

The Role of Hydrogen in Sustainable Aviation





?



No, but.....

There is no viable way to decarbonise aviation that does not involve hydrogen

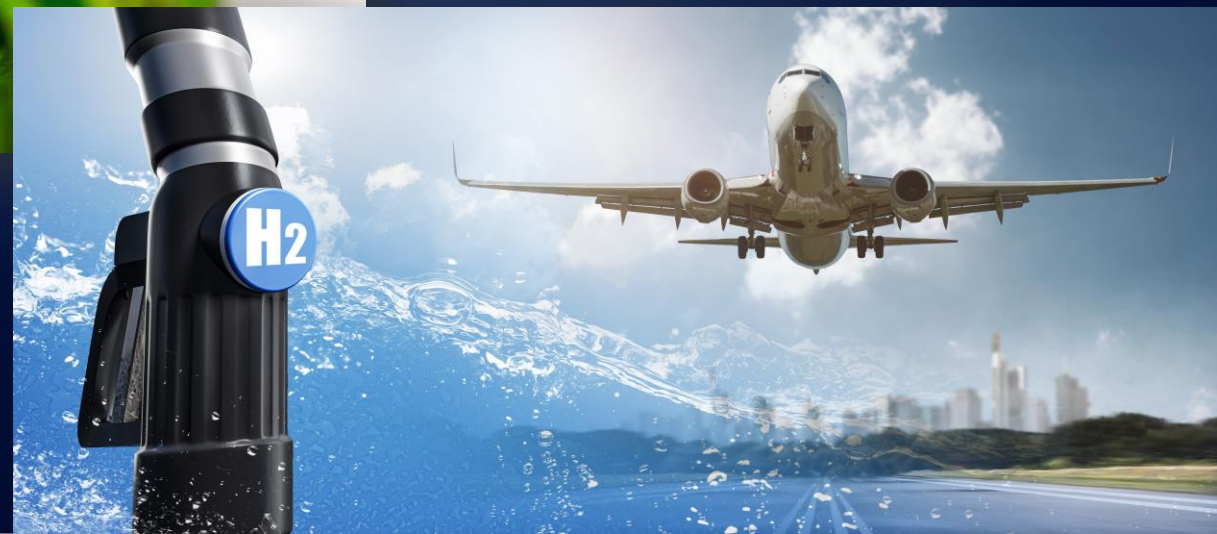


What can we do now?



Sustainable Aviation Fuels

Novel propulsion technologies



What could we do now?



More efficient aircraft & engines

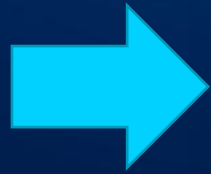


Airspace redesign

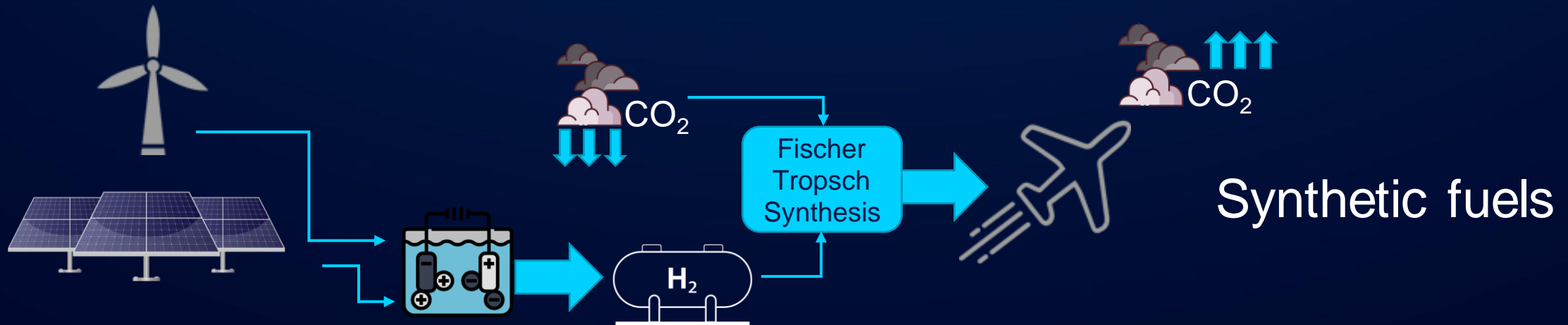


Contrails prediction & management

Sustainable Aviation Fuels



Bio-fuels



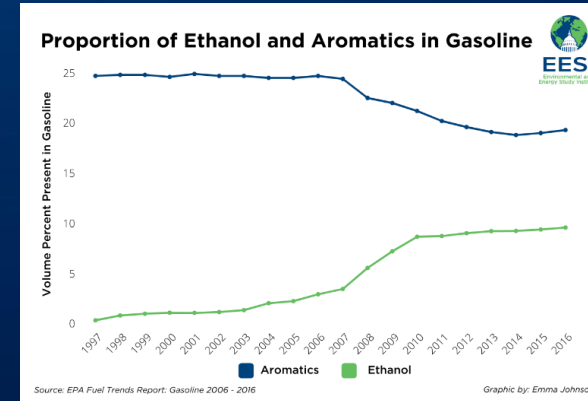
What are the challenges of SAF?



Scaling of the technology



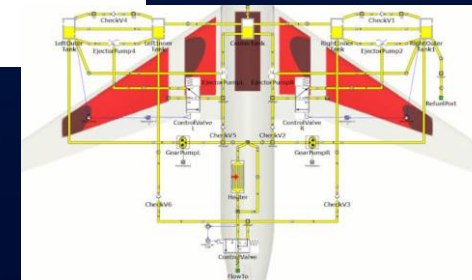
Price



Elimination of aromatics



Engine & fuel system development



Novel propulsion technologies



Battery-only:

- 1/10th energy content of kerosene per kg
- Arduous life-cycles; high replacement
- Short range & small aircraft



Hybrid (conventional/SAF engine + battery):

- Heavy & complex: minimal CO₂ savings
- Potential for aircraft up to regional

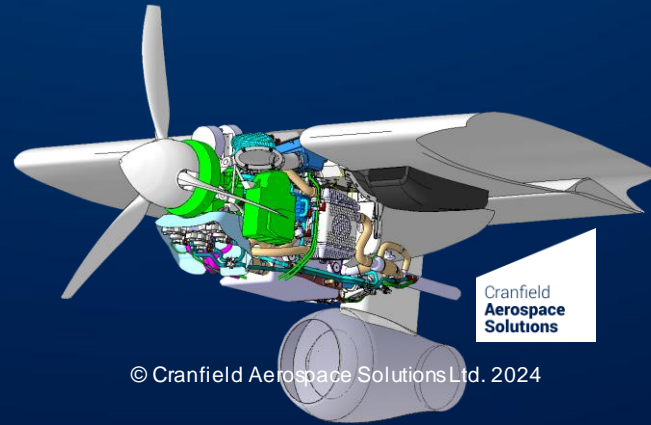
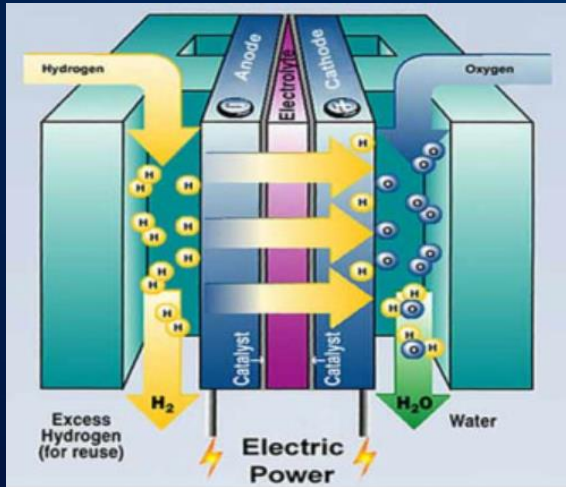


Hydrogen (incl. hydrogen-battery hybrid):

- 3 x energy content of kerosene per kg
- Scalable technology
- Potential for all aircraft types

Hydrogen: propulsion

Fuel cells



- No emissions other than heat & water
- Applicable to aircraft up to 100 seats (for now)
- Missions: lower & slower
- Fuel efficiency: 55%+
- EIS: 2026/7

Direct Combustion



- Produces NO_x + heat & water
- More easily applicable to larger aircraft
- Missions: high & fast
- Fuel efficiency: 35%
- EIS: 2035+

Hydrogen: storage

Gaseous



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Solutions

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- Highly pressurised tanks (350 or 700bar)
- Heavy
- Volume efficient
- Applicable to small aircraft
- Mature technology
- Ideal entry technology

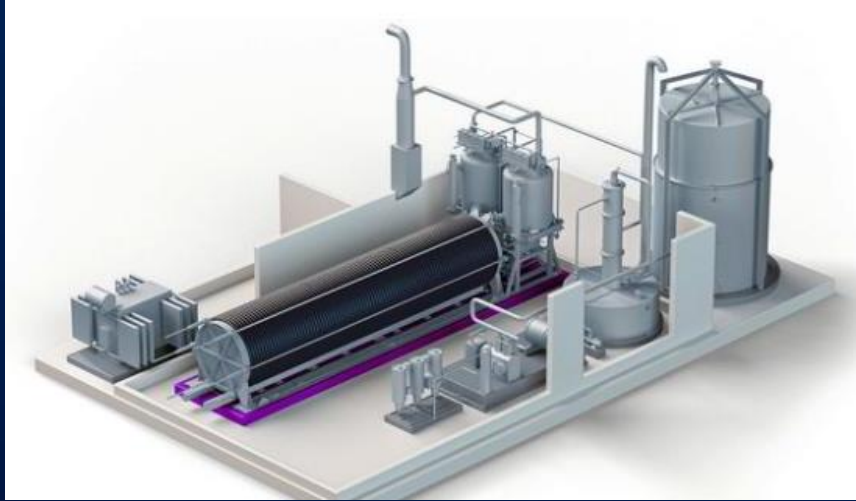
Liquid



- Cryogenic storage: H₂ boiling point is -252.9°C
- Takes up 4 x volume of kerosene
- Only solution for large aircraft
- Immature technology
- Long term solution – ideally requires new aircraft design

Hydrogen: infrastructure

Gaseous



- Mature production & logistics solutions with scale up in progress
- Can be economical in relatively small quantities
- Proximity to production site significantly reduces cost => offers energy resilience opportunities
- Benefits from multiple potential offtakers other than aviation
- Requires increase in renewable energy to provide electricity
- Perfect entry point for small air operations

Liquid



- Mature production process in small quantities
- Logistics & storage of large quantities required for aerospace very immature; boil off issues (1%/day)
- Only likely to be economical if produced in large volumes – gigahubs required
- Large amount of green energy required to liquify
- Aerospace only likely offtaker, making scale up difficult

Hydrogen standards & regulation



Aircraft certification



Airline operations & refuelling



Maintenance, Repair & Overhaul (MRO)

Currently no regulation
for the use of hydrogen
in aviation

Questions?

Comments?

Challenges?