Serosin. Now!

Why the Production of Sustainable Aviation Fuels must be pushed forward more intensively.

Rudolf (Rolf) Doerpinghaus
International Association for Sustainable Aviation e. V. (IASA)
www.iasaev.org

2nd (virtual) European Summit on CO2-based Aviation Fuels
March 23, 2021

IASA International Association for Sustainable Aviation e.V.

Why the production of sustainable aviation fuels must be pushed forward much more intensively.

PtL CO_2

Bill Gates put it straight to the point:

'The negative effects of climate change are much greater than those of the pandemic.'

This brings us to some key questions:

- **How to protect the climate *and* the future of aviation?**
- **How to meet the COP21-Requirements (Paris 2015) on time?**
- **How to avoid severe and permanent burdens and restrictions?**
- **How to act in times of COVID-19 and the worst depression that ever hit aviation and the air transport industry?**

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SEROSIN.
An invitation to secure the future of aviation.

- Today, you may hear for the first time the expression ‘SEROSIN’ (or ‘ZEROSINE’), an acronym for ‘Sustainable Kerosene’.
- That’s why you may ask,
  - what the term SEROSIN stands for and
  - why this acronym should be introduced?

- Is it a new chemical? No!
- Is it a new brand? No!
- Is it a new designation for a chemical formula? No!

As proposed and defined by IASA, it’s

- **a new class of JetFuel, strictly based on Green Energy, Water and CO_2 from the air or from industrial waste *and* it is also**
- **an invitation to jointly speed-up the transformation of aviation into carbon neutrality.**

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How to meet the COP21-Requirements (Paris 2015)? How to avoid severe and permanent restrictions?

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- According to IPCC, global warming shall be limited to 1.5 °C in order to mitigate the worst risks of climate change!

- For aviation and the air transport industry, the COP21-Agreement (Paris 2015) requires a nearly net-zero-reduction in CO_2 – emissions by 2050!

The race is on!

- International air transport must be transformed into the post-fossil age and has to reach nearly net-zero CO_2-emissions in less than 30 years (!!!), an unprecedented challenge!

- If aviation finds no solution to comply with the requirements of COP-21, the international community of nations will most likely introduce severe penalties, high compensation fees, restrictions and heavy financial burdens to limit growth!

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Potential tools or pathways to transform today's aviation into a carbon neutral future.

- Continuous enhancement of today's aircraft
- Ongoing operational improvements
- Developing all new and disruptive aircraft concepts and propulsion systems
  - All-electric concepts
  - Electric-hybrid concepts
  - Hydrogen-based concepts
- Advanced, non fossil aviation fuels
  - SAF (Bio Fuels)
  - SEROSIN-class high sustainable aviation fuels (PtL, E-Fuels)

Fortunately, there are many options to mitigate the impact of aviation on the climate. But, there is only one pathway to meet the Paris Agreement: Non-fossil fuels. Immediate action is required. Timely realizable options should be given priority!

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Helpful: Continuous improvements of today's aircraft help to compensate growth!

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A350-900: Photo Airbus

- **The continuous enhancement of today's aircraft helped to decouple the growth of commercial aviation from the increase of emissions.**

- **By this means, between 1990 and 2016 fuel consumption could be reduced by 42% or to about 3.5 Liters per pax and 100 km** (Source: BDL).

- **As effective the improvements of aircraft and engines are, they can never be enough to make aviation carbon-neutral.**

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Helpful: Improvement of ATC, traffic management, flight operations and infrastructure is a must.

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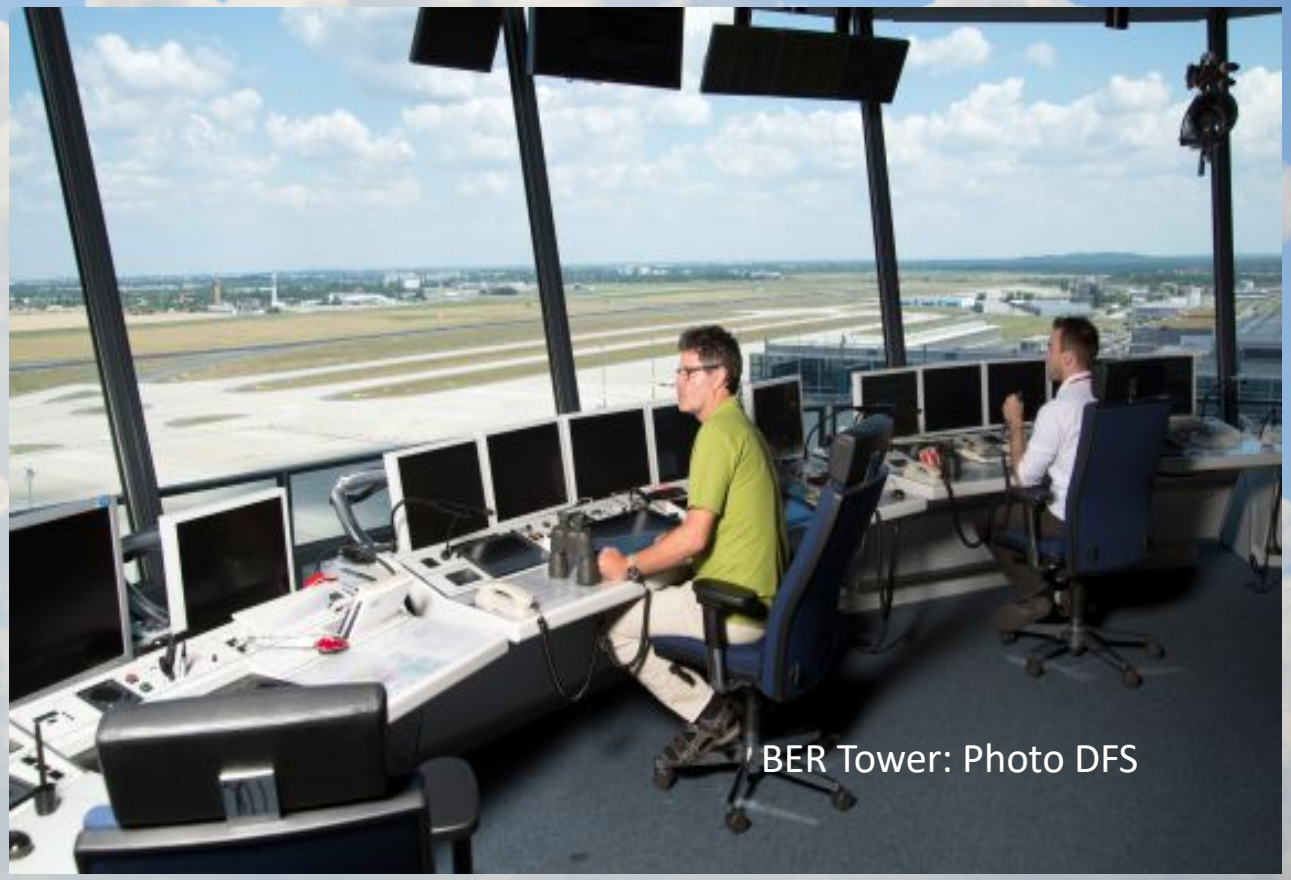
- Sufficient capacity of air traffic control (ATC) is as important as the introduction of advanced airspace structures and better technologies for a more efficient air traffic management.
- Optimized ATC could lead to fuel savings of up to 10% (e. g. direct routings)
- Without an ongoing improvement of ATC and infrastructure (e.g. airports), aviation will be at risk to lose all gains from advanced aircraft and engine technologies.



BER Tower: Photo DFS

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All-electric aircraft concepts offer new horizons for General and Regional Aviation.

PtL CO_2


Photo: Lilium


Photo: TBM

- Helpful for smaller aircraft!
- Presently, there are many hybrid and all-electric aircraft under development.
- Besides the reduction of CO_2 - emissions hybrid and all-electric aircraft offer additional benefits in terms of less noise; less maintenance; and a high engine reliability.
- All-electric aircraft may mainly be used in General Aviation or Regional Air Transport for short and medium range services only or Urban Air Mobility (Air Taxi).

Photo: Tecnam / Rolls-Royce

Extra Aircraft /Photo: IASA

Introducing Airbus ZEROe

September 2020, Airbus revealed three concepts for the world's first zero-emission commercial aircraft which could enter service in 2035, at the earliest.

Source: AIRBUS

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Helpful: Disruptive Airbus ZEROe-concepts for ‘zero-emission’ commercial air transport.

PtL CO_2

- Hydrogen will be the primary power source for the first zero-emission commercial aircraft as proposed by Airbus.

- If designing and building of proof-of-concept testbeds, market research, final product definition, aircraft and engine construction, prototypes, ground and flight testing, certification and - if necessary - the set-up of new certification rules can be done in such a short time, the exchange of an estimated world fleet of then up to 50,000 aircraft would take at least another 40 to 50 years, may be until at least 2085.

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COP21-Requirements (Paris 2015): Nearly complete CO_2 – Net-Reduction by 2050.

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As important as the fundamental research and the development of new and highly disruptive technologies are, the worldwide introduction of hydrogen-driven aircraft may come much too late in order to help aviation meet the requirements of the Paris Agreement on time.

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Suitable solutions must include existing fleets! Large number of today's aircraft still in use in 2050.

- Aircraft are very durable and long-lasting industrial products.
- Production programs may last decades (Boeing 747: First flight 1969 / End of production 2022 / End of service around 2050?)
- Properly maintained, the average life cycle of an aircraft – from entry into service to final retirement – is up to 25 years for typical narrow-bodies and more than 35 years for long range wide-body aircraft depending on the use.
- Retirement decisions are usually made due to economical calculations, mostly referring to the expenses for MRO and fuel.

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ATAG: Non fossil aviation fuels are the most suitable solution!

Basically, there are two families of advanced, non fossil aviation fuels:

- **SAF (Bio-based Sustainable Aviation Fuels)**
- **E-Fuels (Electro-Fuels or PtL-based high sustainable aviation fuels)**

- **As the Air Transport Action Group (ATAG) said last year, non fossil aviation fuels are the most suitable solution**
  - **to meet the deadlines of COP-21**
  - **to include existing and future fleets.**
- **Due to a limited feedstock, limited production capacities and high costs, France intends to replace 2% of fossil fuels by 2025, and Germany about 1% by2028.**

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Recent WHU*– study underlines the importance of sustainable aviation fuels.

WHU* Research Study 11/2020 (Ringbeck & Koenig), published March 17, 2021

Regarding the 'Effectiveness of Decarbonization Measures', there is a clear consensus within the respondents of the poll that

- there is a need for additional decarbonization measures on global government level (78% of respondents)
- until 2050, sustainable aviation fuels are expected to be the most effective lever for the decarbonization of the air transport industry
- a globally binding SAF quota must be introduced (more than 95% % of the respondents support after 2030 a long term SAF quota with anaverage of more that 25%)

About 46% of the respondents see the highest decabonization potential with BioFuels, while only about 21% prefer E-Fuels. Herewith, the poll underlines the need for additional educational work in order to inform the industry, politics and the public about the benefits of 'SEROSIN'-class fuels.

*WHU – Otto Beisheim School of Management

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First Test Flight using 100% SAF.
'Door opener' for non fossil aviation fuels.

PtL CO_2

All Airbus aircraft are certified to fly with up to a 50% blend of SAF mixed with kerosene. But the emissions performance of SAF when unblended with fossil fuels has remained a question mark.

Source: DLR

Toulouse, March 16, 2021

Airbus, German research center DLR, Rolls-Royce and SAF producer Neste have teamed up to start ground and flight tests to compare emissions from 100% SAF made from HEFA (hydroprocessed esters and fatty acids) against those emissions produced by fossil kerosene and low-sulphur fossil kerosene.

Photos: Airbus

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Mitigating the impact of aviation on climate change equals much more than just reducing CO_2–emissions.

PtL CO_2

- The test flight, conducted on March 16, 2021, is the first in a series of clearance tests scheduled to analyze the safety of 100% SAF.
- In April, DLR's Falcon 20E "chase" aircraft equipped with 'sniffer'-sensors will follow 50 meters behind the A350 to measure the emissions directly from the SAF-fuelled engine exhaust.

- SAF have already demonstrated its efficacy in reducing CO_2 emissions.
- The project will help to better analyze the impact of other climate-relevant emissions from aircraft engines, including:
  - Carbon monoxide (CO)
  - Nitrogen dioxide (NOx)
  - Water vapor
  - Soot
  - Aerosol and sulfate aerosol particles
  - Contrails and contrail cirrus clouds (i.e. clouds of ice crystals produced by aircraft engines at high altitude under certain meteorological conditions)

The results of this SAF research project may also be used as an important benchmark to compare SAF with PtL-based E-Fuels (called by IASA as 'SEROSIN').

Sources: DLR, Airbus, NESTE

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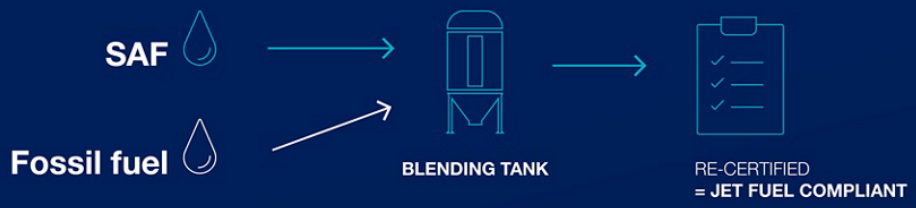
Due to lack of the availability of feedstock SAF may require highly complicated logistics.

- The series of ground and flight tests will compare
  - findings from the unblended SAF mixture made from HEFA
  - against those of standard kerosene and low-sulfur kerosene.
- HEFA feedstock generally consists of globally sourced animal fat and used cooking oil, but locally sourced feedstock from specific regions can also be used. The feedstock supplied to Airbus for the project is of EU origin.
- In addition, the 117 tons of neat SAF that will be used for the entire test campaign were all produced in Europe and supplied by Finland-based Neste.
- The SAF refining process was carried out at the company's refinery in Porvoo, Finland.
- After refining, the SAF was then transported by ship to Rotterdam, where the final processing step, known as fractionation, took place.
- From Rotterdam, transportation via truck brought the SAF to Toulouse, France in ISO containers.
- Initial results from the ground and flight tests are expected later in 2021, and more complete results in 2022.

Sources: DLR, Airbus, NESTE

What is Sustainable Aviation Fuel?

SAF is a “drop-in” fuel that can be blended with jet fuel and used in aircraft without any engine modification required.

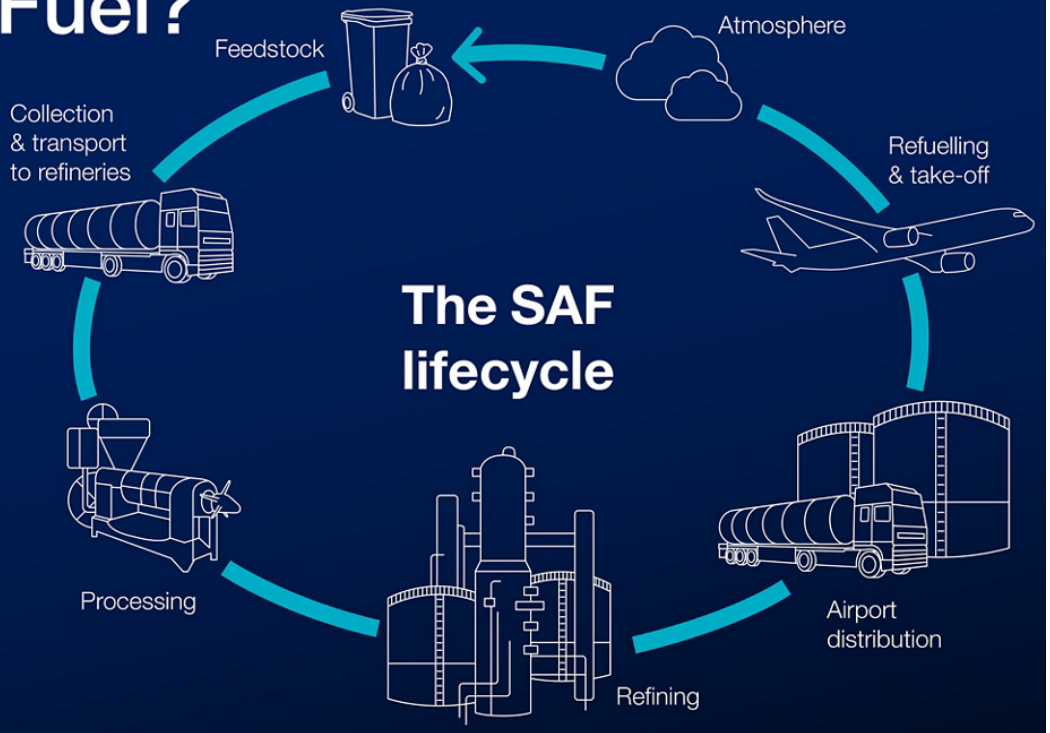


Made of sustainable resources like:

- **Municipal solid waste**
- **Used cooking oil**
- **Food waste/sugars**
- **CO_2 & green H_2**

Up to **80%** less CO_2 over its lifecycle compared to jet fuel

+300,000* flights have run on SAF since 2011



2011 Launch of first series of A321 passenger flights using 50% blended biofuels (Lufthansa)

2012 North America’s first “Perfect Flight” using 50% blended biofuels on A319 (Air Canada)

2015 First flight of A320 operating on 10% SAF blend

2016 First customer deliveries of SAF-enabled aircraft

2019 Launch of SAF use for Airbus Beluga operations

2021 First flight of A350 operating on 100% SAF blend

AIRBUS

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Bio-based Sustainable Aviation Fuel (SAF). Availability of sufficient Bio-feedstock questionable.

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Currently, six mostly bio-based production pathways (ASTM-certified) are usable for blending with fossil kerosene:

- **FT-SPK** (Fischer-Tropsch Synthetic Paraffinic Kerosene) produced by converting bio-mass into synthetic gas and then into aviation fuel. Max blending 50%.
- **FT-SPK/A** is a variation of FT-SPK, based on alkylation of light aromatics. Max blending 50%.
- **HEFA (Hydro-processed Fatty Acid Esters and Free Fatty Acid such as vegetable oils, used cooking oils converted by using hydrogen). Max blending 50%.**
- **HFS-SIP** Synthetic Iso-Paraffinic Kerosene produced by hydro-processing of fermented sugars. Max blending 10%.
- **ATJ-SPK** (Alcohol-to-Jet) Synthetic Paraffinic Kerosene. Converting alcohols such as iso-butanol into hydrocarbons. Max blending 50%.
- **Co-processing**: Using up to 5% bio-crude in petroleum processes.

Source: EASA

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Despite numerous efforts, the shortage of SAF remains disappointing.

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- SAF is available in limited quantities only. Despite an order backlog of 1.6 billion gallons in global forward purchasing agreements, only 10.5 million gallons would be produced in 2020.
- For the foreseeable future, EASA expects that the use of SAF will remain most likely very limited.
- Lufthansa and many other airlines have frequently demonstrated their serious interest in non-fossil aviation fuels, using a blend of fossil Jetfuels and BioFuels on commercial flights.
- Lufthansa and Swiss used SAF blends on regular flights from San Francisco to Europe. Up to one million (?) gallons of SAF should be supplied over the duration of the contract.

- However, Thorsten Luft, Vice-President, Corporate Fuel Management, Lufthansa Group, said at an EU Roundtable on SAF on March 4, 2020, in Brussels that
  - SAF are presently 2-5 times more expensive than fossil kerosene, and
  - SAF-production covered only about 0.01% of the 96 billion gal (about 365 billion liters) of global jet fuel demand in 2019.
- IATA expects an use of 2% of SAF until 2025 (depending on the recovery after Covid-19)
- Due to the limitation of feedstock, SAF may become more expensive the more it is needed.

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FT/PtL-based E-Fuels allow aviation a large scale entry into circular CO_2 – economy.

SEROSIN: IASA-designation for JetFuels meeting highest sustainability standards.

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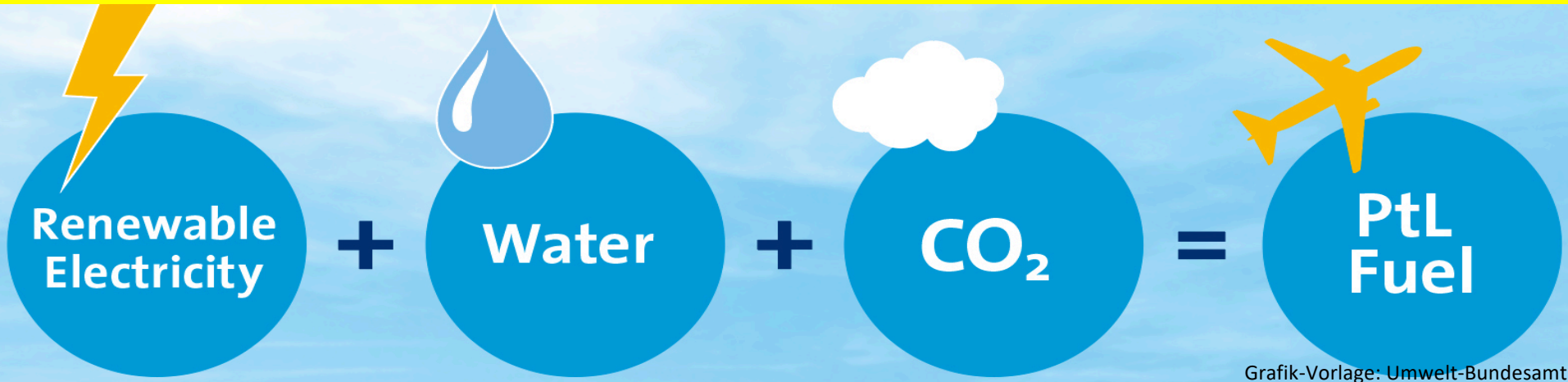
Advanced solution: Combining FT/PtL-Synthesis with latest PtX-insights.

PtL CO_2

Basic advantages of the 'SEROSIN'-class:

- Unlimited scalable.
- Unlimited feedstock.
- Unlimited choice of production locations.



Grafik-Vorlage: Umwelt-Bundesamt

Fischer-Tropsch hydro-processed synthesized paraffinic kerosene is already ASTM-certified since 2009 for an up to 50% blend (ASTM D75665).
However: Carbon capture technologies and systems are subject to further improvements!

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Main requirements to qualify a JetFuel as ‘SEROSIN’.

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Production must be completely based on a highly energy-efficient PtL-technology

- **Use of 100% green energy must be certified**
- **Use of freshwater must be limited to a few Liters per Liter ‘SEROSIN’**
- **CO2-supply must be taken exclusively**
  - **from the air or**
  - **as waste from industrial sources, e.g. from cement plants, biogas plants etc.**
- **In addition, fuels qualified as ‘SEROSIN’ must be**
  - **AMST-certified**
  - **drop-in-capable without any restrictions**
  - **worldwide chemically standardized**
  - **decentralized producible in unlimited amounts, wherever green electricity, water and CO_2 is available**

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Why the designation ‘SEROSIN’ will help to accelerate the introduction of high sustainable E-Fuels.

PtL CO_2

- Until now, the designation of synthetic aviation fuels is mostly based on its chemistry or its production pathway, causing a Babylonian confusion in public relations.

- The acronym ‘SEROSIN’ (ZEROSENE) as proposed and introduced by IASA stands for a class of highly sustainable aviation fuels, not for a single brand or a single product.

- SEROSIN (derived from Sustainable Kerosene) shall be a collective term for a class of most sustainable and economical most advanced JetFuels.

- In order to ease political and public discussions and to accelerate the transformation of aviation into a climate-friendly future, the standardized and certified classification ‘SEROSIN’ shall show the sustainable value of a specific aviation fuel at the first sight.

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Invitation to join the ‘SEROSIN’ – Group

- As ‘SEROSIN’ describes a class of highly sustainable JetFuels, IASA invites each and every producer of such fuels to join the group and to improve aviation’s fuel infrastructure.

- The ‘SEROSIN’-Group is open for every production pathway as long as the ‘SEROSIN’-qualification standards are met and certified.

- In addition, IASA invites all producers of qualified Jetfuels to join forces on political, international and public stages to support and accelerate the introduction of these fuels, especially in view of financial support based on CORSIA- and/or ETS-fees.

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Commercial air transport: CORSIA and EU ETS may help to introduce FT/PtL-based fuels.

PtL CO_2

CORSIA, the Carbon Offsetting and Reduction Scheme for International Aviation (ICAO), and EU ETS should be used to foster the introduction of non-fossil aviation fuels.

- **IATA estimates that just CORSIA may cost air carriers***
  - **2.2–$6.2 billion $ in 2025,**
  - **$4.3–$12.4 billion $ in 2030 and**
  - **$8.9–$23.9 billion $ in 2035.**
- **This corresponds to a total of**
  - **59.3–$165.3 $ billion from 2021 to 2035, assuming carbon costs ranging from $ 15 to $35 billion in 2025, and $20 to $40 billion in 2035.**

*Source: POLICY UPDATE/ INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION /February 2017

IASA is asking decision makers in politics and international organizations to use the scheduled mandatory financial contributions to CORSIA and EU ETS to support the worldwide introduction of FT/PtL-based 'SEROSIN'-class aviation fuels.

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People want to fly!
People want to protect the climate!

PtL CO_2

Aviation connects people, nations and economies around the globe!

Due to the limited use of land,
the incomparable flexibility of its route-networks,
and the high speed of its services,
aviation has the unique potential to become one of the
most efficient, climate- and environment-friendly means of transportation.

The ability to reduce the impact on climate change
will define the future of the air transport industry.


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‘It always seems
impossible
until it's done.’
Nelson Mandela
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