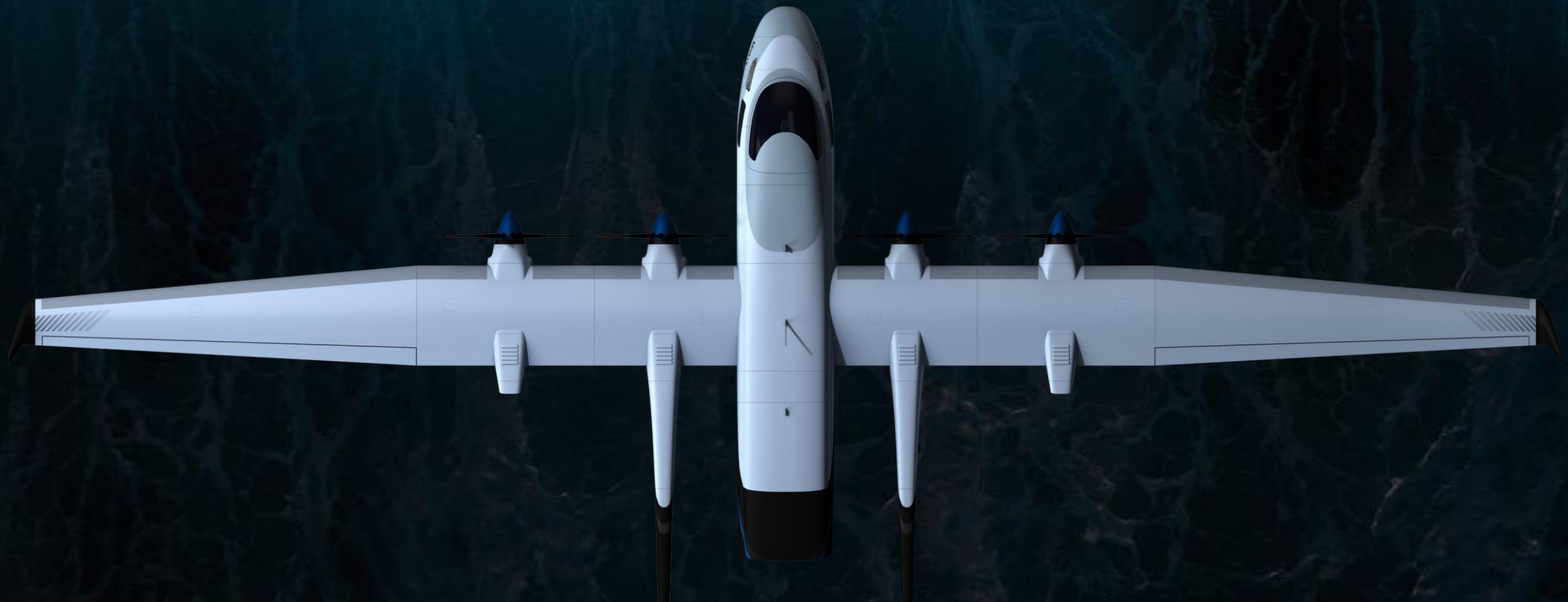
APUS GROUP

Wasserstoff - emissionsarmes Fliegen in der Anwendung

Phillip Scheffel, 08.09.2022



APUS – Location

The headquarter of **APUS Group** is located 30 km east of Berlin. The offices and workshops are directly connected to the runway and taxiway of the highly developed airport EDAY. The team behind *APUS* has an expert reputation in the aviation industry, being a leader in electrification, aircraft design and aircraft development challenges of the future. Hydrog

APUS Group
Lilienthalstraße 2
15344 Strausberg
GERMANY

EASA

APPROVAL CERTIFICATE
EASA.21J.638

Pursuant to Regulations (EC) 216/2008 and (EU) 748/2012 and subject to the conditions specified below, the Agency hereby certifies

APUS – Aeronautical Engineering GmbH
Flugplatzstraße F4 1
15344 Strausberg
Germany

as a DESIGN ORGANISATION

approved according to Part 21, Section A, Subpart J.

CONDITIONS :

1. The approval is limited to that specified in the enclosed Terms of Approval, and
2. This approval requires compliance with the procedures specified in the Design Organisation Handbook, reference Design Organisation Handbook Doc.No.: P90-900900, in the latest revision, and
3. This approval is valid whilst the approved Design Organisation remains in compliance with Part 21, Section A, Subpart J.
4. Subject to compliance with the foregoing conditions, this approval shall remain valid until surrendered or revoked.

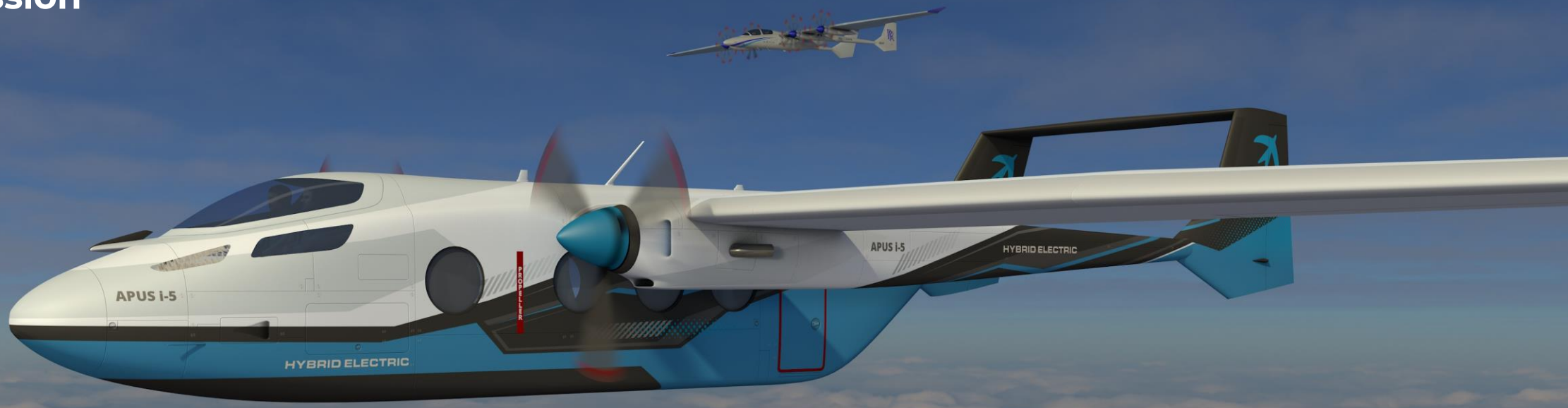
For the European Aviation Safety Agency,
Date of Issue: 07/09/2018

Francesco Maria CARDEI
Design Organisations Section Manager

Facts – APUS Group

Founded	**2014**
Experience (Key Staff):	**30 Years**
Approvals/Certificates:	**EASA 21J / 21G / ISO 9100**
Staff:	**35+**
Infrastructure:	**350 sqm Offices** **1.300 sqm Work-Shop** **1.500 sqm Test-Area**

APUS Mission



What does APUS want to do?

We will offer the first certified zero emission (hydrogen electric) commercial aircraft

- 9 – 19 seats
- Cargo up to 1,7 t
- 2 x 350 kW Hydrogen Power
- 160 KTAS cruise-speed, range of 500 NM
- Replacing conventional RAM-aircraft by zero emission aircraft
- Providing lower cost (cost/passenger/mile) by using hydrogen*
- Using patented structurally integrated hydrogen storage system TUBESTRUCT™

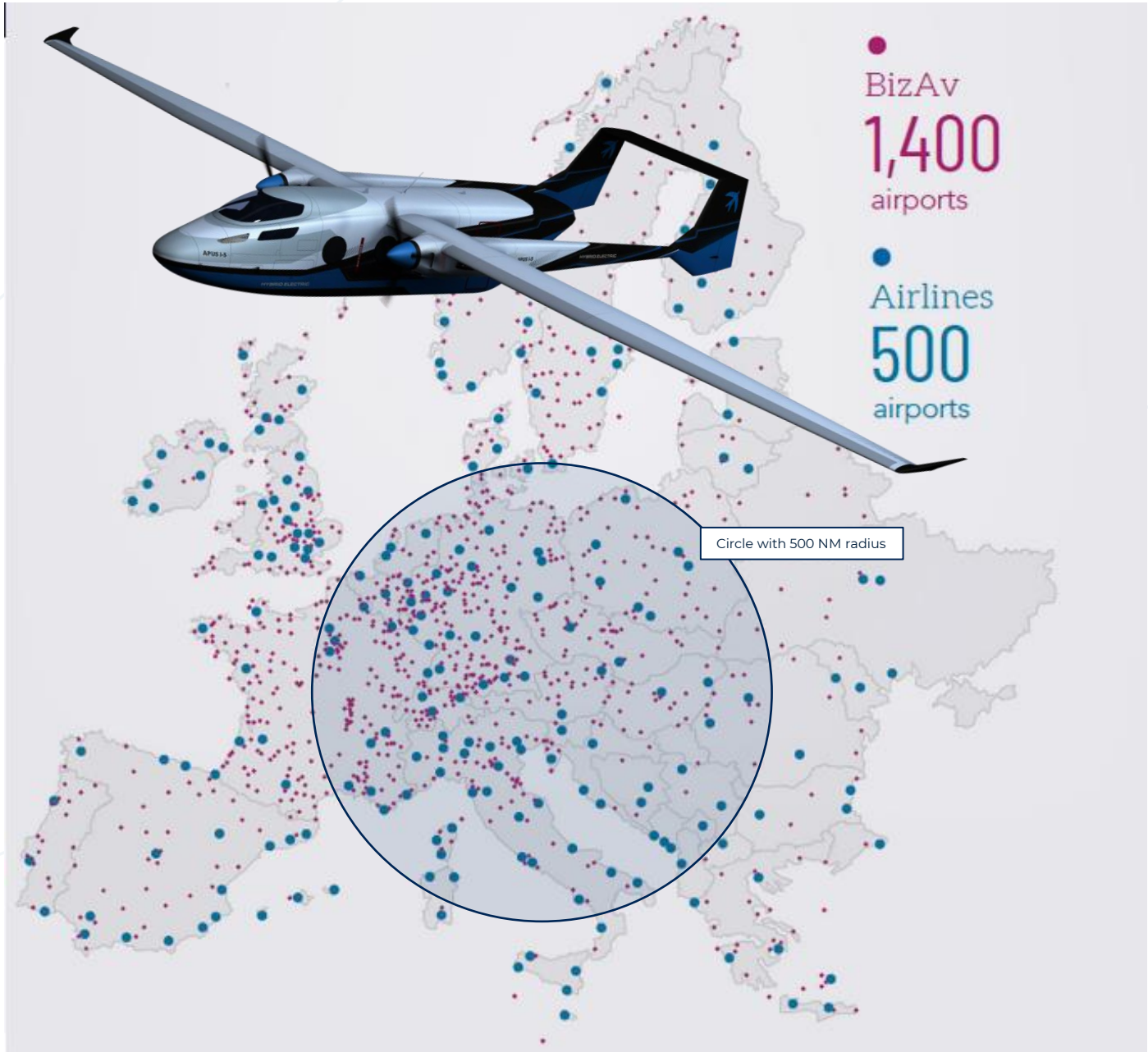
)* direct operational costs (DoC) costs would be lower than todays conventional a/c, when the price of hydrogen becomes lower than 6,25 EUR/kg

Departing from almost every town in Europe

There is always an airport within a maximum radius of 50 km. Well over 80% of the population lives less than 20 kilometers from the nearest airport.

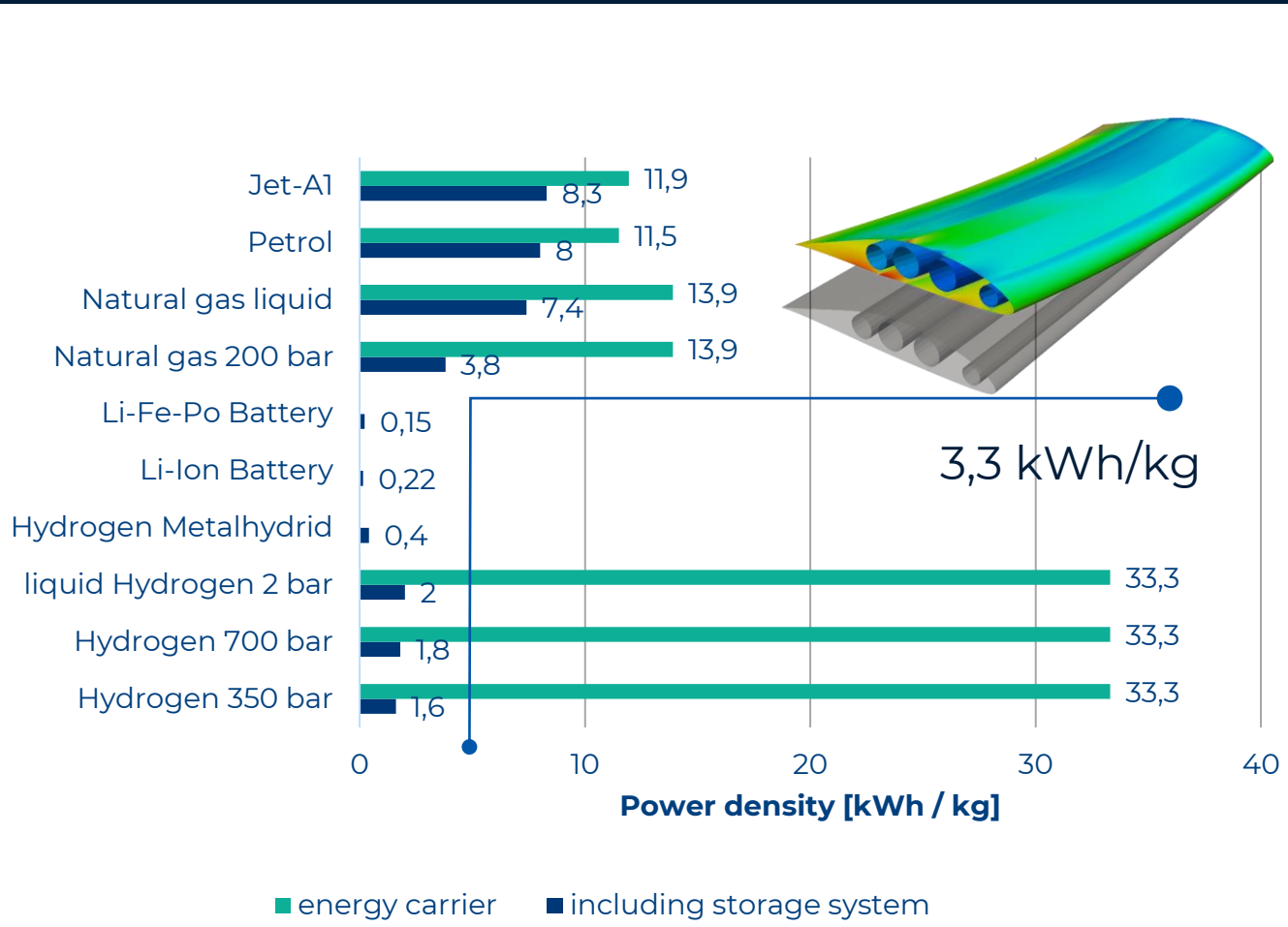
The largest share of all global passenger flights are flights with a flight duration of less than 2 hours (300 NM) and fewer than 10 passengers on board.

From 2035 on a few countries allow only zero emission regional flights (Denmark, Norway, New Zealand, ...) Only APUS i-5 can provide competitive performance with zero emissions so far.



Energy Density – TUBESTRUCT ™

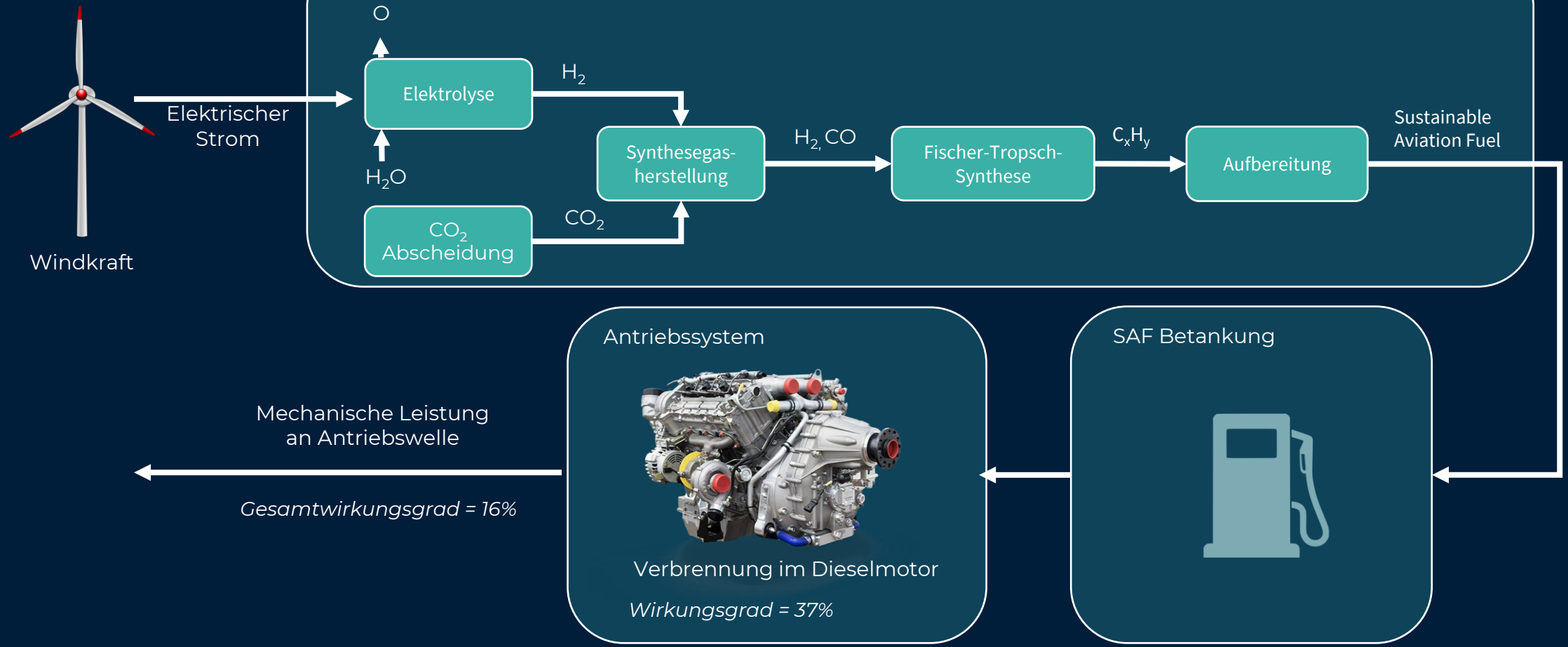
With APUS patented energy storage systems APUS offers best energy density worldwide.
With **METALIQ™**-energy storage system the safest hydrogen storage system worldwide.



Operational Costs

						
Model	**Unit**	**i-2**	**E-Panthera**	**Ampaire**	**ZeroAvia**	**SR22 (Reference)**
MTOW	kg	2200	1315	1900	2310	2200
dry payload	kg	400	100	200	300	400
pax		4	1	2	3	4
Power Unit		400.000€	200.000 €	400.000€	400.000 €	100.000 €
TBO (time between overhaul)	h	6000	6000	6000	6000	2000
energy consumption	kW/h	165	130	165	165	480
price per kWh	EUR/kWh	0,21	0,21	0,21	0,21	0,16
price per h	EUR/h	35,00	27,58	35,00	35,00	75,59
cruise speed	kts	150	150	150	150	150
Energy Costs	EUR/NM	0,23 €	0,18 €	0,23 €	0,23 €	0,50 €
including PowerDriveCosts		**0,68 €**	**0,41 €**	**0,68 €**	**0,68 €**	**0,84 €**
cost per pax and NM	**EUR/NM/pax**	**0,17 €**	**0,41 €**	**0,34 €**	**0,23 €**	**0,21 €**
Compared to conventional Cirrus SR22	**EUR/NM/pax**	**81%**	**194%**	**162%**	**108%**	**100%**

Efficiency Chain:
Windkraft, Elektrolyseur, Fischer-Tropsch Synthese zu SAF, Verbrennung im Dieselmotor



Efficiency Chain: Windkraft, Elektrolyseur, Speicherung, Verdichtung und Kühlung beim Tanken (300bar-System), BSZ-Wirkungsgrad, E-Motor

Windkraft

Elektrischer Strom

H_2 Erzeugung und Speicherung

Wirkungsgrad PEM-Elektrolyse-Anlage = 56%

Gleichrichtung → Elektrolyse → Gastrocknung → Verdichtung (1 -> 200 bar)

O

H_2

H_2O

H_2 Betankung (300 bar)

Wirkungsgrad: 96%

Verdichtung (200 -> 500 bar) → Vorkühlung (-33...-40°C) → Dispenser

Antriebssystem

Wirkungsgrad = 54%

Elektromotor → Elektronik & Systeme

Wirkungsgrad = 95%

Wirkungsgrad = 95%

Mechanische Leistung an Antriebswelle

Gesamtwirkungsgrad = 29%

Elektrischer Strom

Brennstoffzellensystem

Wirkungsgrad PEM-Brennstoffzellensystem = 60%

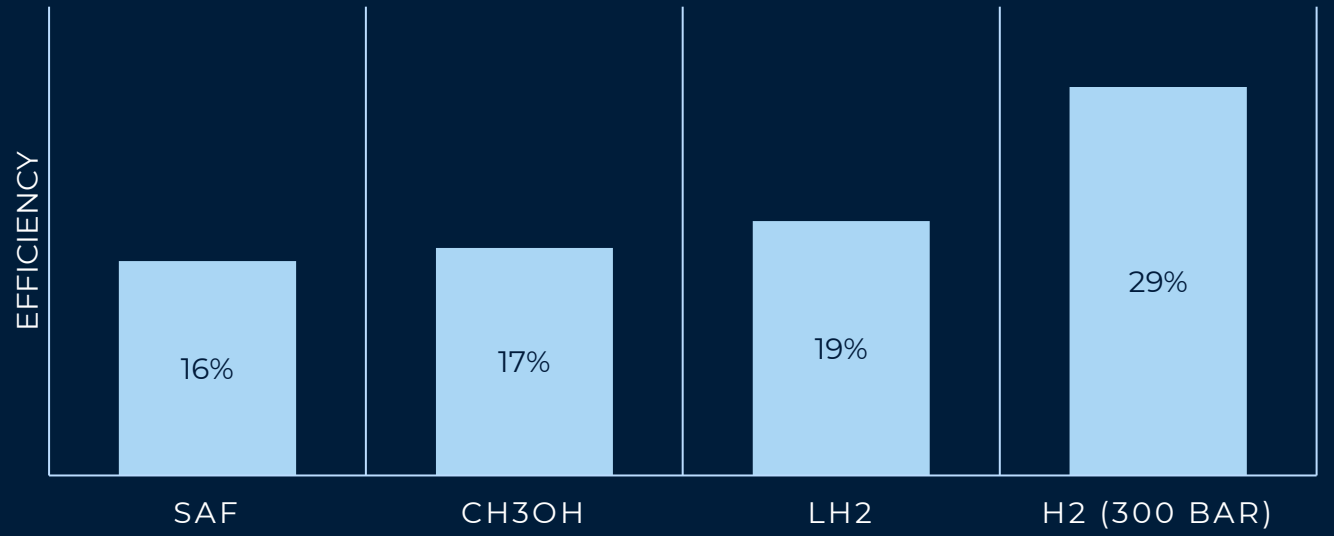
Umgekehrte Elektrolyse

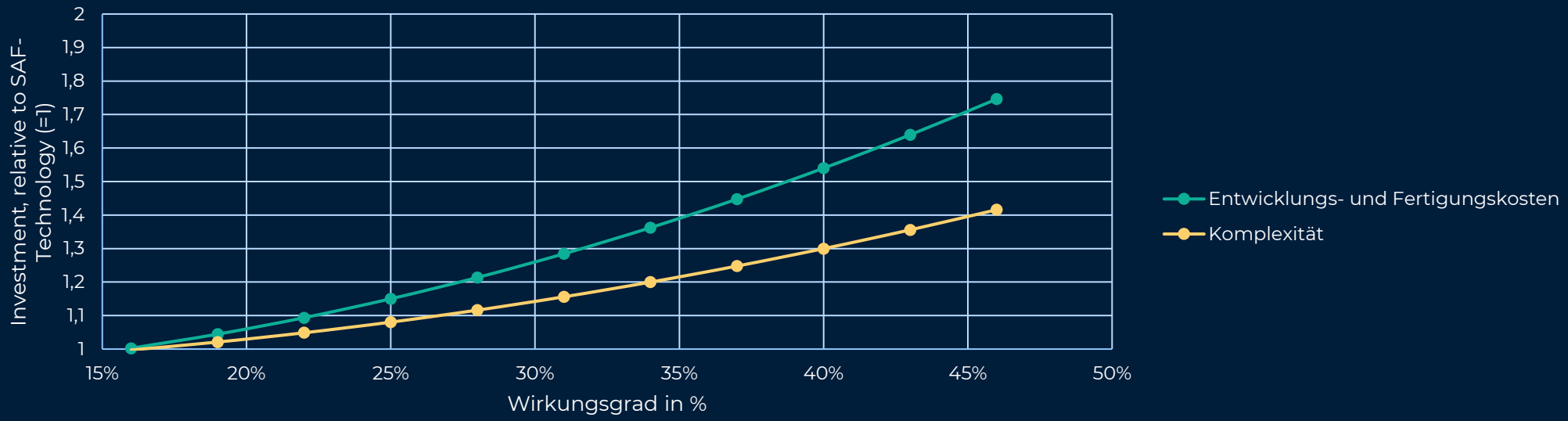
H_2

H_2O

Luft

Qualitative comparison of the variants with regard to the development effort





An urgent need for immediate emission reduction in aviation.

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920 million

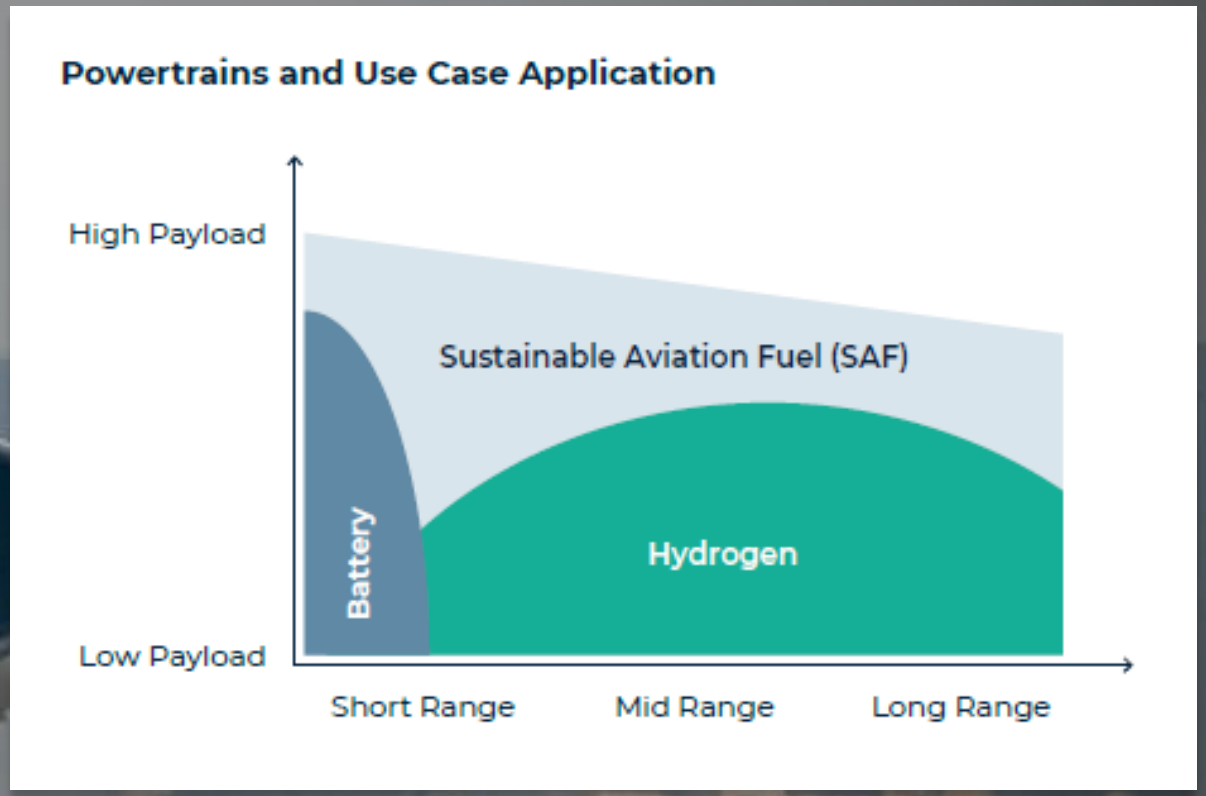
Metric Tons of CO_2

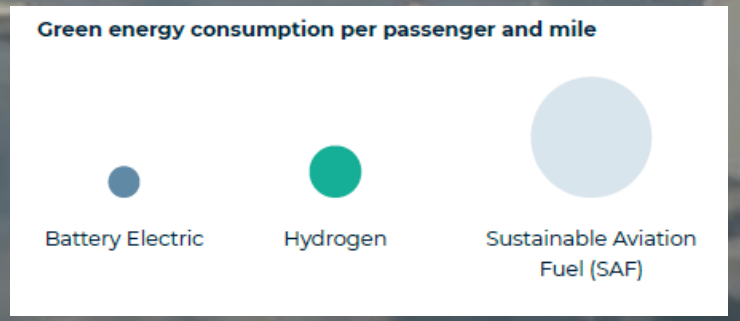
In commercial aviation worldwide per year

50% of the pollution
by regional and short haul flights.
Without new technologies
Expected to
increase 3x by 2050.

-75%

The required reduction of the aviation industry's CO_2 emission by 2050
EU Green Deal, proposed by the EU Commission





More individual travelling, less crowded airports and ZERO EMISSION!

- Save time at boarding and arrival.
- Be closer to your final destination.
- Travel more individually.

- Avoid Emissions!

Autonomous self-production on airstrips

Together with renewable energy producers APUS develops the necessary hydrogen ground infrastructure to provide enough energy on each destination.

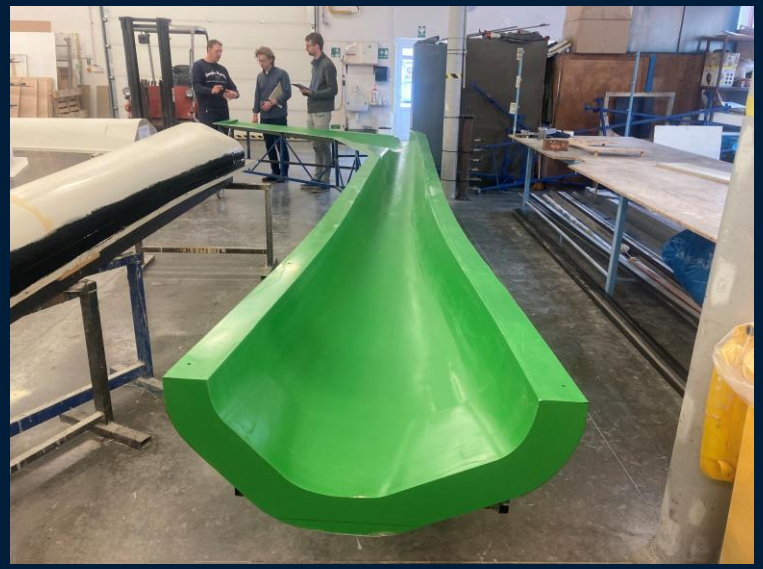
H2-Airports of the future – in Brandenburg already reality

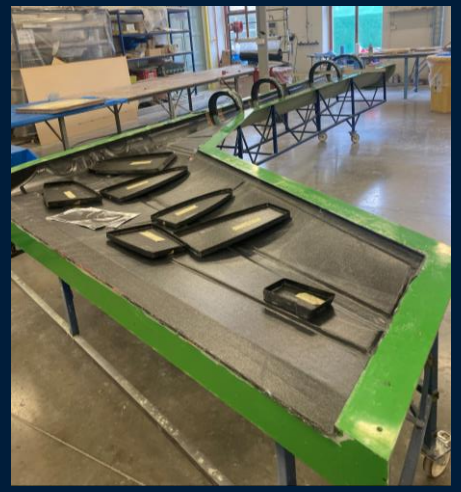
Not so different from today, but with much more PV

- liquid hydrogen on all national airports
- 300bar gaseous hydrogen on most general aviation airports
- On small airstrips only bottles with 400bar necessary
- No drainage necessary

Hydrogen Fuel-Tank and Powertrain

Impressions from the workshop “APUS i-5”



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High power battery
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Partner network

Benefit from APUS as a renowned aviation expert for your future-oriented entry into the multi-billion market of sustainable aviation.

Together with **Rolls Royce**, one of the most established powertrain supplier in aviation, APUS is developing complex high voltage systems, integration concepts and certified products on highest safety and industrialization level.

Fraunhofer is the leading research institute for high voltage converters. Together with APUS Fraunhofer develops a completely new DC/DC converter for aviation with lowest gravimetric power density.

Powercell SE produces industrialized fuel cells for automotive industry. Together with APUS Powercell SE will shape the aviation sector for aviation fuel-cells.

HEGGEMANN is an established supplier of certified aviation metal parts since almost 60 years. With HEGGEMANN, APUS targets the market for all hydrogen supply components.

Federal Republic of Germany invests currently **238 mn €** in the technology, 39 mn € already approved for 2022.

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