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
- Separation of power generation and thrust generation
- Distributed propulsion
- Vectorized thrust

- Useful range
- Decreased fuel flow & emission
- Silent propulsion
- Increased aerodynamic efficiency
- eSTOL, eVTOL
Our core portfolio – electric propulsion units (EPU) for applications with high power/weight requirements

Condition-based Services
System Integration
Controller

Battery
Fuel Cell
DC/DC Inverter

Turbine/ICE
Generator
AC/DC Inverter
Power Distribution
Signal Distribution
DC/AC Inverter
Motor

Siemens
Trading item
Extra 330LE
FAI Official World Record Flights at Dinslaken Schwarze Heide Airfield

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 Kampsman
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.
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%

**SP260D-A**

<table>
<thead>
<tr>
<th>Weight</th>
<th>Power Density</th>
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<tbody>
<tr>
<td>50 kg</td>
<td>5.2 kW/kg</td>
</tr>
<tr>
<td>44 kg</td>
<td>5.9 kW/kg</td>
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</table>

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

\[ P_{\text{max,cont}} = P_{\text{max,5min}} = 204 \text{ kW} \]
\[ N_{\text{cont}} = N_{\text{max}} = 1300 \text{ RPM} \]
\[ M_{\text{cont}} = M_{\text{max}} = 1500 \text{ Nm} \]

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)

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

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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.
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### Specifications

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<thead>
<tr>
<th>Specification</th>
<th>Range</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Continuous Power</td>
<td>200 – 450 kW</td>
<td></td>
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<tr>
<td>MOTM</td>
<td>1990 Kg</td>
<td></td>
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<tr>
<td>Wingspan</td>
<td>10 – 18 m</td>
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<tr>
<td>Flight time</td>
<td>4 – 8 h</td>
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<tr>
<td>Range</td>
<td>1800 – 2300 km</td>
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</tr>
<tr>
<td>Cruise Speed</td>
<td>400 – 450 Km/h</td>
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IBEFA „Innovationsbündnis für emissionsarme Flugzeugeantriebe“, 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
→ $\text{H}_2$ Electrolyzer
→ CO Electrolyzer
→ Green Fuels
Power to Green Fuel:
Renewable Energy $\rightarrow$ H2 Electrolyzer $\rightarrow$ CO Electrolyzer $\rightarrow$ Green Fuels

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

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

- Ethylene
- Ethanol
- Methane
- Methanol

Increase of huge surplus of cheap renewable energy mandatory

Chemical synthesis/fermentation

Green fuel/chemicals
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

Renewables (on-grid / off-grid)

- 200 MW wind farm
- 560 GWh$_{el}$

Power-to-Fuel Plant

- Integrated plant
- Electrolysis
- Hydrogen storage
- CO$_2$
- Chemical synthesis
- Fuel

Liquid fuel infrastructure

- 280 GWh Green Fuel
- 280 GWh fuel

Air traffic

- 8.7 mil. km air mileage fleet with 6 planes

Road transport

- 85 mil. km road mileage fleet with 2000 trucks

Private transport

- 520 mil. km road mileage fleet with 50,000 cars
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Chance für Brandenburg: Nachhaltige, innovative E-Mobility
Windenergie → Power-to-Green Fuel → Hybrid-Elektrisches leises Flugzeug

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Green fuel production

Zero Emission

IBEFA i-6
Thank you for your attention

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