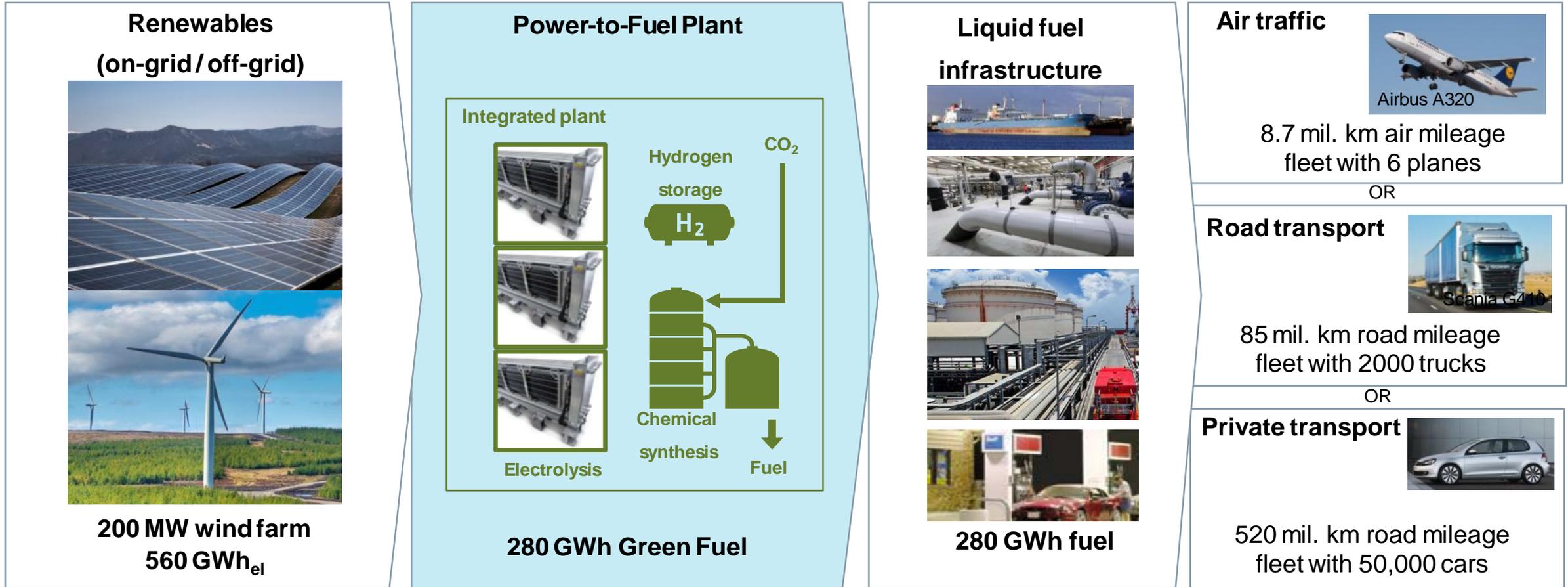
Hydrogen production per
hour

1.25 MW

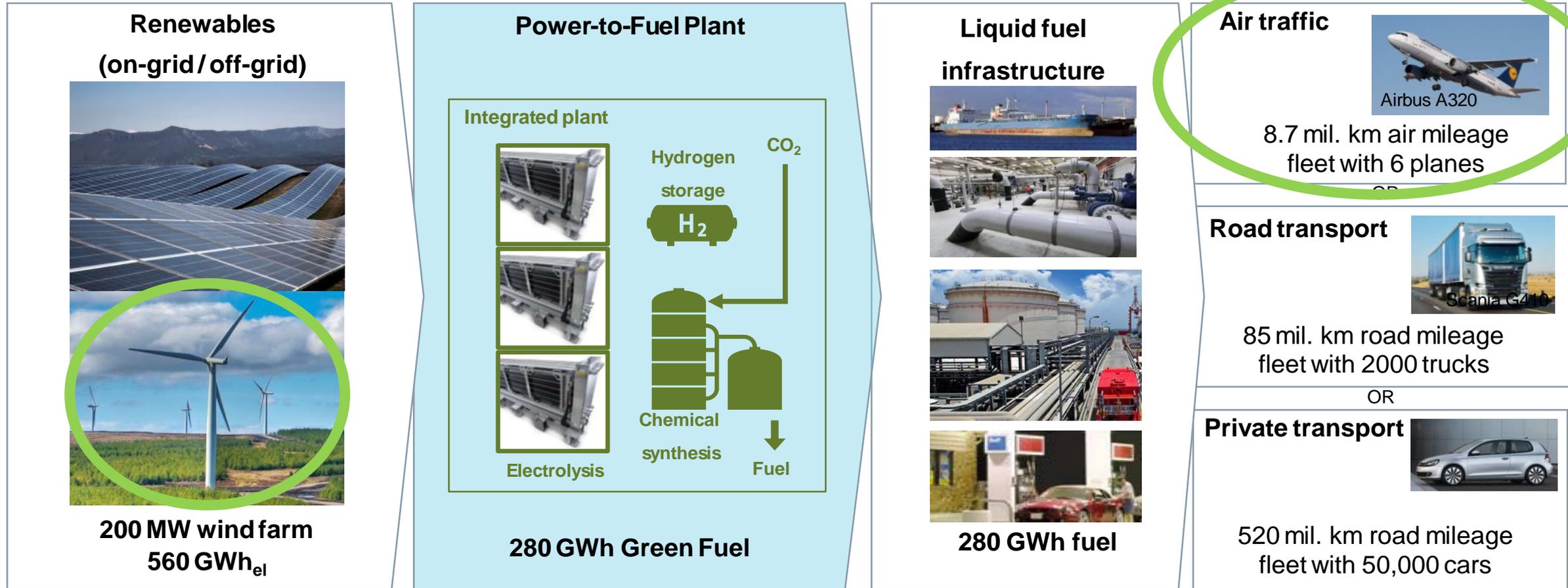
Rated stack capacity,
peak power 2 MW



Power-to-Fuel plants as missing link for electricity-based green fuels and the utilization of the existing liquid fuel infrastructure



Power-to-Fuel plants as missing link for electricity-based green fuels and the utilization of the existing liquid fuel infrastructure



Chance für Brandenburg: Nachhaltige, innovative E-Mobility

Windenergie → Power-to-Green Fuel → Hybrid-Elektrisches leises Flugzeug

Renewables

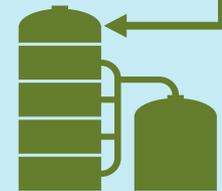
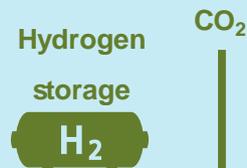


Power-to-Fuel Plant

Integrated plant



Electrolysis



Chemical synthesis

Fuel

Liquid fuel infrastructure



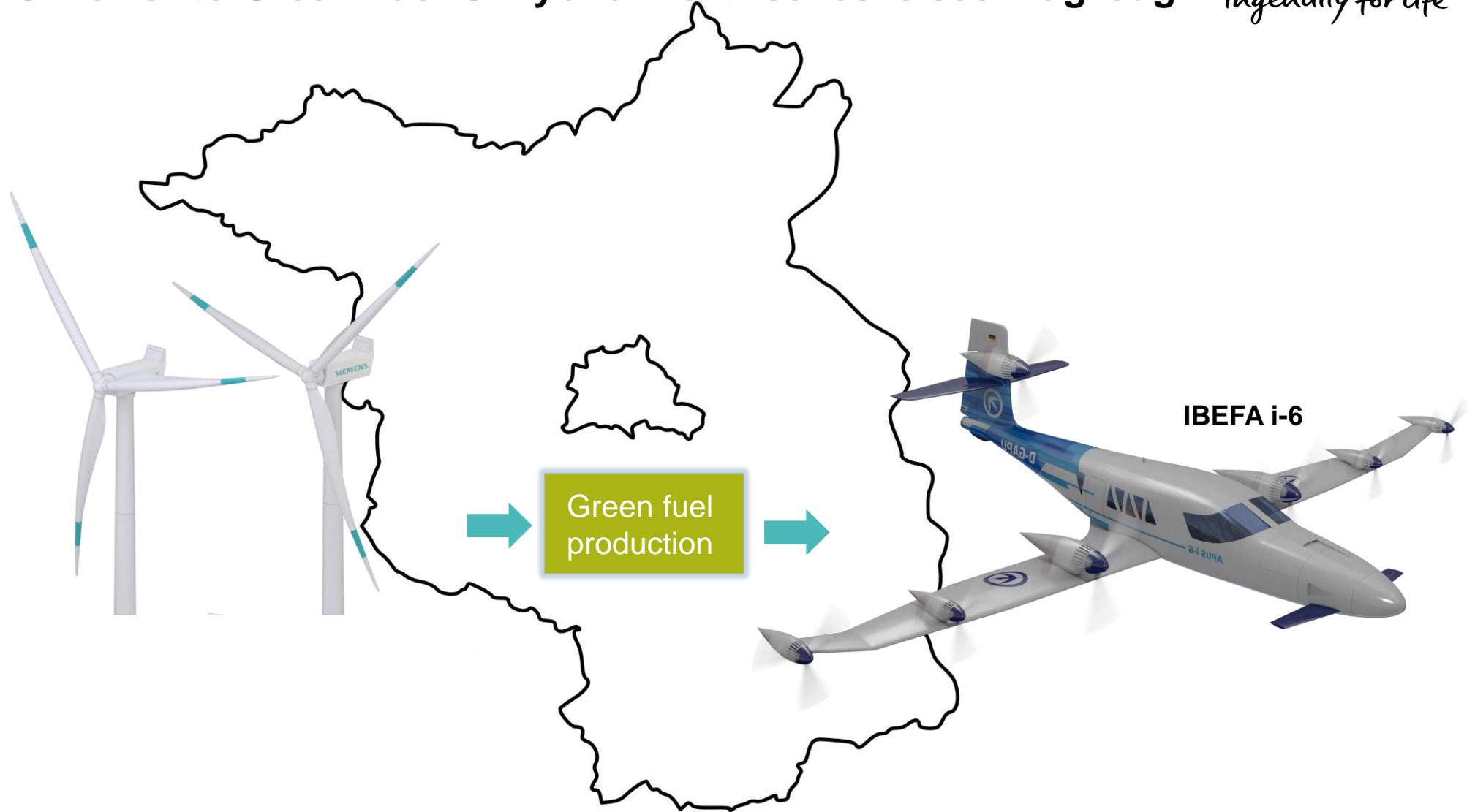
Air traffic



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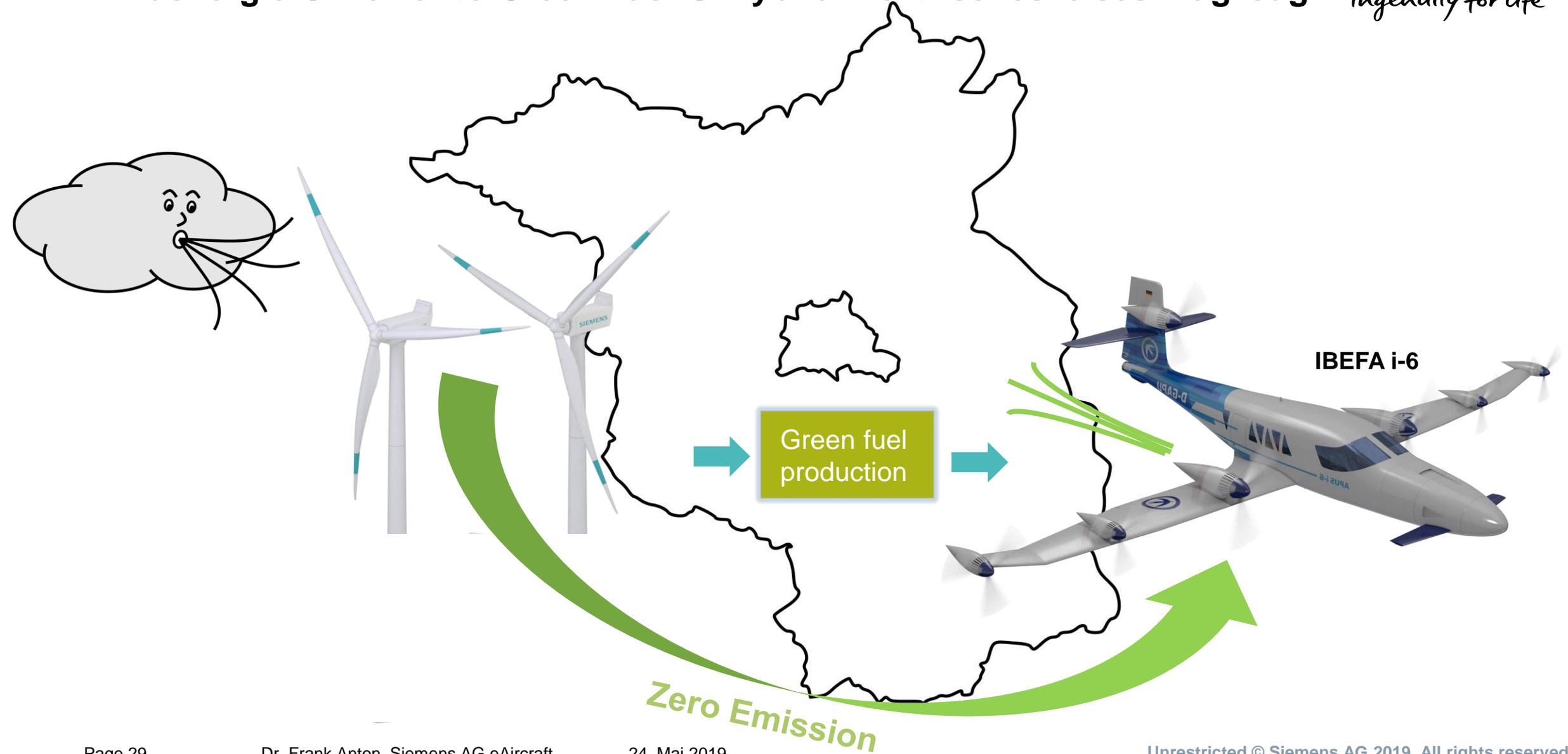
Windenergie → Power-to-Green Fuel → Hybrid-Elektrisches leises Flugzeug

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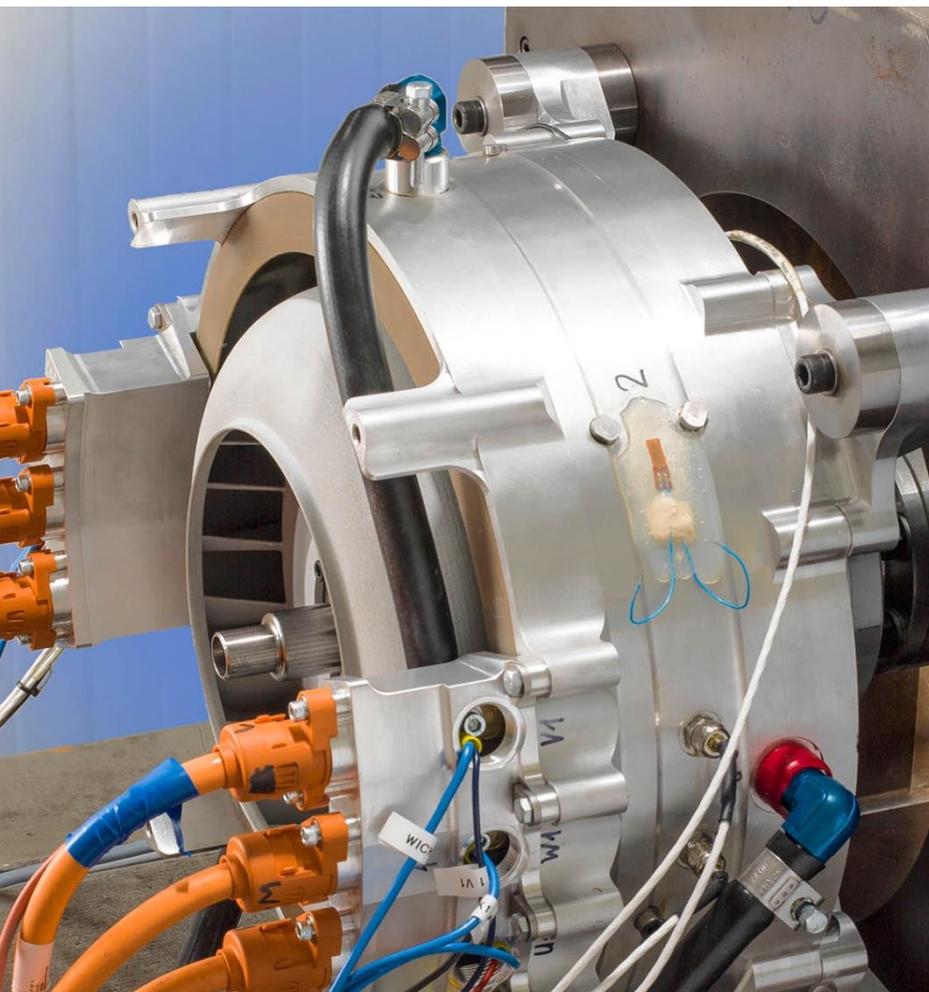


Chance für Brandenburg: Nachhaltige, innovative E-Mobility Windenergie → Power-to-Green Fuel → Hybrid-Elektrisches leises Flugzeug

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Thank you for your attention



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