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Sustainable Aviation Fuel

The Bridge between Energy and Aviation Worlds

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The Bridge between Energy and Aviation Worlds….today!

Climate change: a function of emissions (CO_2, NO_x, contrails,..) - their location, their quantity & the point in time

Layout intended as script for handout

Introduction – Aviation…has history…needs future

- Aviation has transformed the world
- Indispensable element of social and cultural communication / understanding
- Tool for regional development and avoiding creation of social conflict areas
- Millions fly daily – for business, holidays, help those in need, or visit relatives. Banning any of this is a wrong step
- The industry grows on average 3% p.a.
- Aviation pays for its infrastructure
- Aviation shows energy production and its consumption CO_2 in its reports

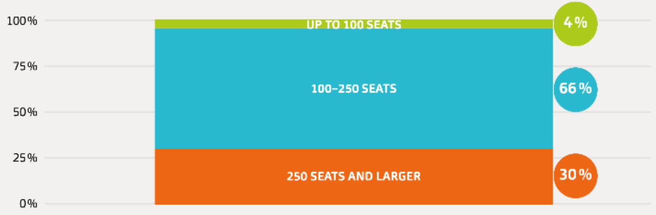
- Aviation is an integral part of mobility

Facts and Figures

- Aviation works with technology readiness levels; these indicate that it will take at least two decades to really mature a brand-new fuel such as hydrogen for true EIS
- Aviation >100 seats uses ca 95% of energy, commuter <50 seats roughly 1%, 50-100 seats roughly 4% … what would be the big impact approach…

96 % of Emissions Come from Aircraft with over 100 Seats

Applying the use of kerosene consumption and percentage of traffic to the categories of commercial aircraft, it becomes evident that the market up to 100 seats is irrelevant when it comes to battling climate change.

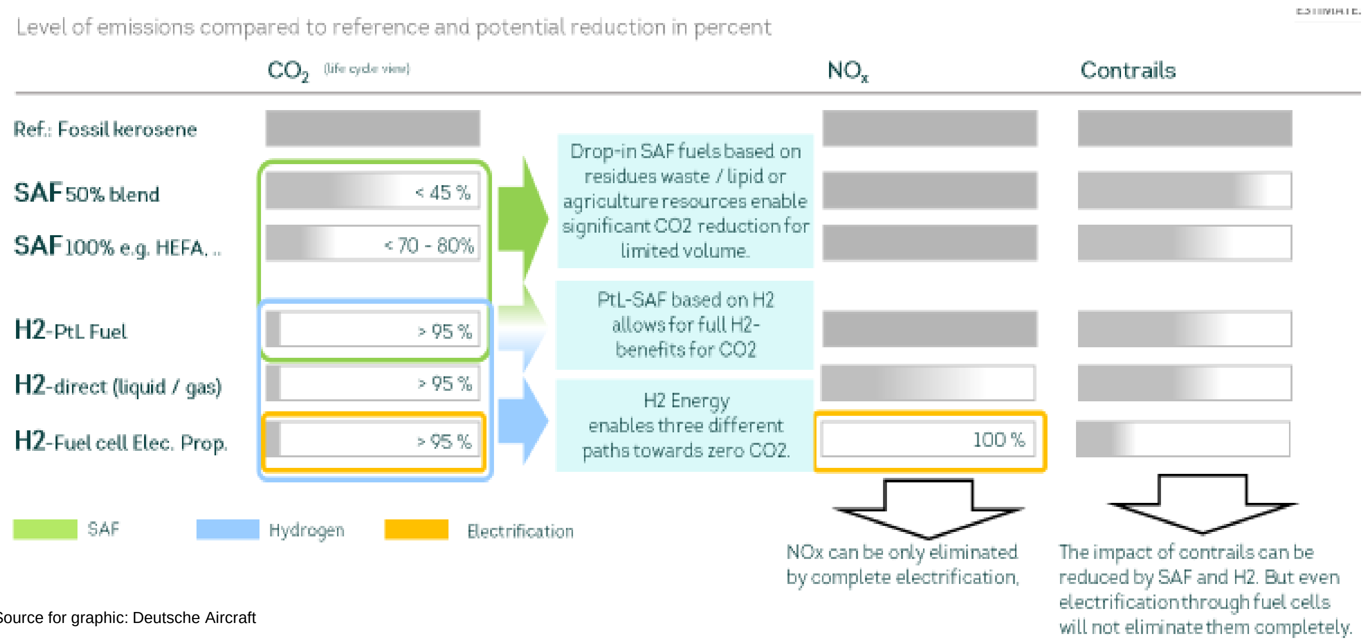


The vast majority of today's emissions in aviation are stemming from the segment above 150 seats covering medium and long haul, so the potential impact of some regional aircraft changes is close to none and would not justify a separate infrastructure.

Source for graphic: Sustainable Aerolab, Hamburg

- OEMs produce 1500-2000 aircraft p.a. *(in service ca 30.000a/c, expected in late 2030s 40.000 a/c)* which will remain in service up to 30 years; these products are based on **today's energy infrastructure**
- 60% of aircraft are financed/leased. A global asset approach is required
- Efficiency jumps during the last 50 years realistically amount to ca.1% energy saving p.a.
- Holistic? - "zero e" at tail pipe are "exporting" emissions to other sectors and/or countries
- Don't forget other "inefficiencies" which can be addressed to reduce consumption

Not to be forgotten…



Source for graphic: Deutsche Aircraft

Some Laws of Physics and a bit of Science

- Conventional takeoff needs much less energy than vertical takeoff
- **Batteries** ...
  - Aviation defies gravity, hence heavier needs more energy to transport a unit over a distance
  - A 737/A320 would need a battery pack weighing over 100tons; fuel cell into the same aircraft capabilities would quadruple the energy requirement but only allow for roughly 25% of the capacity
  - Heat management adds complexity and safety challenges
- **Hydrogen** ...
  - Lighter than batteries/kerosene, but more volume is needed, reducing capacity and/or increasing energy needs per unit, less though than for batteries
  - Can be used to create SAF fuels (PtL, eFuel, SynFuel,…) but also inserted into fuel cells when ready
  - LH_2 fueling process takes longer prompting more airport space needs
  - H_2 can create contrails thus global warming; currently researched to reduce
- **SAF in all forms**
  - Similar to kerosene, scalable if PtL etc
  - Available today to blend AND can largely use today's infrastructure

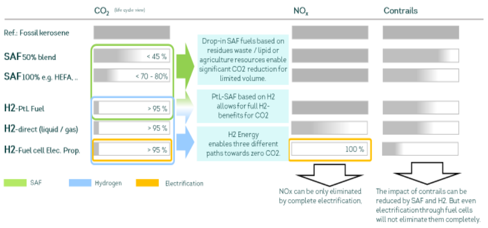
Operations – infrastructure - safety

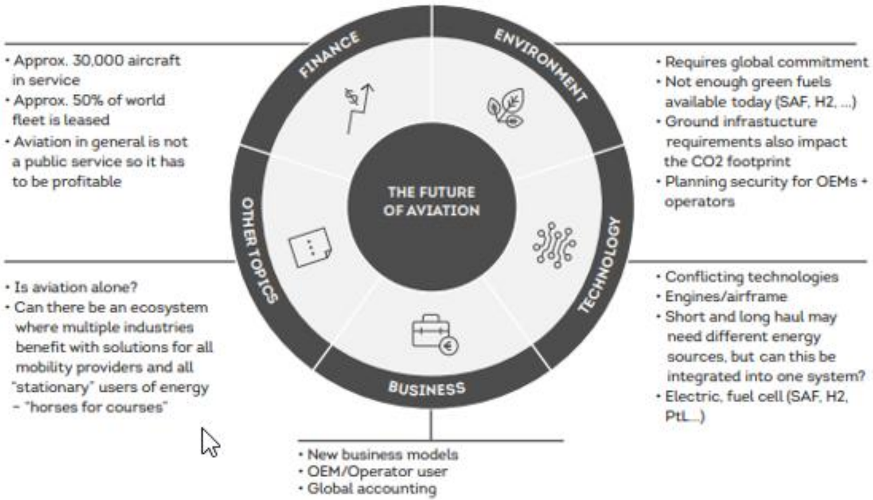
- Aircraft operate globally and require a (global) ground infrastructure
- All ends of a trip need the same energy availability
- Fueling different fuels creates a different system
- Route specific aircraft would kill financing structures and require even more reserves in planes and ground and thus using more natural resources
- Aviation is a safety sensitive system with high and complex regulations because of the third dimension as such it is preferable to keep complexity on ground and in the supply chain rather than in the air
- Requiring more space on ground, hence larger aprons, sealed surfaces *(if aircraft get larger or need longer to refuel)* – this applies to ALL airports

Reality and Environment

- SAF can yield the effects required today
- SAF is available to certify for all aircraft today, even if only blended.
- New aircraft coming into the same infrastructure can increase the blend and even be certified to 100% SAF/PtL
- SAF allows environmental benefits at scale today rather than waiting close to another two decades
- H_2-direct/H_2-Fuelcell only offer required TRL about a decade after tests end…
- *Note: small eVTOLs etc are not replacing but will complement aviation of today and that only in the segment with the least energy consumption*

Source for graphic: Deutsche Aircraft





Conclusion for a better climate performance

- To avoid increasing airport sizes for new energies *(ground times and/or a/c size increases)* **and** if we want to ensure a de-facto drop in potential *(which could be occasionally be replaced by kerosene)* **and** if we don't want to add another safety layer in complexity **and** if we want to reduce energy consumption *(less is always better)* per unit transported **and** if we want to see results for the environment, we globally have only **one realistic choice** to move the needle for the direction of a **tangible 2050 result: SAF and/or PtL**

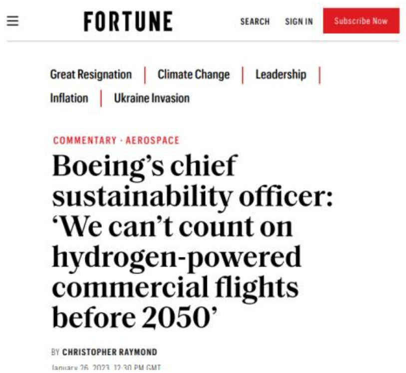
PtL: it can still largely use existing infrastructure unlike burning LH2 but using for example H2 in the production process, the Hydrogen activities of some countries are not in vain. It is just better used directly elsewhere and to create a fuel which does not take the hydrogen risk into the air and aviation infrastructure whilst also be scalable

- This should be incremental to more efficient ATC procedures, better allocation of environmental flight levels and the use of a propulsion which is 20-30% more efficient that a jet engine and would be acceptable in terms of travel time:

RE-INVENT THE TURBOPROP

A few more issues to consider….SAF is not a fossil fuel

we require more political support creating a planning framework for all players if politics are serious regarding a serious improvement in CO_2 footprint - the industry like NESTE, SASOL, CAC and the large oil companies are waiting for it, not only the rest of the aviation industry – we need a serious production increase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Boeing's chief sustainability officer: 'We can't count on hydrogen-powered commercial flights before 2050'
BY CHRISTOPHER RAYMOND
January 26, 2023 12:30 PM GMT

Many are becoming increasingly concerned that in aviation, too much speculation about future technologies could cost us decades in lost opportunities and investments to dramatically reduce carbon emissions and global warming - SAF is ready to be used, we need to increase the volume because to reach 2050 goals there is no choice

- *Remark: History has shown how running in the wrong direction on propulsion can be costly and detrimental to the environment - enter the CFM56 DAC engine (less NO_x, more noise, more fuel burn, more CO_2);*

SAF as energy and Turboprop as propulsion where possible will yield the biggest impact

Thank you

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