APUS
Zero Emission

APUS i-2
The Zero Emission GA Aircraft

Meet the APUS i-2
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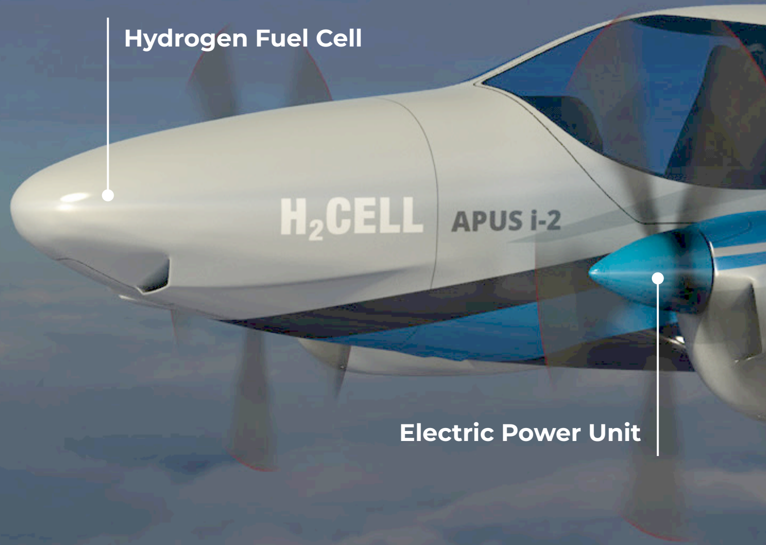
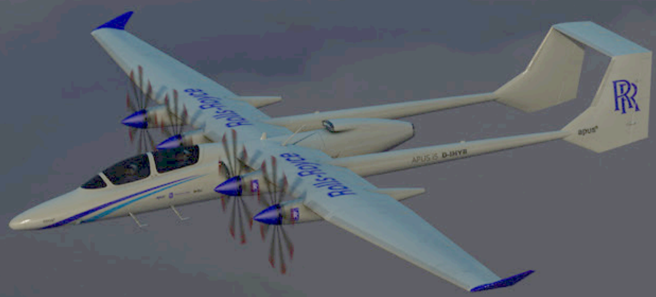
APUS i-2 is the first emission-free aircraft for daily use. It is a four-seat normal-category (CS-23) aircraft with 2,200 kg MTOM, a range of 500 NM and a maximum cruise speed of 160 KTAS – competitive performance data comparable to most modern four-seat aircraft.



Employing a hydrogen fuel cell as its primary source of energy makes APUS i-2 100 % emission-free, i.e. zero CO_2, zero NOx, zero noise – nothing less than a revolution in emission-free flying! This is achieved through APUS's patented structurally integrated hydrogen storage system. It permits up to 25 % higher specific energy density compared with standard hydrogen fuel tanks and ten times better energy density than battery-electric aircraft, all while avoiding the use of rare minerals that batteries employ.



Performance

Cruise	160 kts
Payload	400 kg
PAX	1 + 3
Range	500 NM
Service Ceiling	16,000 ft

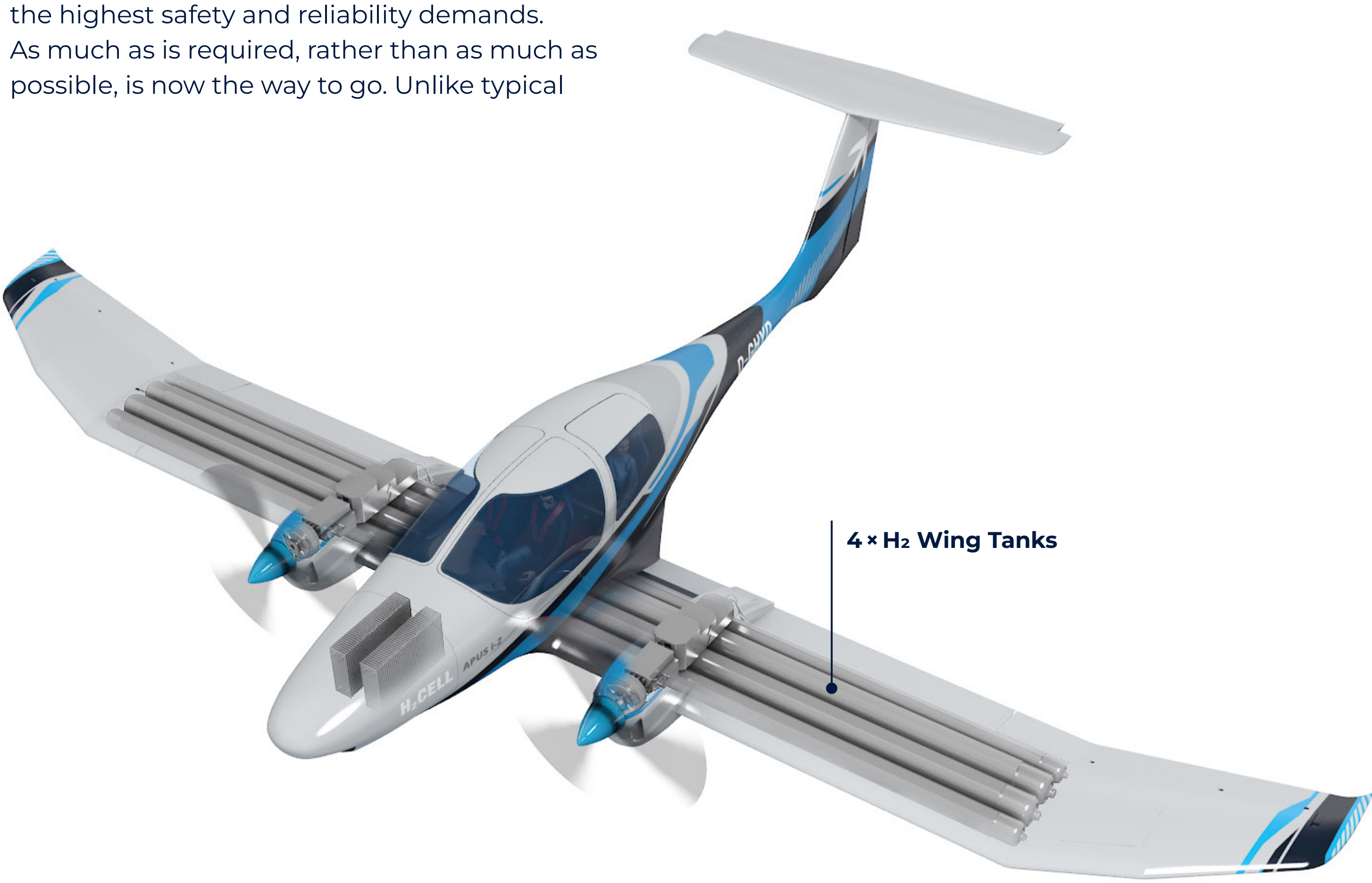
Dimensions

Wing Span	13.2 m
Length	8.86 m
Height	2.88 m
MTOW	2,200 kg


D-GHYD
HV Batteries
Hydrogen Storage Wing Structure

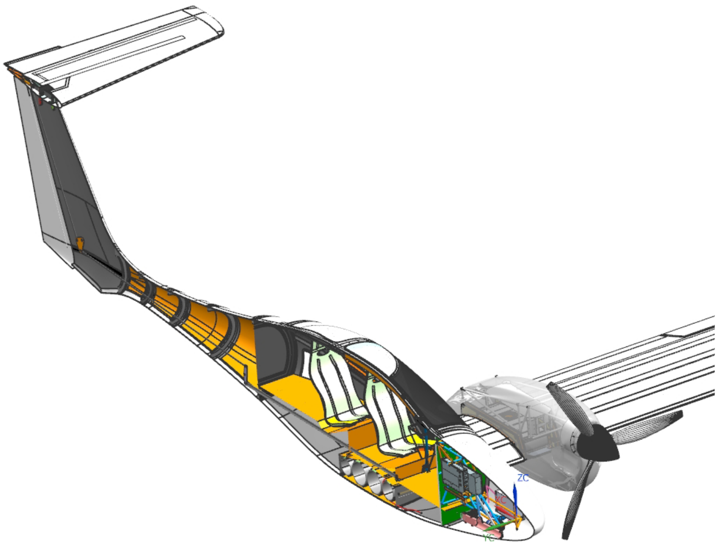
The i-2 will outperform competition from both established conventional aircraft as well as competitors with new hydrogen electric powertrains. New hydrogen electric competitors struggle with payload and volume. Competition is less cost-efficient.

The H_2 technology is currently not available as commercial of the shelf on the aviation market. Therefore, the technology is derived from other sectors than aeronautics, and initially it is challenging to convert highly featured, complex devices into ones that comply with the highest safety and reliability demands. As much as is required, rather than as much as possible, is now the way to go. Unlike typical implementations in the automotive sector, the fine granular, overall controlled approach is replaced by one with minimal complexity in order to gain reliability.



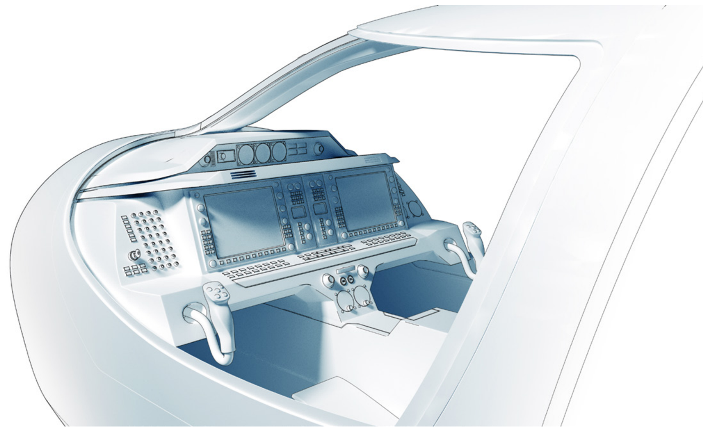
MTOW	2,200 kg
Dry payload	400 kg
PAX	4
TBO (time between overhaul)	6,000 h
Energy consumption	165 kW/h
Cruise speed	160 kts

Price per pax and 100 NM — 80 % compared to Cirrus SR22 (price assumption of 5 EUR/kg hydrogen)



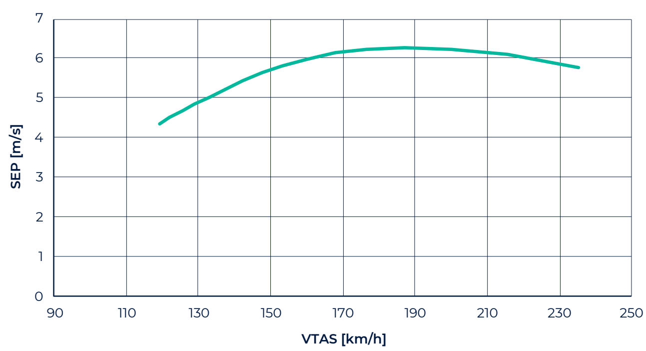
Airframe & Aircraft Systems
The full composite airframe is highly adapted to the zero emission propulsion system, resulting in an extremely lightweight, reliable and efficient design. This includes a hydraulically retractable landing gear and optimised air inlets and outlets for the complex cooling and ventilation system, reducing the aerodynamic drag to a minimum. The spaceous cockpit with state-of-the-art avionics provides an excellent flight comfort and unique flight experience for 4 persons. The cockpit is proposed for 2 additional PAX in a later variant.

Hydrogen Wing Structure Design
The wing structure of the APUS i-2 consists of several round spars and a shaping aerodynamic shell. The four tubular spars each form a pressure tank for storing gaseous hydrogen and carry the applied flight loads at the same time. Compared to a conventional design, the empty space in the wing is optimally used in this way. In addition, there are mass savings through the combination of pressure and flight load-bearing spars. The wing is built in an integral construction from high-performance carbon fiber. Lengthy and small-scale production steps are eliminated thanks to a one-shot design, which enables complex and heavy adhesive joints to be reduced.



Flight Performance
The APUS i-2 features benchmark performance data compared to conventional and electric aircraft of its class. Performance estimates for the APUS i-2 include up to 160 kts cruise speed and more than 500 NM range. Carefully designed aerodynamics allow a glide ratio of up to 17 and climb rates up to 6.2 m/s. The key performance data is summarized below.

Climb rate for MTOP

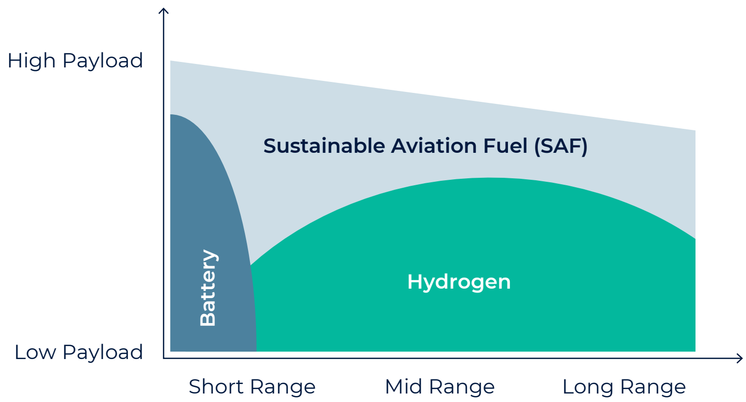


Design manoeuvring speed	VA	70 m/s	136 kts
Design cruising speed	VC	80 m/s	160 kts
Design dive speed	VD	112 m/s	218 kts
Range		>926 km	>500 nm
Best L/D		17	
Best climb		6.26 m/s at 187.3 km/h	1,232 fpm at 101 KTAS
Take-off distance above 50 ft		640 m	2,100 ft
Landing distance from 50 ft		750 m	2,460 ft

With lowest emissions, green hydrogen will be the renewable energy source for mid range aircraft in the 21st century. The development of the hydrogen electric powertrains will be the key to success and the core asset of future green aviation OEMs.

Sustainable Aviation Fuels (SAF) are CO_2-emission-free when you look at the CO_2-cycle. With SAF, today's gas turbines and piston engines can continue to be operated. However, SAF are made from hydrogen – with an efficiency of just 30 %. That means that 70 % of the hydrogen is wasted. But the "green hydrogen" resource is extremely limited, as wind, solar and hydropower plants are not yet sufficiently available. Therefore, an attempt must be made to cover as many transport applications as possible with either battery (90 % eff) or hydrogen drives (50 % eff).

Powertrains and Use Case Application



Green energy consumption per passenger and mile

Powertrains and their applications

Battery Electric

→ **Air Taxi**

Good for very short flights, efficient but applications restrained by low battery capacity.

Sustainable Aviation Fuel (SAF)

→ **Long Range**

Very good CO_2 balance, however still substantial emissions. Limited amount of SAF for supply on large scale.

Hydrogen (Hybrid) Electric

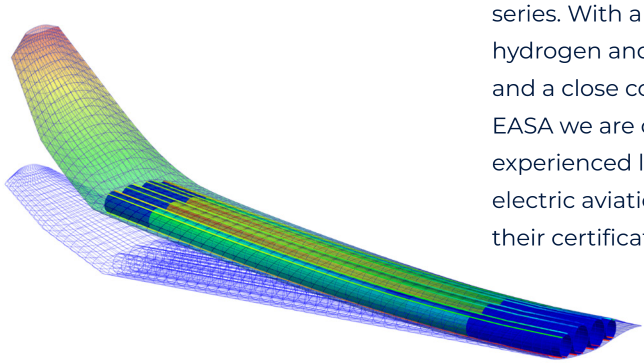
→ **Regional and Mid Range**

Highest energy density, clear route to large volume green hydrogen, compensates for lack of SAF with higher thrust efficiency and reduced loss during production.

World's first structural integrated hydrogen wing tank concept
Instead of the usual spar, the hydrogen tanks are designed to take up the external aerodynamic loads in addition to the pressure-induced internal loads. Compared to other hydrogen-powered aircrafts with conventional cylinder tanks, replacing the spar results in a weight-saving for the entire system. The wing tank is constructed from carbon fiber composite plastics.

Integration and Certification
As a professional provider of aviation engineering services with a responsibility to fulfill customer orders, we are obliged to comply with the stringent requirements of the European and national aviation authorities. Our permits and certifications testify to our expertise. APUS is an EASA Design Organisation according to Part 21, Section A, Subpart J. We are certified as a production organisation according to EASA Part 21 Subpart G and according to EN 9100 and we are able to certify prototype parts and small-scale series. With a strong focus on hydrogen and hybrid powertrains and a close cooperation with EASA we are one of the most experienced leaders in the field of electric aviation powertrains and their certification.

The Powertrain
The overall propulsion system consists of two identical power lanes, each feeding one propulsion unit. These lanes are separated in normal operational mode and may become interconnected by a switchable cross feed to balance the load. One power lane comprises a fuel cell system, which sources the power primarily for the propulsion units. A high voltage battery compensates for lack of power during slow power ramp-up of the fuel cell and power-intensive operations. Finally, an electric motor with an integrated inverter drives a low-speed propeller with very low noise emissions. The main components are designed to be self-contained and fail-safe. A reliable power controller keeps the correct voltage level on the main bus.


Calculated optimum of hydrogen volume and aerodynamic performance

Over the past five years, APUS Zero Emission has built up a strong network and strategic partnerships with key players in the industry, maintaining IP & certification rights on the existing and future development of hydrogen electric powertrains and aircraft.

Together with **Rolls-Royce,** one of the most established powertrain suppliers in aviation, APUS develops high voltage systems, integration concepts and certified products at the highest safety and industrialisation levels.

PowerCell SE produces industrialised fuel cells for the automotive industry. Together with APUS, PowerCell SE will shape the aviation sector for aviation fuel cells.

In cooperation with **GP JOULE**, an integrated energy supplier in all areas of the energy value chain, the infrastructure for the production, transport and filling of 100% green hydrogen will soon be available at many airports.

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

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

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