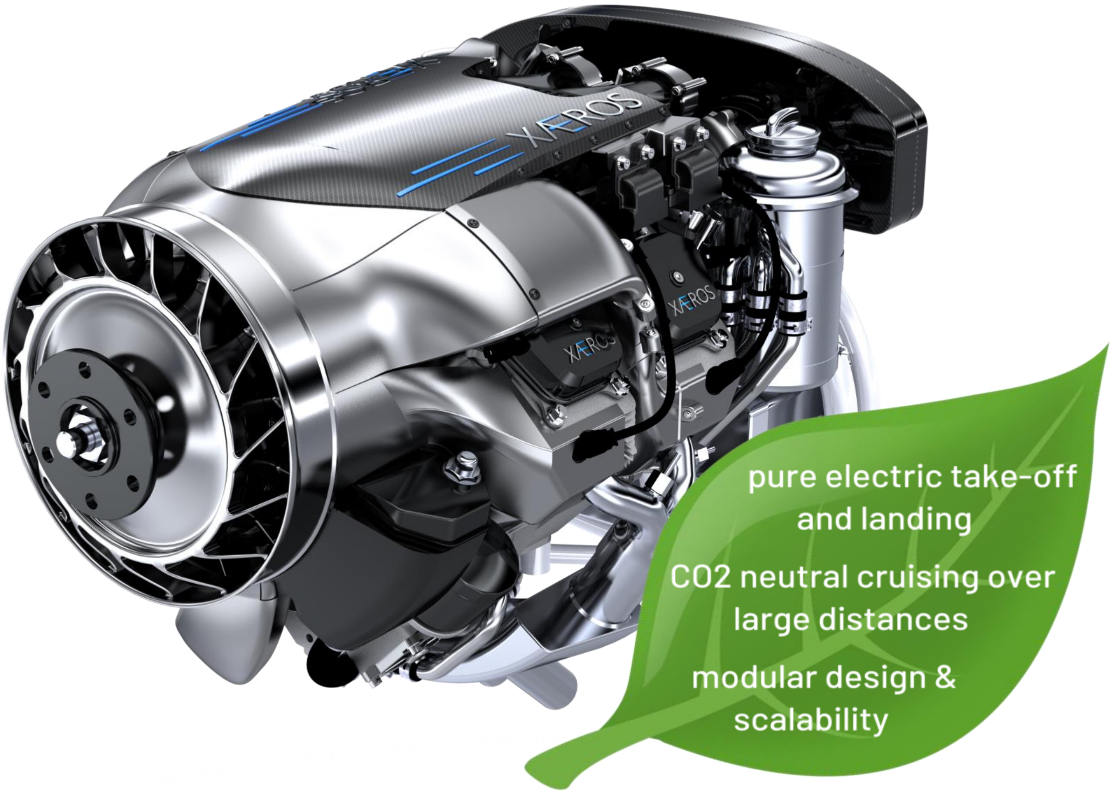
XÆROS
Hybrid Aircraft Engine



The bridging technology for general aviation, eVTOL aircraft, drones and more. For today and for the next 30+ years!

EXECUTIVE SUMMARY

February 2023 – v04.3

1. *Executive Summary*

The future of aviation faces major challenges.

These are a significant increase in safety, minimize noise and exhaust emissions and much more. more info

The goal would be pure battery-electric flight. However, batteries as energy storage system are still 20 times heavier than fuel systems, so the range and power with electric aircraft are very limited. more info

We're talking about blacking out due to a lack of electricity, but there's talk of using green electricity to produce green hydrogen in temperate climates. However, this is only possible to a very limited extent.

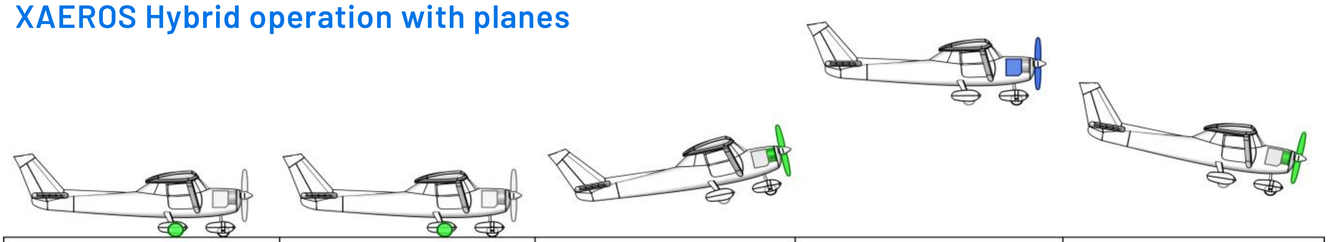
Green hydrogen can be produced from water, solar and wind energy and CO2 from the air in sunny and windy regions around the globe. But hydrogen is very difficult to transport by sea and entails enormous losses. more info

But urgent action is needed to protect our environment. We can't wait 30 years for new technology to become available and planes to be swapped out for new technology.

For CO2 neutral operation of aircraft and ships, the solution will most likely be found in the production of synthetic fuels in sunny and windy regions around the world. The entire infrastructure is already existing for the transport, refueling as well as the existing aircraft and ships. more info

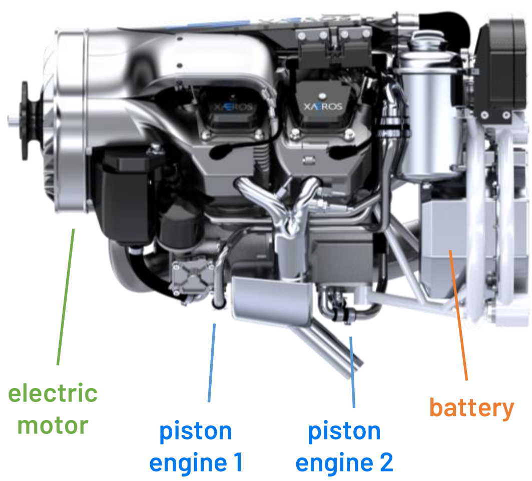
XAEROS develops a bridge technology for the next 30 years and probably much longer. It combines the advantages of electric propulsion with the enormous CO2 neutral range and power provided by synthetic fuels.

XAEROS Hybrid operation with planes



Taxi at the airfield: noiseless, only with **electric wheel drive** (optional)	**Accelerate on the runway:** silent, with **electric wheel drive** (optional)	**From taking off** to leave the airport area: very quiet with **electric driven propeller**	**Cruise:** with efficient, redundant piston engine with **synthetic e-fuels** (+ recharge battery)	**Landing approach and landing:** very quiet with **electric driven propeller**

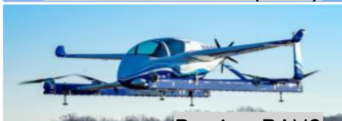
Yes, that sounds like fantasy, but the revolutionary XAEROS Hybrid 200 is designed to offer this solution. The system consists of one electric motor and two 2-cylinder V-engines (redundancy for safety), which are integrated with all components and the drive battery in a very compact drive unit with a width of only 50 cm and a system power of 270 hp / 200 kW. The FADEC controller also controls the optional wheel drive. The integrated battery is recharged during cruising for pure electric approach and landing.



The outstanding properties of the XAEROS hybrid system are not only of great advantage for certified aircraft, ultralight- and experimental aircraft but also for light helicopters, the upcoming eVTOL aircraft and air taxis, for manned and unmanned drones through to motorboats and ensure a generation change in safety drive technology.

XAEROS Hybrid operation with eVTOL aircraft


AUTOFLIGHT Prosperity


Boeing PAV2


Beta-Technologies ALIA

The trend in eVTOL (vertical take-off and landing) air taxis is increasingly towards lift & cruise configurations. Optimized propellers are used for electric take-off and landing, which are aligned in flight direction during cruising flight and thus cause hardly any air resistance. In horizontal cruising flight, the eVTOL aircraft is powered by a separate propulsion system. Many such eVTOL aircraft are currently under development.

If these new eVTOL aircraft are equipped with the XAEROS Hybrid Drive in the rear, the range increases from 30-50 km to 1000 km and more.

In combines pure electric take-off and climb to cruising altitude with the CO2 neutral cruise flight with the power and range of the redundant eFuel engine.

The XAEROS Hybrid 200 is not only designed for all new aircraft, but also specifically for retrofitting of tens of thousands of older generation aircraft, which today still fly with noisy engines with technologies from the 1960s and are operated with leaded and polluting AVGAS.

The target is to make general aviation, from ultralight up to twin commuter aircraft and many other forms of mobility, much more efficient, ecological, safer and quieter with the XAEROS Hybrid 200. It is equipped with catalytic converters and designed to run on unleaded Mogas, car gasoline and future eFuels. The XAEROS Hybrid 200 is the basic development for a whole range of engines for the future of general aviation and much more. The system has a modular structure, is scalable and offers countless possible uses.

A later kerosene version and an even more powerful 400 hp (300 kW) version are planned.

1.1. The target groups

are aircraft manufacturers for equipping new aircraft and light helicopters, aircraft owners and maintenance companies for retrofitting of tens of thousands of existing aircraft, manufacturers of unmanned and manned drones and the manufacturers of future air taxis, right through to equipping of new and existing motorboats.

1.2. Founder

Hans Schwoeller,

himself a pilot, is the initiator, CEO and owner of XAEROS AvioPower GmbH. Hans Schwöller is a visionary. He creates innovative ideas and strategies and pursues the set goals with great enthusiasm, implementation power and perseverance in order to realize the set goals and visions. Thanks to his "out-of-the-box" thinking, he also knows how to master difficult tasks in a short time.

Hans´ background includes a technical and economic education, 35 years of experience in the areas of company development and management, technical development, production, marketing and sales.
He has a large network of contacts and also likes to take up ideas from employees and implement them in an optimized way. He also goes unusual ways and means. With his implementation power and perseverance in realization Hans founded the ScaleWings group and developed the SW-51 Mustang from scratch. www.scalewings.com

1.3. Project Status

- detailed CAD basic design is completed
- adopting the design of many parts of aircraft engines that have been certified and tested thousands of times enables minimization of financial resources, risk and development time
- project partners we are in contact with are experts from engine development, electric motors, electronic, certification and reliable companies from various areas up to and including aviation control systems.
- the most important patents for the XAEROS engine are granted in the EU, the USA and China, further patents are pending and in progress

1.4. Financing

Fundraising is planned in three financing rounds:

Seed Round A / Short Term Loan 2/2023 100K EUR

With this short-term loan of 100K EUR with a term of 1 year and 10% interest the upfront costs are covered.

Investors who fund Seed Round A get 10% discount on Seed B subscription!

Seed Round B / Equity Investment 5/2023 8,9M – 13,3M EUR

Variant 1: 8,9M EUR Detailed development of the redundant piston engine up to flight tests.

The first step is the detailed development of the redundant piston engine up to first flying engines within two years. The development of the electric motor, battery, electronics will start with the Series A round from the 3rd year. End of year 3 the redundant piston engines are ready for series production.

Variant 2: 13,3M EUR Detailed development also of the electric drive components just from the 1st year.

This means that the XAEROS Hybrid engine is ready for series production already 1½ years earlier from mid of the 4th year instead of beginning of year 6.

Series A / Equity Investment 5/2025 from 5M EUR (depends on realized public and crowdfunding)

The delivery of 500 units is planned for the 4th year. In year 5 a delivery of 800 units are planned. The break-even point is reached already with the 4th year.
The very detailed financial plan show a high expected return.

We would like to invite you to be part of this highlight.

TAKE YOUR CHANCE and invest in the future-oriented XAEROS project now!

Don't miss this chance, contact Hans Schwoeller today:

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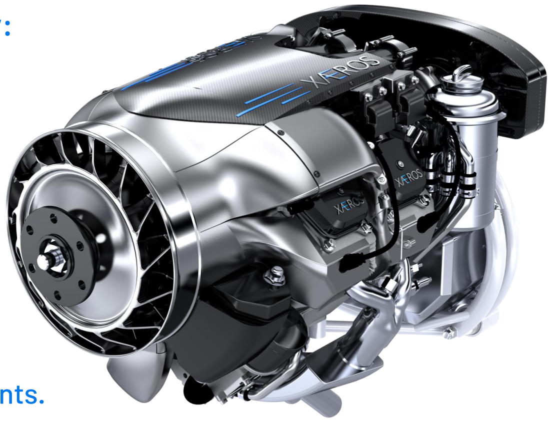


Background information can be found in the following attachments.

ATTACHMENTS

A Challenges for Future Aviation

The future of aviation faces major challenges:

1. Safety

This list shows the top 10 Causes of Fatal Accidents in General Aviation 2001-2016 (FAA, USA):

1. loss of control in flight (pilot error)
2. Controlled flight into terrain (pilot loses reference to terrain, pilot error)
3. System component failure – engine failure (technical error)
4. Fuel related engine failure
5. Unknown or indeterminate
6. System component failure - non-engine
7. Accidental flight in instrument flight conditions
8. collisions in the air
9. low altitude operations
10. other

(https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=21274)

According to these statistics, engine failure is listed as one of the top causes of fatal accidents in general aviation. And from technical causes:

Engine failure takes FIRST PLACE of

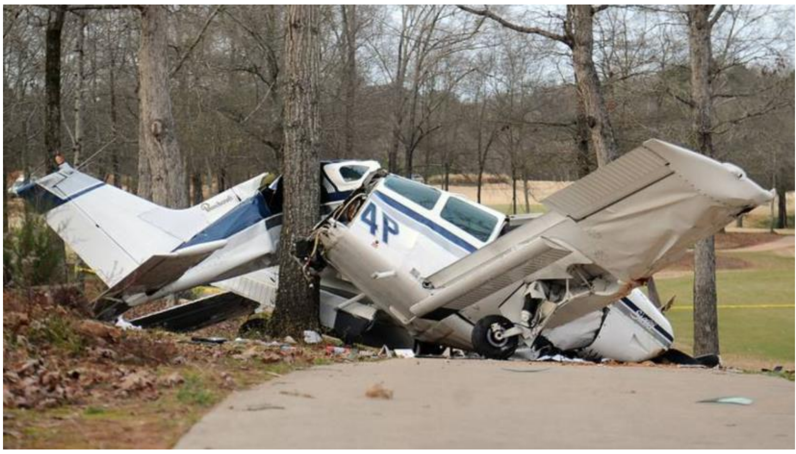
technical causes of FATAL AIRCRAFT ACCIDENTS !

... and that doesn't even take fuel issues into account!

Even the smallest technical part can fail !

Due to engine failures during the flight and the resulting dangerous and possibly fatal consequences for pilots and passengers, one of the most important starting points is therefore to make flying airplanes safer.

This also applies in particular to single-engine instrument flights, where the pilot and passengers have hardly a chance to survive if the engine fails without having any sight.



2. Noise Emissions

Airfield residents are becoming more and more sensitive to noise pollution. It can be observed worldwide that airfield residents are mobilizing due to the noise pollution to restrict or completely stop flight activities on the airfields. A central argument of local residents and activist groups is the pollution caused by noise, and that for the fun of a few who can afford it. Envy also plays a big role here

For leisure and private aviation to survive and grow in this challenging environment, it is imperative that solutions are found to address noise pollution.

Especially in times when quiet electric cars significantly reduce noise pollution, aviation must also reduce noise emissions as quickly as possible. Especially on and around airfields.

We have to act before next airfields are closed due to high noise emissions, or before operating times at airfields are reduced even further.

3. Exhaust Emissions

The very high emissions of aircraft engines due to suboptimal combustion in the old engines and the use of leaded AVGAS will lead to far-reaching restrictions.

Leaded AVGAS is banned in the EU from May 2025.

35 years after the introduction of catalytic converters for car engines, they are still not to find in aircraft engines. Although leaded fuel was banned from the road more than 20 years ago, most sport planes worldwide still fly with leaded AVGAS.

There is an urgent need to provide solutions for the future.

The trend towards electric drives is a step in the right direction. However, the very slow increase in the available battery energy densities and the associated enormous weight of the batteries shows that most of the flight requirements of general aviation will probably not be able to be met with battery-electric operation in the coming 20 to 30 years.

4. Maintaining the Usual Range and Flight Performance

Even the most economical aircraft with low engine power can only be sold with tanks from 70 liters or more. This means a minimum flight time of 4 hours and a range of at least 800 km. A drive power of around 70 hp is assumed for the cruising flight.

The vast majority of general aviation pilots see this as a minimum requirement when purchasing an aircraft.

Only a small fraction of these requirements can be achieved with batteries or hydrogen for the next 25-30 years or longer.

More information to this topic please find here: more info

5. ... for all NEW and for all EXISTING AIRCRAFT

for NEW and EXISTING aircraft

If a new propulsion system is only suitable for new aircraft and new aircraft types, then it will take decades after the propulsion and all its components have been implemented and new aircraft are developed, produced and old aircraft are replaced. It would take many decades before changes in terms of environmental pollution can be reached.

In order to achieve noticeable changes in terms of environmental pollution as soon as possible, it is very important that new propulsion systems are also suitable for equipping existing aircraft types and hundreds of thousands of existing aircraft.

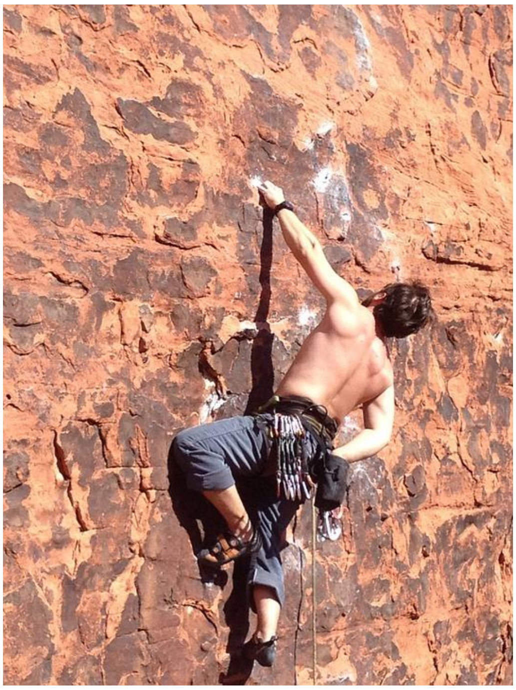
6. Time is the Key: Implementation in the Next Few Years

It's nice to hope and dream, but we need the solutions in the short term.

... not just in 30 years!

There is currently no known technology that can do this. We therefore need a bridging technology for the next 30 years and even longer in order to be able to find solutions as quickly as possible.

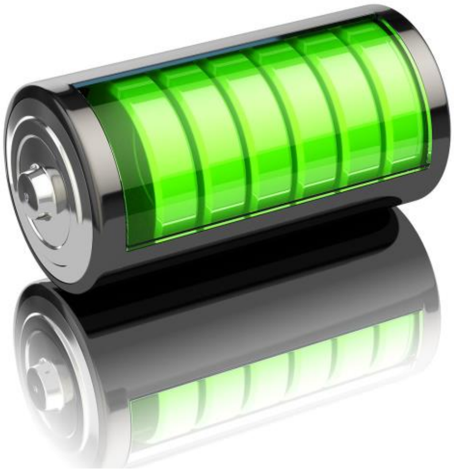
We don't take the easiest way, we go the best way !



B Alternative Energy Sources for Aviation

B.1 The Battery-Electric Flight

Where are we today with the ENERGY DENSITY of BATTERY SYSTEMS ?



Here is an overview of the realized energy densities of car batteries:

Audi e-tron: 95 kWh / 700 kg	136 Wh/kg
Ford Mustang Mach-E: 68 kWh / 485 kg	140 Wh/kg
Audi e-tron GT: 93,4 kWh / 630 kg	148 Wh/kg
Porsche Tycan: 93,4 kWh / 630 kg	148 Wh/kg
Jaguar I-pace: 90 kWh / 599 kg	150 Wh/kg
BYD Han EV: 85 kWh / 568 kg	150 Wh/kg
Mercedes EQS: 107,8 kWh / 692 kg	156 Wh/kg
Tesla S: 100 kWh / 625 kg	160 Wh/kg
Tesla 3: 75 kWh / 439 kg	171 Wh/kg
Tesla Y: 75 kWh / 437 kg	172 Wh/kg
Rimac: 120 kWh / 599kg	200 Wh/kg

So the average at brutto energy density is 157 Wh/kg. And also these energy densities are calculated without the weight of cooling liquid, tubes, pumps, coolers, etc. These energy densities above are brutto battery energy densities. The useable energy is normally about 5 - 10% less.

Taking all these factors into account, the average of the actually realized net energy densities which can be really used for the drive are around 145 Wh/kg.

Significantly higher battery requirements apply to aviation batteries. Crash safety and fire resistance in particular play a major role here because in case of fire it is not possible to stop and leave the aircraft.

This further reduces the actually available energy density.

For example the Pipistrel aviation battery: PB345V124E-L

One pack with 10,35 kWh weighs 74 kg = 140 Wh/kg of energy density, and this without cables, tubes, cooling liquid, pump, cooler, crash-resistant case, etc. More information can be found here: more info

Airplanes are about 10 times more weight sensitive than cars. Even if the battery-electric drive for road traffic is emerging as the future solution, this is by far more difficult for the significantly weight-sensitive aircraft. Most developers of electric aircraft and eVTOL (vertical take-off and landing) aircraft calculate with a usable energy density of 350 to 400 Wh/kg.

This is hyped by the media, but these are the brutto energy densities of the single cells under laboratory conditions. Unfortunately, the reality is different as the list shows above.

The following physical energy consideration is intended to show what performance is currently achievable for cruising with battery-powered aircraft (not for gliders or motor gliders):

➢ **Battery** (2x Pipistrel PB345V124E-L, weight ca. 148 kg)	**20 kWh**
➢ Energy losses (motor, inverter, cable, ...)	-10%
➢ **Available drive energy**	**18 kWh**
➢ Acceleration and fly to cruising altitude	-1.2 kWh
➢ legal minimum reserve 30 min. @ 27 hp (20 kW)	- 10 kWh (min. power assumption!)
➢ **remaining energy for planned cruise flight**	**6.8 kWh**

What flight time can be achieved with 6.8 kWh of energy ?

	cruise power setting	
	standard	minimum
Assumed cruise power	**70 hp (50 kW)**	**40 hp (30 kW)**
Legally plannable flight time	**8.2 minutes**	**13.6 minutes**

This calculation does not consider the power consumption for the avionics, electric landing flaps, retractable landing gear or even a cabin heating or pressurized cabin !

It can therefore be assumed that purely battery-powered sport aircraft will essentially remain restricted to operations close to airports, at least for the next 25-30 years, unless a battery miracle happens.

Even most economical aircraft with low engine power can be sold with tanks from 70 liters or more. This achieves a minimum flight time of 4 hours and a range of at least 800 km with a drive power of around 70 hp.

The vast majority of general aviation pilots see this as an absolute minimum requirement when purchasing an aircraft.

Let's have a look at the weight calculation:

A battery to power an electric motor with **70 hp for a flight time of 4 hours** weighs around **1.145 kg** with today's most modern battery technology. (51,5 kW / 90% efficiency x 4 hours = 229 kWh / 200 Wh/kg = 1145 kg)

In comparison, a filled **70 liter gasoline tank weighs around 58 kg** including pump, tubes, etc., which drives a **piston engine for 4 hours at 70 hp !**

This results in the **well-known weight factor of 1:20** (1145/58 kg), it means to bring the same energy to the propeller, **a battery system weighs twenty times more than a fuel system**. And that with the best batteries currently available. But we know, in aviation counts every kilogram !

It has to be considered that light planes have a maximum take-off weight of up to 600 kg, but we want to **replace a full 70 liter / 58 kg tank with a battery of 1.145 kg ? It is advisable to think realistically!**

This clearly shows that we are far away from replacing piston engines by electric motors at airplanes. Only a small fraction of the requirements can be achieved with batteries or hydrogen for the next 25-30 years or longer. **So we need a bridge technology for 30 years and probably more – XAEROS is developing it !**

B.2 Hydrogen as an Energy Carrier

Hydrogen does not occur in nature in a directly usable form. Hydrogen has to be technically produced in order to make it usable. Hydrogen is always colourless, but several names have become common to distinguish it in terms of the manufacturing process.

The so-called green hydrogen is produced by electrolysis. Here, the so-called renewable energy is obtained from water, sun and wind power for the splitting of water (H_2O) into hydrogen and oxygen. This process is only possible with an efficiency of around 80%. This means that 20% of the valuable renewable energy is already lost in the first step.

If you turn the surplus green energy into hydrogen on sunny and windy days, then around 10% of the hydrogen requirements for industry can be covered. We will therefore not be able to produce enough green hydrogen in temperate zones to be able to use it for e-mobility. On the contrary, there is a lot of talk about an electrical blackout because we don't have enough electrical power for current applications.

Hydrogen would therefore have to be produced for the most part in sunny and windy regions around the world. However, hydrogen is not so easy to transport across the oceans in large tankers. This requires cryo-tankers with very well insulated pressure vessels that can transport the hydrogen in liquefied form, i.e. cooled down to minus 253 Celsius.

The latest and largest hydrogen tanker model was developed by Dutch energy company LH2 Europe. It will not be operational before 2027. And even then, there is only one tanker available worldwide !

The 142-meter-long liquid hydrogen tanker holds 37,500 m^3. However, liquefied hydrogen is very light at only 71 kg/m^3, which means that this largest pressure tank tanker can only transport 2,660 tons of liquefied hydrogen. A proportion of around 15 - 20% of this is also lost through boil-off while driving. Part of it can be used to propel the tanker.

This means that only around 2,260 tons of hydrogen arrive at the port of destination, which corresponds to energy of around 75 million kWh.

In comparison, a medium-sized oil tanker, which can also be used to transport eFuels, holds around 250,000 tons, which corresponds to an energy of 3.000 million kWh.

It means, 40 hydrogen tankers can transport as much energy as one tanker for eFuels !

In addition, oil, diesel and kerosene tankers are gradually becoming free because of the energy transition and can be used to transport eFuels. Hydrogen tankers do not currently exist and would have to be developed, produced and deployed from scratch. Huge investments would be required here.

Other manufacturing processes, such as so called "grey hydrogen", use natural gas, i.e. methane, as the basis. When converting methane into hydrogen, which is how most of the hydrogen today is produced, around 10 kg of CO_2 are released per kg of produced hydrogen, which is why this is very questionable from an environmental point of view.

Hydrogen as an energy carrier is associated with difficult-to-solve challenges in General Aviation:

Infrastructure

Most general aviation aircraft are flown at small airfields, very often in club operations. It is unlikely that airfields and clubs would invest around € 1 million per hydrogen filling station if they can buy 3-6 brand new aircraft for the same money. The question also arises as to whether investing in a hydrogen filling station will ever pay off.

Technology

To fly with hydrogen must also be considered

- enormous weight and extensive technology of the components (tanks, fuel cell, lines, technology, etc.)
- large volume of hydrogen tanks, so it´s not possible to store hydrogen in the wings
- converting existing aircraft is very difficult. This means that new aircraft for hydrogen propulsion would have to be developed, produced and purchased
- it would take many decades to replace the existing aircraft, which all are made for fuel operation

It can be assumed that it would therefore take decades before the switch to hydrogen-powered aircraft would have any impact on environmental protection, which urgently needs to be promoted.

The big players such as AIRBUS with the ZEROe project have also postponed long-term their hydrogen projects. AIRBUS said, they don't see the realization of hydrogen propulsion before 2050.

B.3 Synthetic Fuels - eFuels

SAF, Sustainable Aviation Fuels, synthetic fuels and biomass fuels are the next step in aviation propulsion. These can be implemented much earlier than purely electric drives or hydrogen-based drives.

Synthetic fuels are made from CO_2 from the air, water and solar or wind energy. Exactly as much CO_2 is absorbed from the air during production as is later released again during combustion. Therefore, with synthetic fuels, so-called eFuels, a CO_2-neutral operation of aircraft is possible without without having to change anything in the engine or fuel system.

Often the efficiency of eFuels is compared to hydrogen, but assuming direct on-site manufacture and use in temperate climate zones. However, this comparison is not correct because we cannot produce significant amounts of green hydrogen in temperate regions. It would be more correct to compare hydrogen and eFuels with production in sunny and hot regions all over the world and transport it to temperate climate zones.

The efficiency in the production of Hydrogen is about 80%, that of eFuels is around 60% if eFuels are produced from green electricity in a closed process. But eFuels do not have to be cooled down to -253° C and transported with special tankers with very limited capacity. However, liquid fuels have the advantage that transport is much easier and cheaper and the infrastructure required for transport to refueling at the airport is already available.

The cooling process requires about 35% of the energy of hydrogen and the reshaping into gaseous hydrogen at the port of destination again requires large systems and results in energy losses. This means that the cooling losses and the losses of hydrogen on sea transport are by far higher than the lower efficiency in the production process of eFuel/SAF.

The transport of eFuels over long distances is cost-effective and much more energy-efficient. Synthetic fuels can therefore be produced where there is an abundance of regenerative energy, i.e. in sunny and windy regions around the world. With the same investment, installing a solar system in a desert region produces around three times the amount of green energy compared to systems in central Europe, for example. Transport ships can also be operated CO2-neutrally with eFuels.

The chain of conversion from green energy to e-fuels goes through three stages, from electrolysis through synthesis gas to Fischer-Tropsch synthesis.

The typical Fischer-Tropsch product contains around 10-15% gases (propane and butanes), 50% gasoline, 28% kerosene, 6% soft paraffin (slack wax) and 2% hard paraffins. The paraffin products can be used to make plastics instead to make it from fossil oil.

In the future, road traffic will be largely electrically powered. It's the most efficient way. However, airline aviation will still be dependent on kerosene for many decades, but it can be produced synthetically using the Fischer-Tropsch synthesis. In this procedure around twice as much gasoline is produced as kerosene. It can therefore be assumed that synthetic gasoline will be significantly cheaper than kerosene. This will mean that diesel/kerosene-powered piston engines will become massively less important, since they already have significant disadvantages compared to gasoline aircraft engines.

B.4 Conclusion

Developing new aircraft for battery-electric or hydrogen-based propulsion will take many decades. It would take additional decades before the new aircraft are in operation and the first noticeable effects in terms of CO2-reducing operation become apparent. Quite independently of this, the question arises as to whether the required ranges and requirements of aviation can ever be achieved with these technologies.

eFuels do not make sense where battery electric solutions are applicable.

But with eFuels air and ship traffic can be converted to CO2-neutral operation in the foreseeable future. This is possible with the existing ship and aircraft fleets. The entire infrastructure network is also available for this. As a result, appropriate measures can be taken regarding the urgently needed environmental protection in a much shorter period of time.