Insights into Future Propulsion Technologies

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Hamburg Aerospace Lecture Series, 23rd October 2025
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RAeS Hamburg in cooperation with the DGLR, VDI, ZAL & HAW invites you to a lecture

Insights into Future Propulsion Technologies

James Hunt, BSc

Future Propulsion Lead, Advanced Manufacturing Research Centre (AMRC), University of Sheffield

Date: **Thursday, 23 October 2025, 18:00**

Location: **HAW Hamburg, Berliner Tor 5, Hörsaal 01.10** (in-person only!)

Aerospace Technology Institute (ATI), FlyZero, © ATI

The aviation sector has set ambitious targets to achieve net zero flight by 2050, there are several legislative, operational and technological pathways that will contribute towards this. Some of the greatest challenges are faced in developing solutions that will directly reduce the emissions of the aircraft. This presentation will provide some insights into what technologies are being explored for future propulsion systems based on new and alternative fuels such as battery, hydrogen and sustainable aviation fuels (SAF). It will explain how the incumbent primes are adopting different approaches to decarbonisation, while emerging companies are seeking to carve out niches with their disruptive technologies and business models.

James has over 25 years of experience in applied research in industry and academia, specializing in materials and manufacturing. After a decade in the UK steel industry, he joined the University of Sheffield to advance metals processing, including additive manufacturing and electron beam welding. As Future Propulsion Lead at AMRC, he works with industrial partners on zero-emission transport technologies. He authored a report on hydrogen storage for the ATI's FlyZero programme and collaborates with ATI's Hydrogen Capability Network on hydrogen aircraft adoption.

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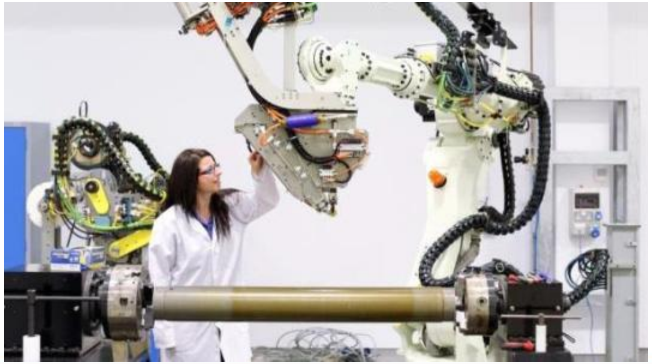
- Introduction to the AMRC
- Setting the scene
- Overview of propulsion systems
- Technology developments
- External factors
- Summary

Introduction to the AMRC

What is the AMRC?

A world-class centre for advanced manufacturing

- Established in 2001 as a collaboration between industry & the University of Sheffield.
- Helps manufacturers of any size to become more competitive by introducing advanced techniques, technologies and processes.
- Specialises in carrying out world-leading research into advanced machining, manufacturing and materials, which is of practical use to industry.
- Expertise in machining, automation, robotics, digitally assisted assembly, casting, additive manufacturing, composites, designing for manufacturing, testing and training.



MANUFACTURING DONE BETTER

40x faster
Lower cost
Secured UK jobs

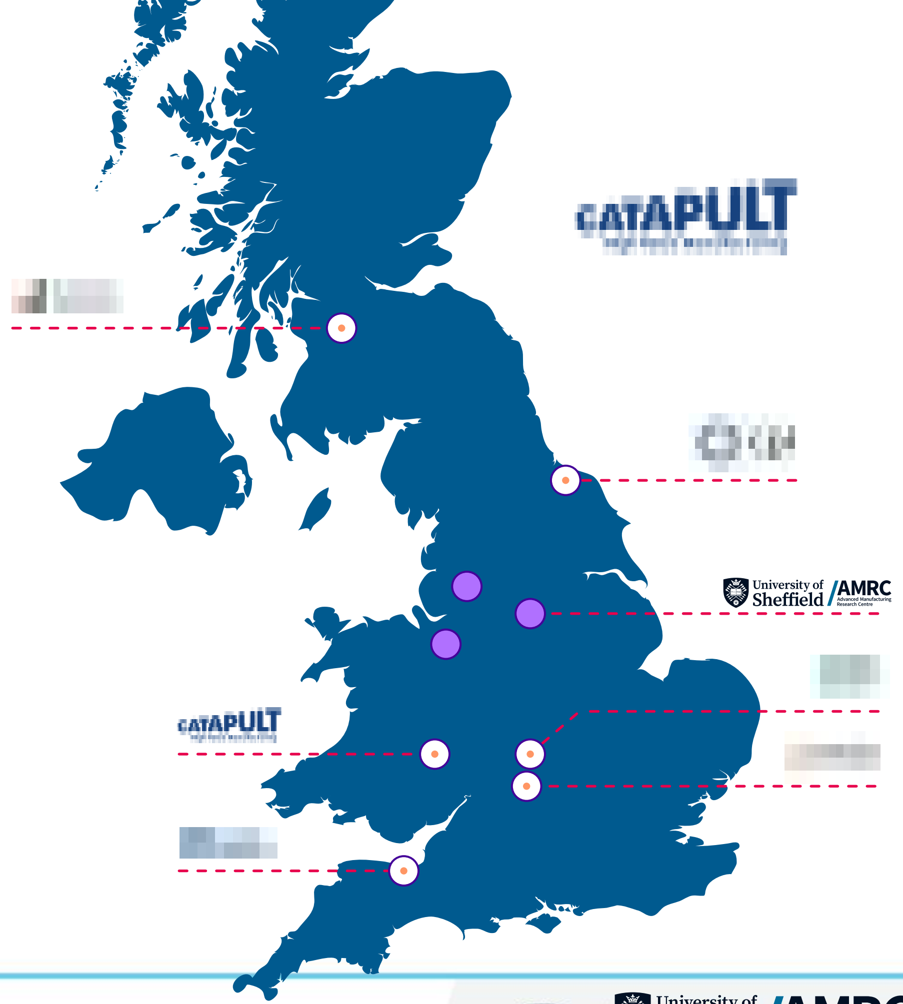
National reach
High Value Manufacturing Catapult

The AMRC is a core part of the

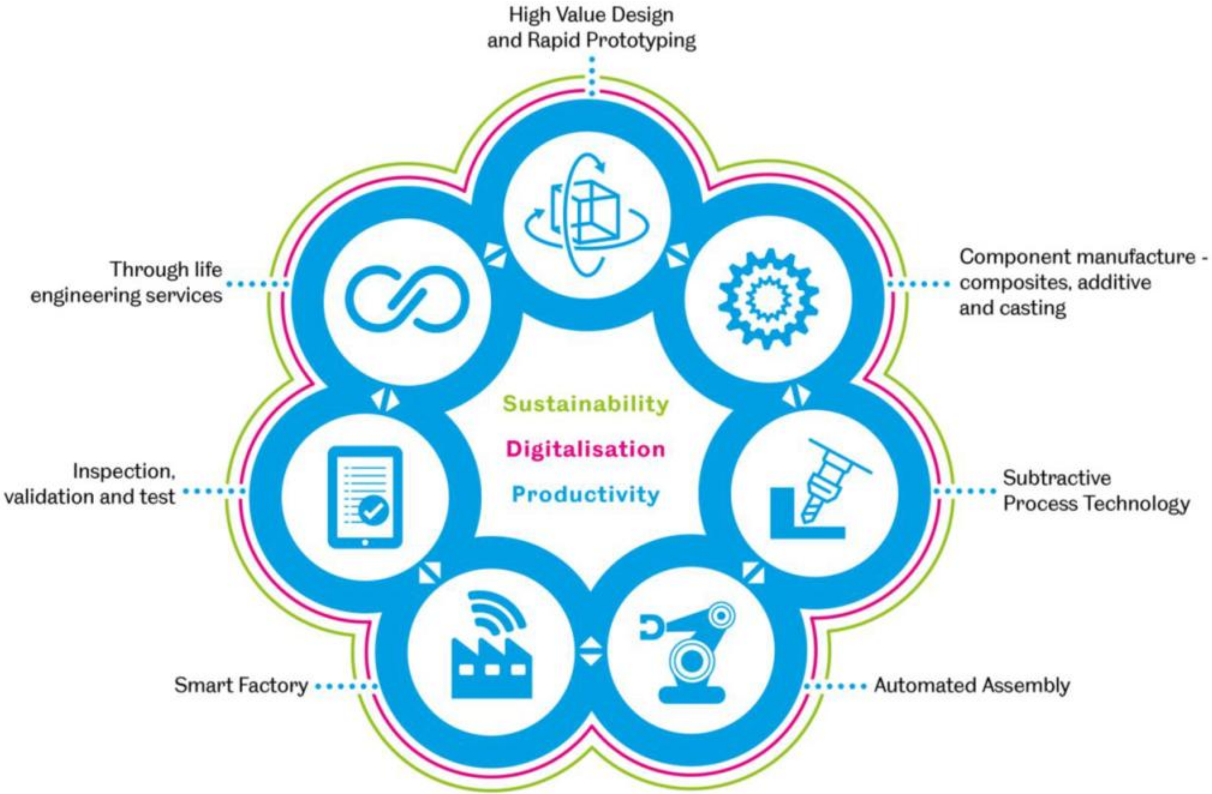
High Value Manufacturing Catapult, an alliance of leading manufacturing research centres backed by the UK's innovation agency, Innovate UK.

The High Value Manufacturing (HVM) Catapult is a thriving alliance that works with companies of all sizes to bridge the gap in – and accelerate the activity between – technology concept and commercialisation.

Being part of the Catapult ensures that we play a core role in the revival of the national manufacturing sector.



Manufacturing Capability



Setting the scene

Why do we need new propulsion technologies?

Commercial aircraft evolution

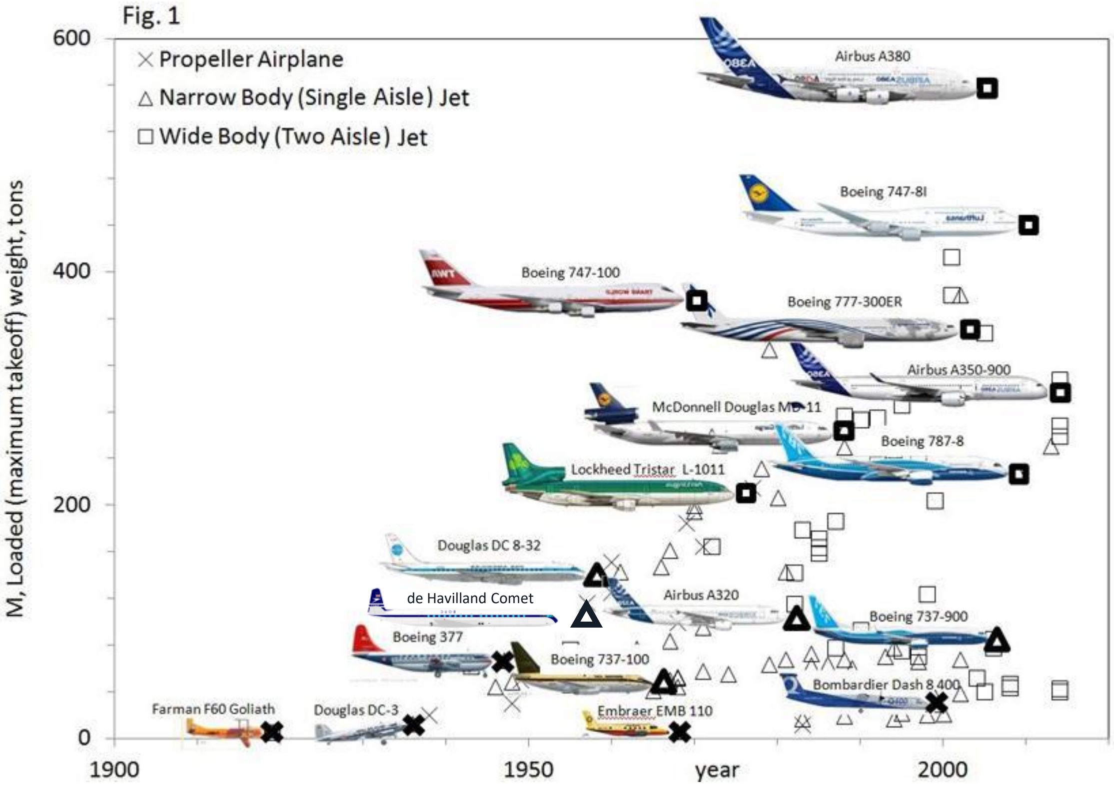


Image source: The Evolution of airplanes, A. Bejan, 2014

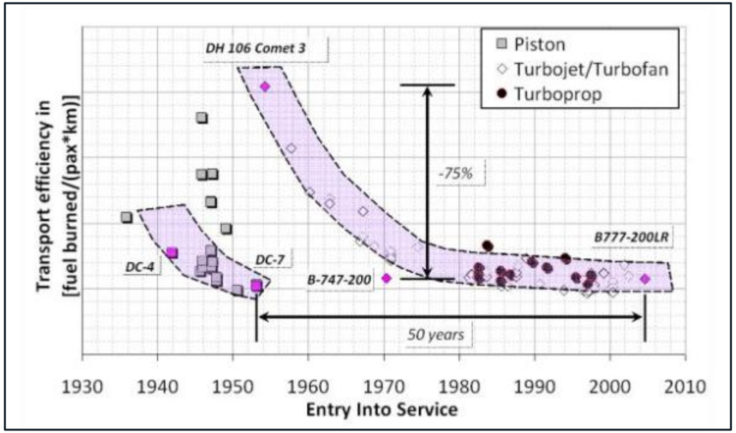


Image source: Future Aero Engine Designs: An Evolving Vision, K Kyprianidis, 2011

Trend continues	1990	2019
Energy per pkm	2.9MJ	1.3MJ
CO_2 per pkm	357g	157g

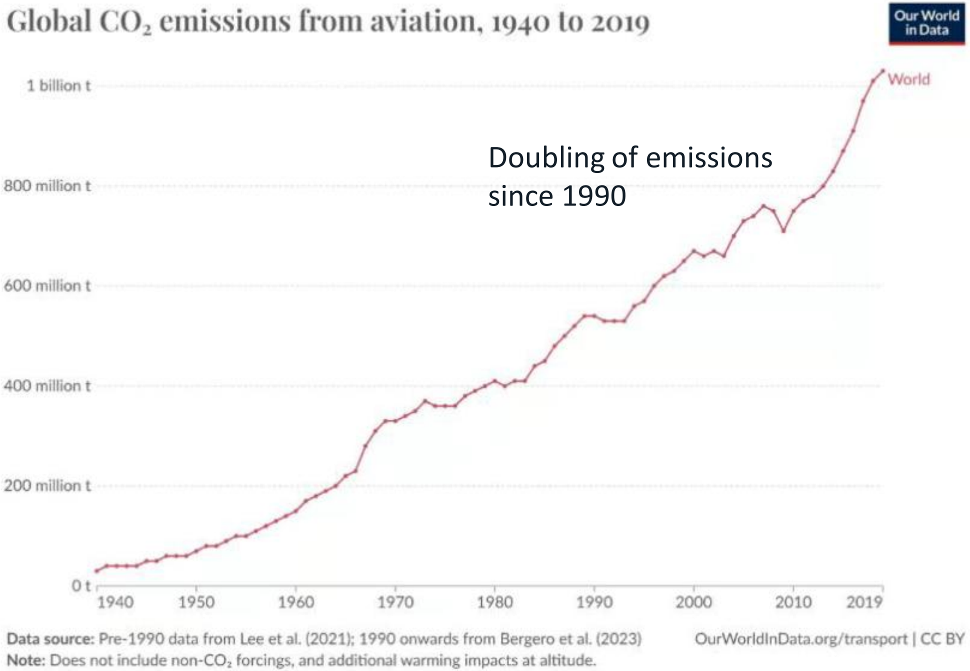
Enabling technologies

- Larger aircraft
- More efficient engines
- Lightweight materials
- Higher lift wings

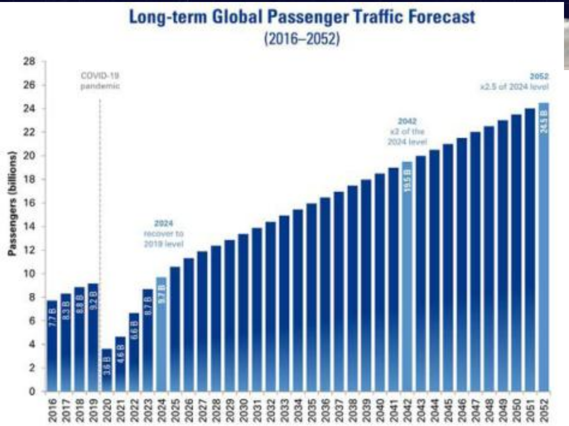
Aviation's contribution to global warming

4 fold increase in traffic since 1990

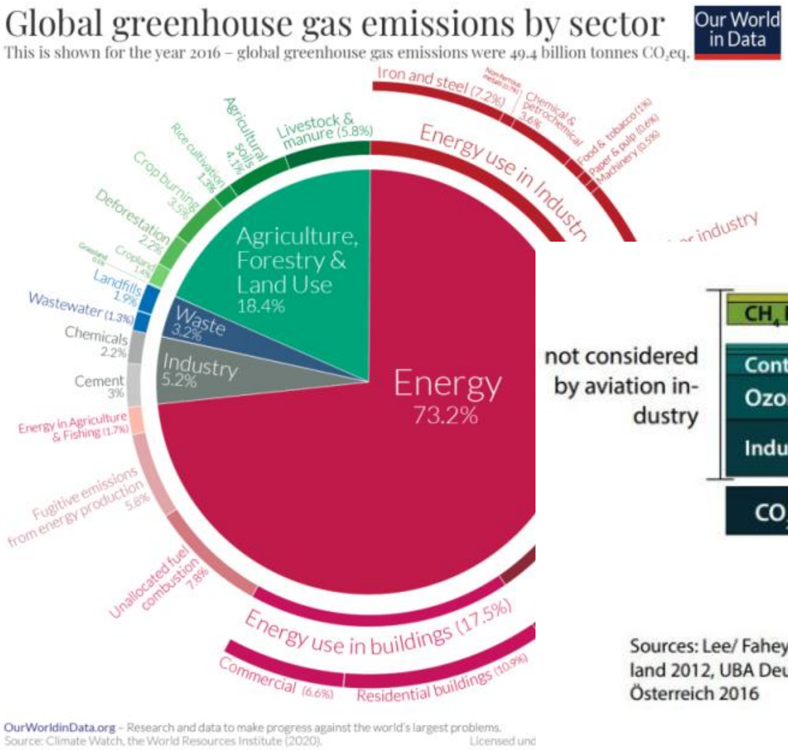
8 trillion passenger kilometres in 2019

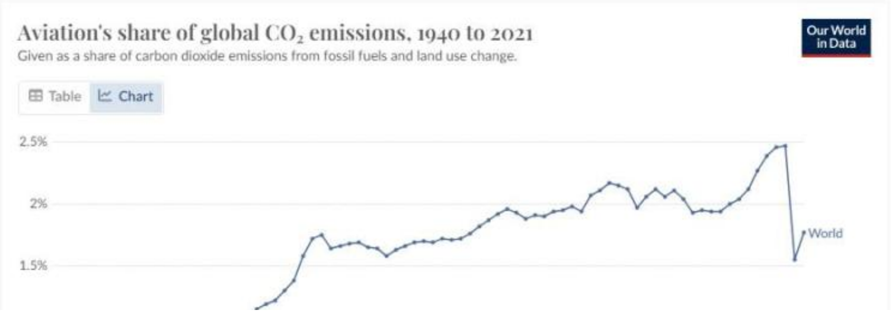


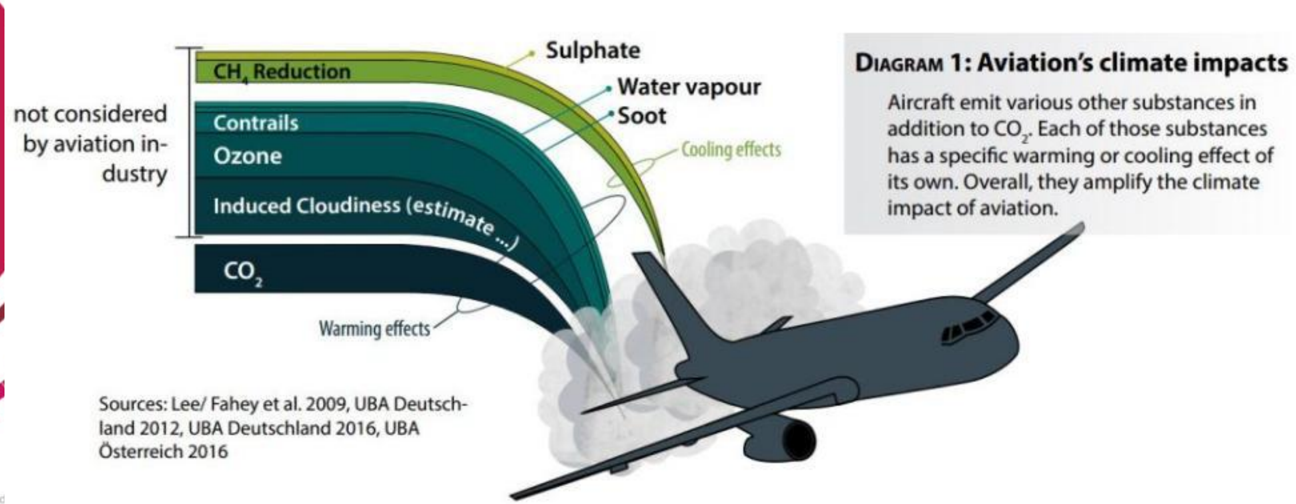
Doubling of emissions since 1990



Aviation’s contribution to global warming - context



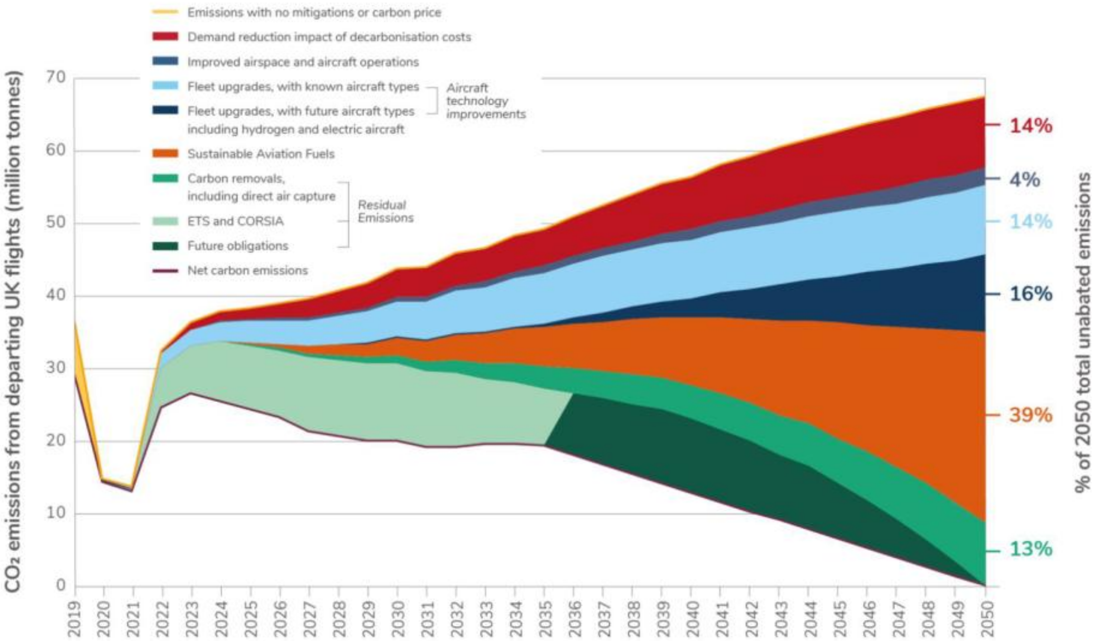




University of Sheffield /AMRC

There are many routes to decarbonising air travel

Target net zero aviation by 2050



Source: Sustainable Aviation 2023

Key Technology Areas

More efficient aircraft

- Fleet renewal
- Light weighting
- Aerodynamic improvements
- Ultra high by-pass ratio engines
- Thermal efficiency improvements
- More electric systems

Net-Zero

- Sustainable Aviation Fuels

Zero Carbon

- Battery electric
- Hydrogen Fuel Cell
- Hydrogen combustion

Propulsion systems

Conventional

Turbofan

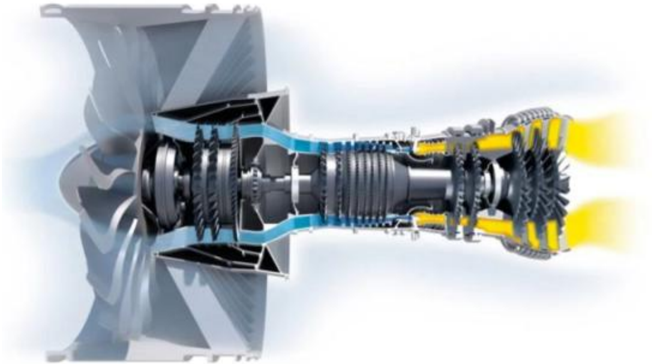
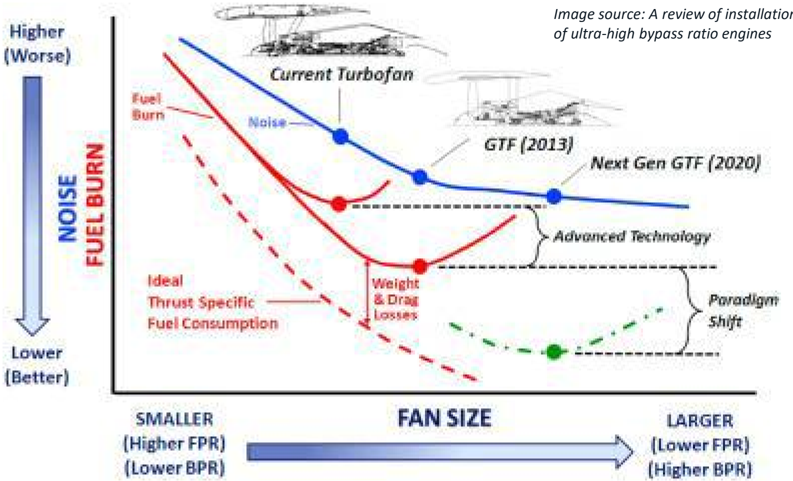
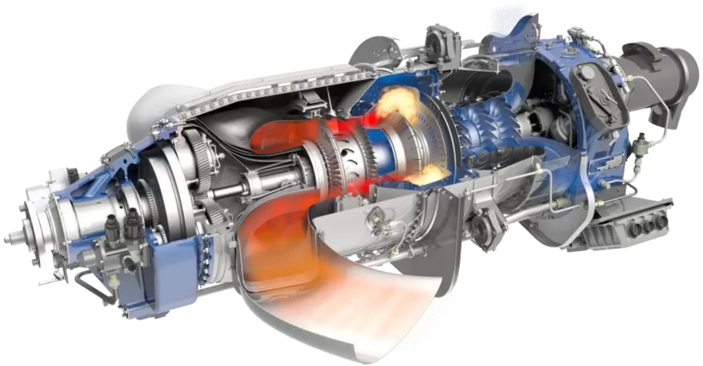


Image source: A review of installation effects of ultra-high bypass ratio engines



	HondaJet	Embraer E170	Airbus A320neo	Boeing 777-8
No of passengers	4-10	66-78	150-194	395
Range	1547NM	2150NM	3450NM	8745NM
T/O power	2 x 1MW	2 x 8MW	2 x 20MW	2 x 80MW

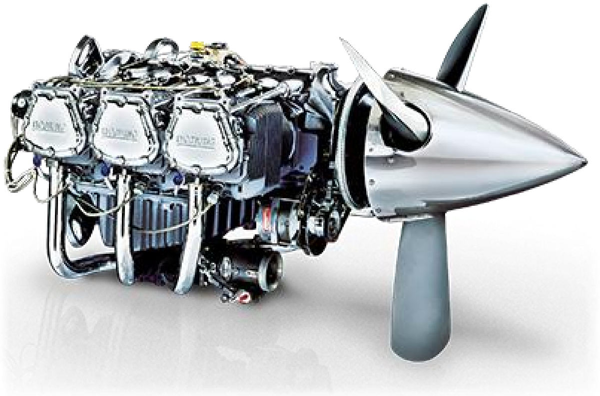
Turboprop



More efficient than turbofan
Slower cruising speed
Lower altitude operation

	Praga Alfa SM-92T	Dornier 228	ATR 72-600
No of passengers	6	19	44-78
Range	750NM	650NM	740NM
T/O power	500kW	2 x 540kW	2 x 2MW

Piston-prop



More efficient than turboprop
Cheaper operating costs
Wider range of fuels
Low speed & altitude operation

	Britten-Norman Islander	HAV Airlander 10
No of passengers	4-9	Up to 100
Range	675NM	4000NM
T/O power	2 x 220kW	4 x 400kW

Other variants

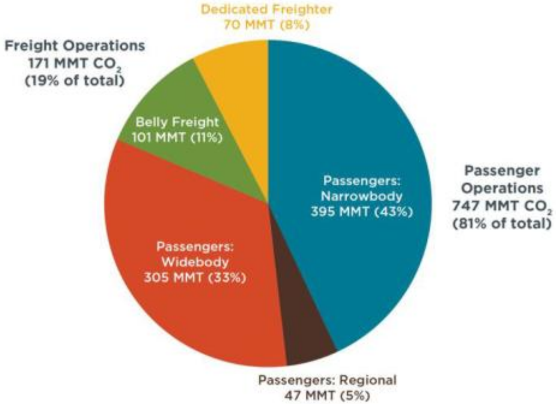


Figure 1. CO_2 emissions in 2018 by operations and aircraft class

Image source: Internation council on clean transportation

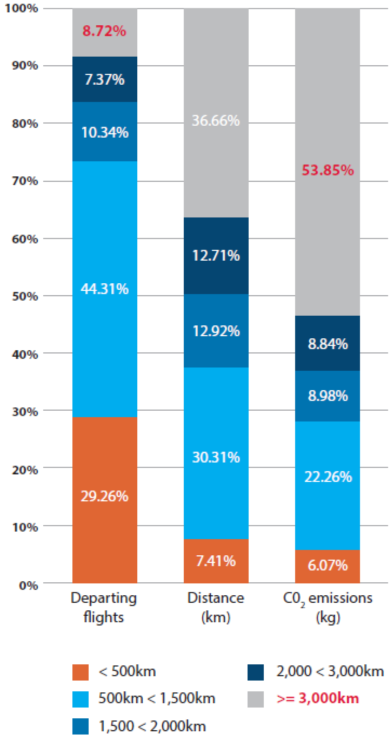


Image source: Eurocontrol

Technology developments

Battery electric

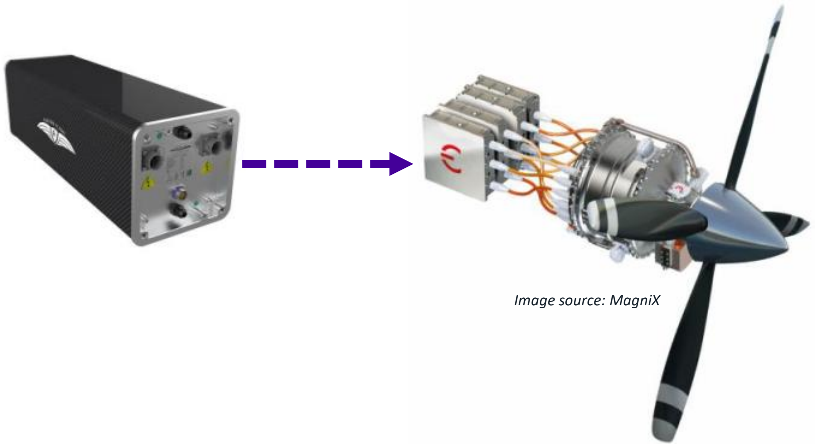


Image source: MagniX

Image source Evolito

Rolls-Royce Spirit of Innovation
400kW peak power
385.4mph

Lilium Jet eVTOL
Up to 6 passenger
30 ducted fan e-motors 100kW each

Battery electric challenges

Image source: MagniX

Battery technology

A320neo LHR-LIS 1565 km
Estimated total fuel burn 3.6t
43MJ x 3,600kg = 154,800MJ
Assume GT 50% efficiency = 77,400MJ required
Assume 90% electric efficiency = 71.6t battery
A320neo dry weight = 64t

Other issues:
Cooling
Fire protection
Packaging on aircraft
Durability
Charging time
Critical minerals Li, Co

Spirit of Innovation
Pack energy 72.9kWh
Assume 400kW power requirement
Run time approx. 10 minutes

Mass: 450kg pack, 300kg cells
Energy density approx. 160Wh/kg (0.5MJ/kg)

State of art 1.2MJ/kg

Kerosene typically 43-48MJ/kg

Ambition

Wright Spirit
Retrofitted BAe 146
100 passengers
Range approx. 1hr

1000Wh/kg battery

4 x 2MW electric ducted fan motors

Fuel cell electric

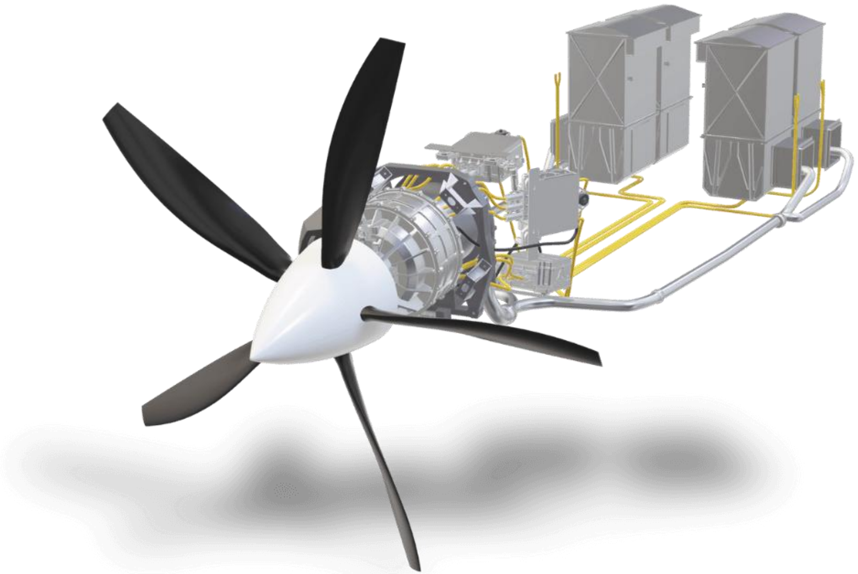


Image source: ZeroAvia

Proton exchange membrane (PEM) Fuel Cell

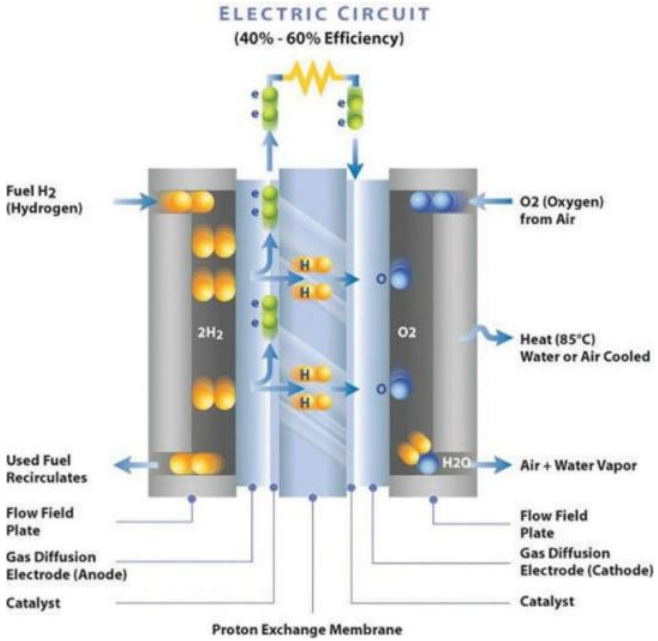


Image source: TheSix Technology Solutions

Fuel cell electric

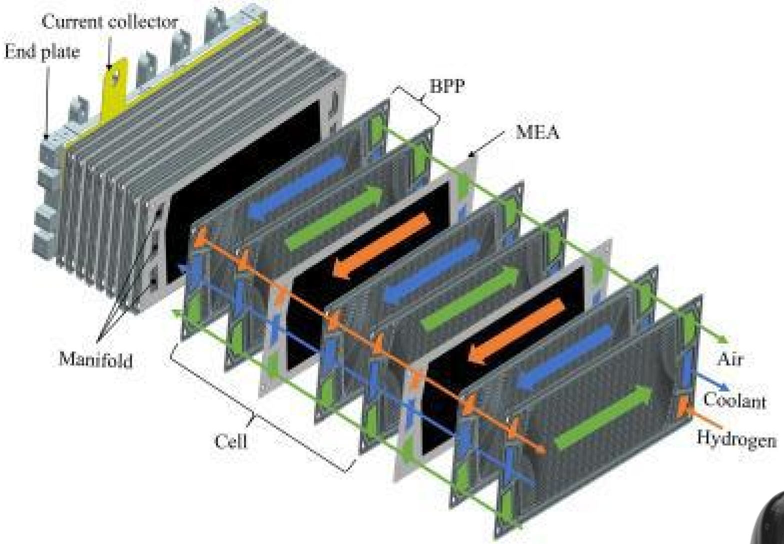
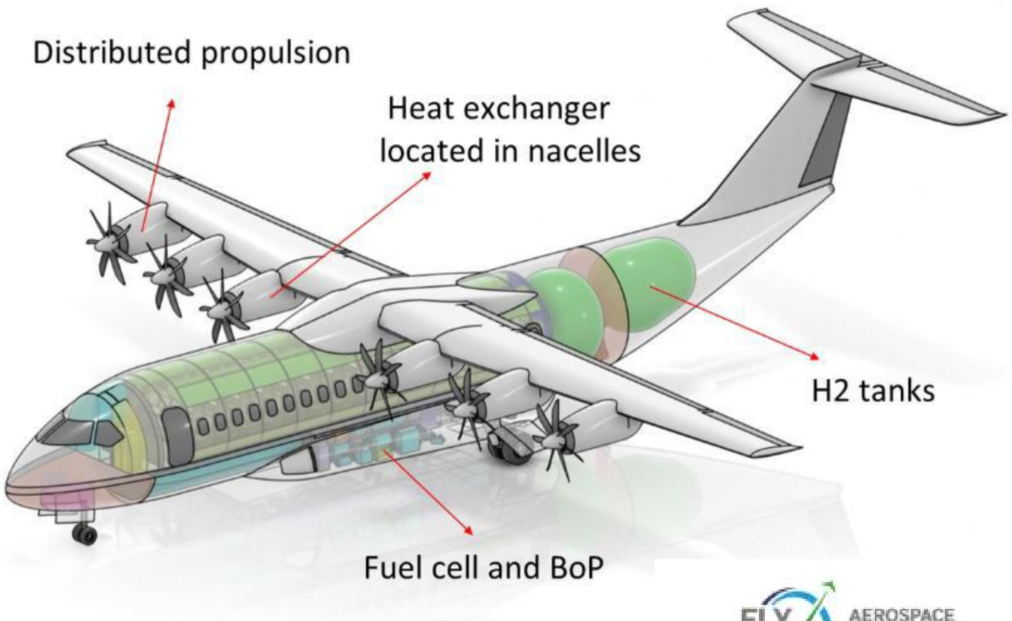
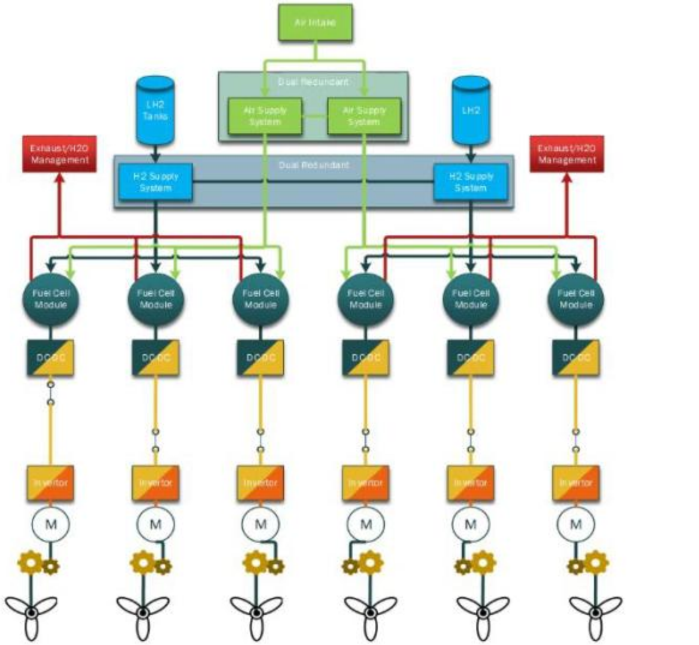


Image source: ZeroAvia

Potential FC powertrain layout



FlyZero regional aircraft concept



ATI © 2022.ATI Proprietar

Fuel Cell challenges

Efficiency and heat rejection

250kW

1kg H2 = 33kWh

Image source: ZeroAvia

16.5kWh

14.9kWh

250kW
50% efficiency

220kW
90% efficiency

Fuel Cell challenges

Efficiency and heat rejection

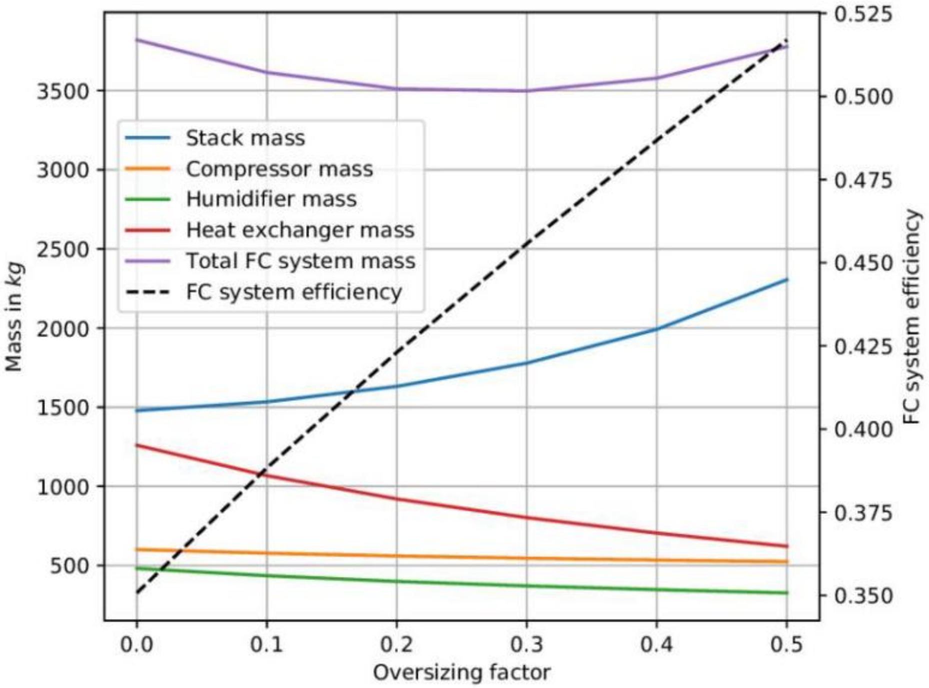
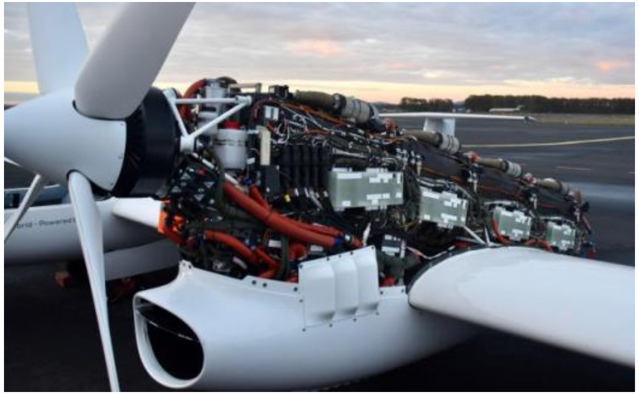


Image source: Preliminary Propulsion System Sizing Methods for PEM FC Aircraft, D. Juschus, 2021



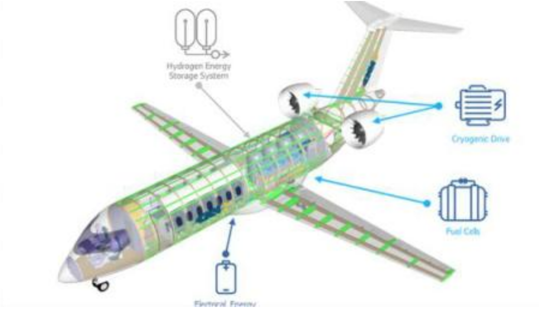
Mitigation

- Highly efficient low drag heat exchangers
- Evaporatively cooled thermal cycle
- High Temperature PEM stacks

Other issues:
Durability – flight cycles
Transient loads
PGMs for catalyst
Water management
Contrails

Fuel Cell propulsion UK activity

Intelligent Energy



GKN AEROSPACE

Cranfield
Aerospace
Solutions

ZEROAVIA

University of Sheffield /AMRC

Electric motors

Safran ENGINeUS 100
Air cooled PM radial flux
125kW 3500rpm
5kW/kg peak, 3.5kW/kg continuous

MagniX Magni500
Liquid cooled radial flux
560kW 2800rpm
3.4kW/kg peak, 3.1kW/kg continuous

Evolito D500 1x3
Liquid cooled axial flux
350kW 9000pm
12kW/kg peak

Various motor topologies being considered
Permanent magnet AC synchronous – high speed eVTOL
Brushless DC – low speed high torque
Wound field – superconducting machines

Challenges:

Fault tolerance	Magnet technology
Mass/packaging	Partial discharge
Efficiency	Certification

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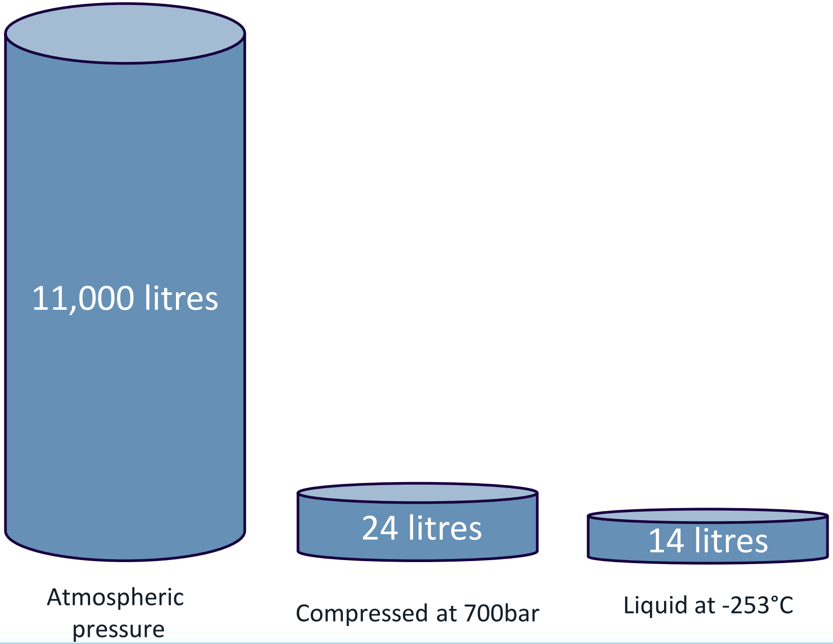
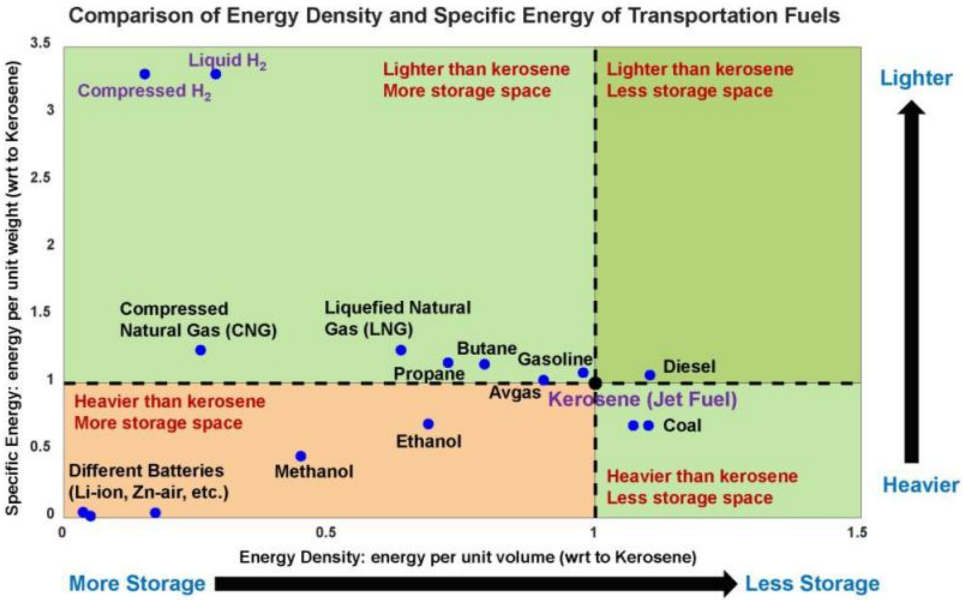
Hydrogen storage

1kg Kerosene approx. 48MJ

Storage volume for 1kg hydrogen (142MJ)





LH_2 = 1/3 mass of kerosene
But 4 times volume

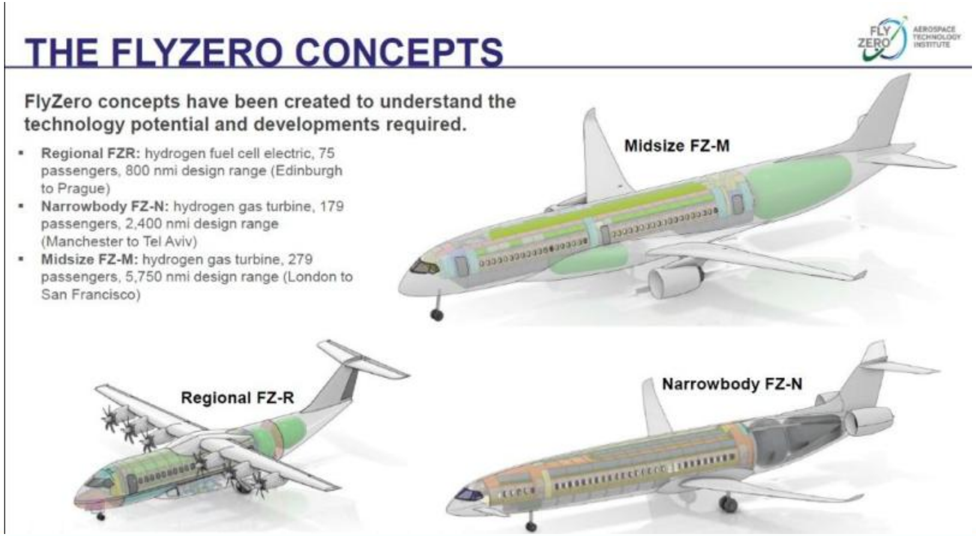
Hydrogen aircraft concepts

Also fully electric version
4 pods
- 6 FC stacks for 2.4MW
- 2.1MW motor
- EIS 2035

'Is it safe?' | Boeing executives cast doubt on viability of hydrogen as an aviation fuel

Aircraft maker says H2 is best used in the production of sustainable aviation fuels

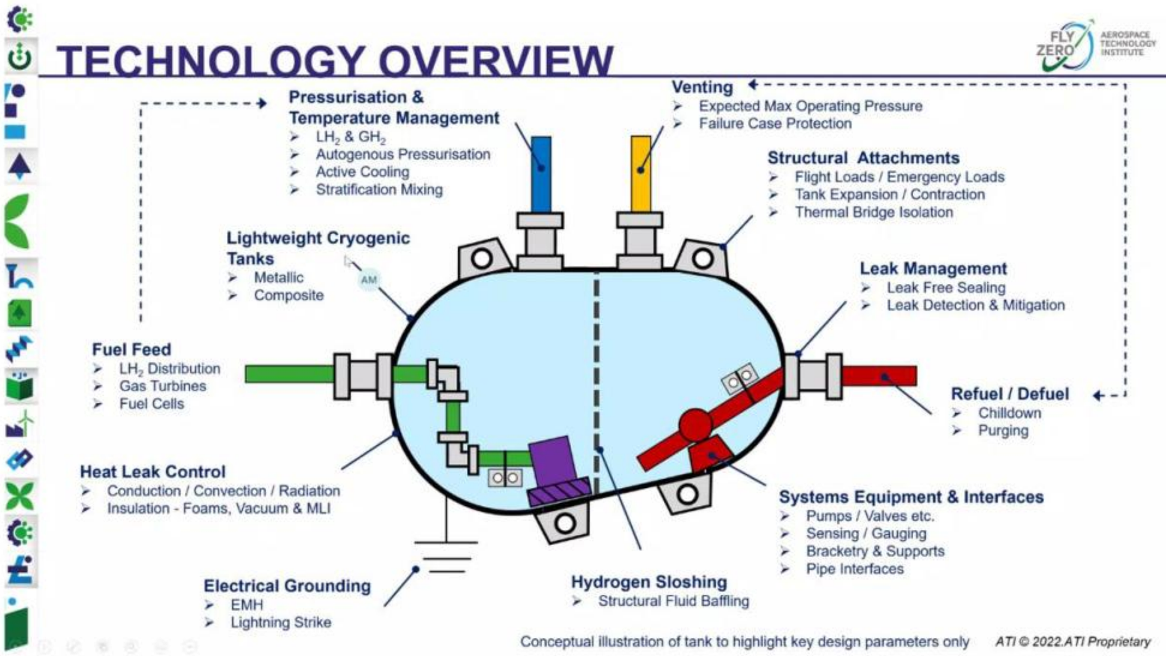
"Boeing's position is that the first, best and primary use of hydrogen in aviation should be used to develop and scale SAF [sustainable aviation fuels]," a spokesperson for Boeing told *Hydrogen Insight* today. "SAF is



Hydrogen storage

Key challenges

- Materials compatibility
    - Hydrogen embrittlement
    - Permeability
    - Cryogenic
- Boil off
- Sloshing
- Gravimetric efficiency
- System integration
- Location on aircraft
- Leakage



Hydrogen combustion


Transport

'World first' | Rolls-Royce and Easyjet tests show 100% hydrogen combustion can power aircraft take-off

Engineers develop fuel spray nozzle system to control fast-burning H2 in plane engine

2022 trials on modified AE2100 turboprop
2023 Pearl jet engine combustor trials
Full scale Pearl engine trails planned for 2025

Challenges cf kerosene

- Larger temperature gradients
- Increased heat transfer of combustion products
- Short quench distance
- Increased water vapour
- Hydrogen embrittlement

Mitigation

- New combustor/nozzle design
- Higher creep resistance alloys
- Improved hot corrosion resistance
- Improved coating systems

Sustainable Aviation Fuels (SAF)

Various non-fossil based derivatives

- Gen 1 produced from vegetable oils , crops
- Gen 2 produced from biomass (e.g. waste wood)
- Gen 3 synthetic fuels, power-to-liquid

All essentially a drop-in fuel and can be blended

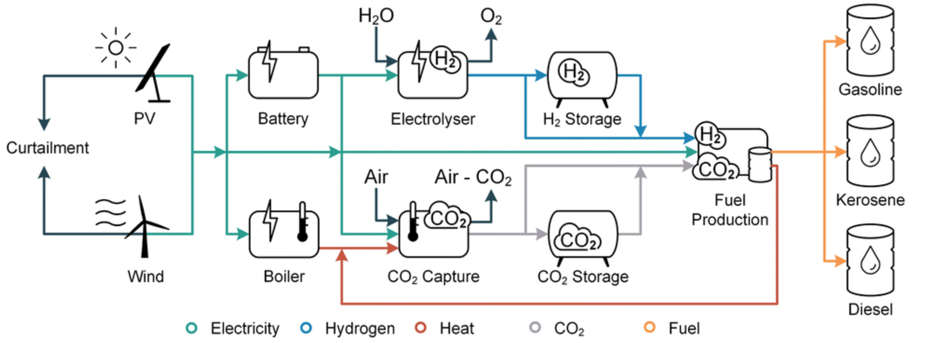


Image source: Royal Society of Chemistry

Difficult to achieve true net zero

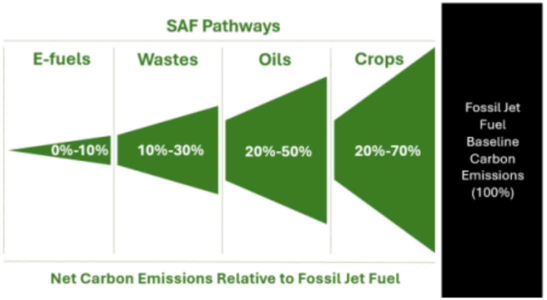


Image source: Climatedrift.com

Potential other benefits of SAF

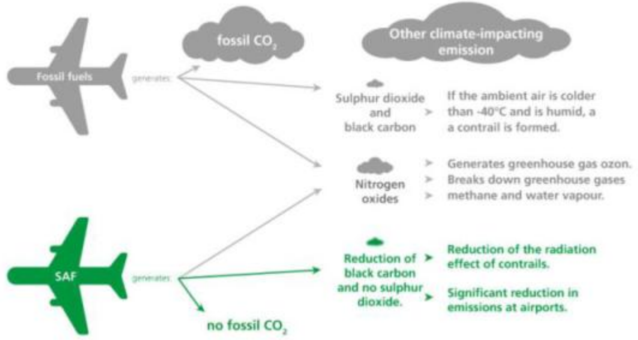


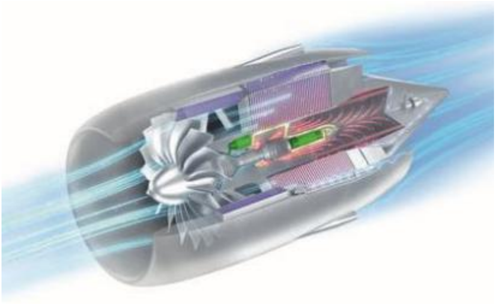
Image source: FOCA

Gas turbine developments

Ultra high bypass ratio (e.g. UltraFan)

140” fan diameter (ByPass Ratio 15:1)
25,000 to 100,000 lb thrust
Carbon fibre fan blades with Ti leading edge & composite case (saves 700kg)
Geared fan
Turbine stages reduced from 10 to 6
Ceramic matrix composites
Additive Manufacturing
10% more efficient than Trent XWB
100% SAF compatible

Advanced hybrid (SWITCH)

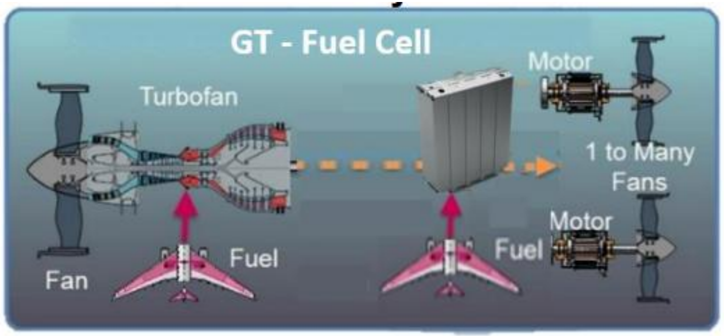


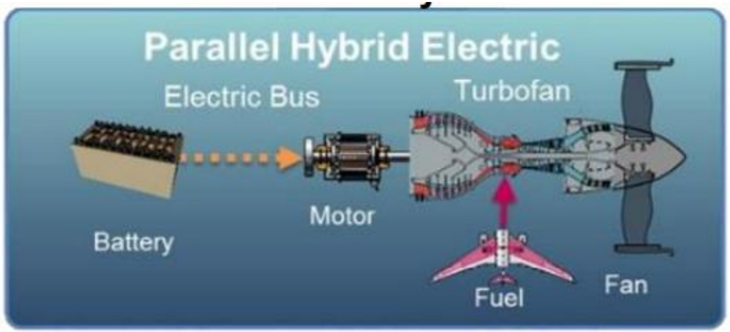
Dual spool geared turbofan
Hybrid-electric
Water Enhanced Turbofan (WET)
20% improvement in fuel burn
50% reduction in climate impact (CO_2, NO_x, contrails)
100% SAF compatible

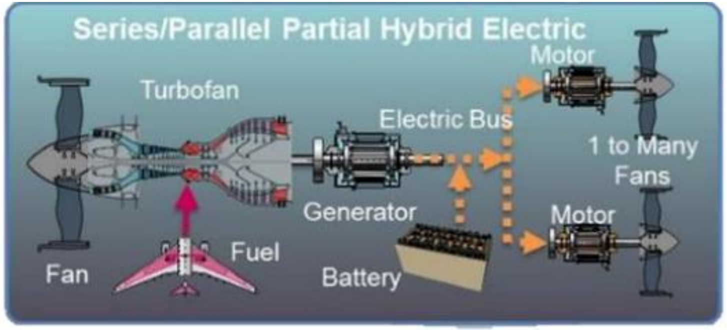
Open rotor/unducted fan (e.g. RISE)

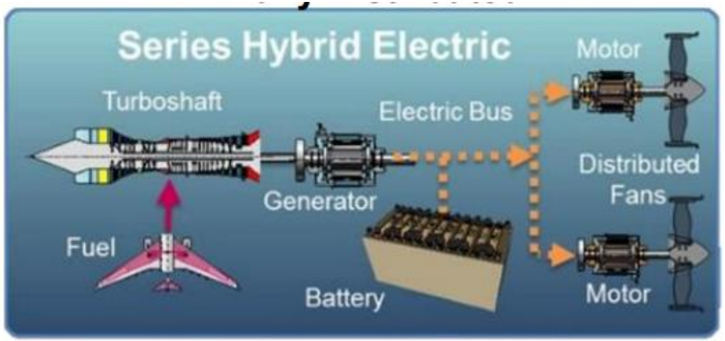
ByPass Ratio up to 20:1
Single rotating fan plus variable pitch de-swirling vanes
All composite fan blades
Advanced metal alloys and CMCs
Additive manufacturing
20% efficiency improvement target
100% SAF compatible
Potentially compatible with hydrogen

Hybrid solutions









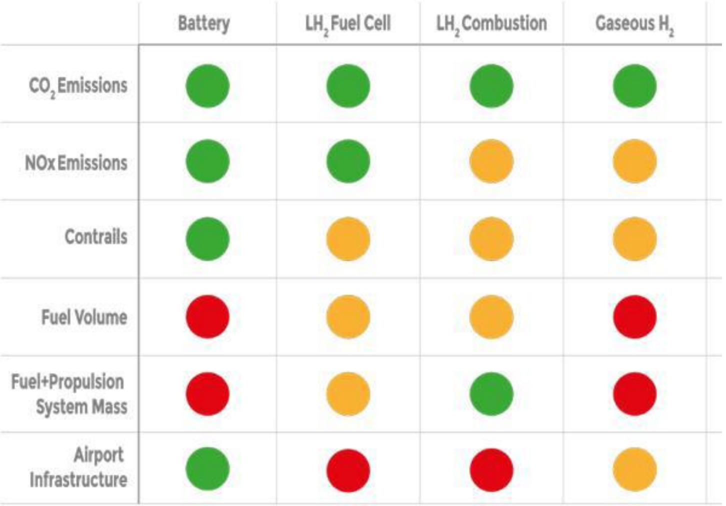
Partially distributed

Fully distributed

Hybrid system introduces mass challenge, but potentially unlocks specific fuel consumption benefits

The scale of the benefits is still unclear, but the underlying battery and motor technologies are key enablers.

Propulsion system options



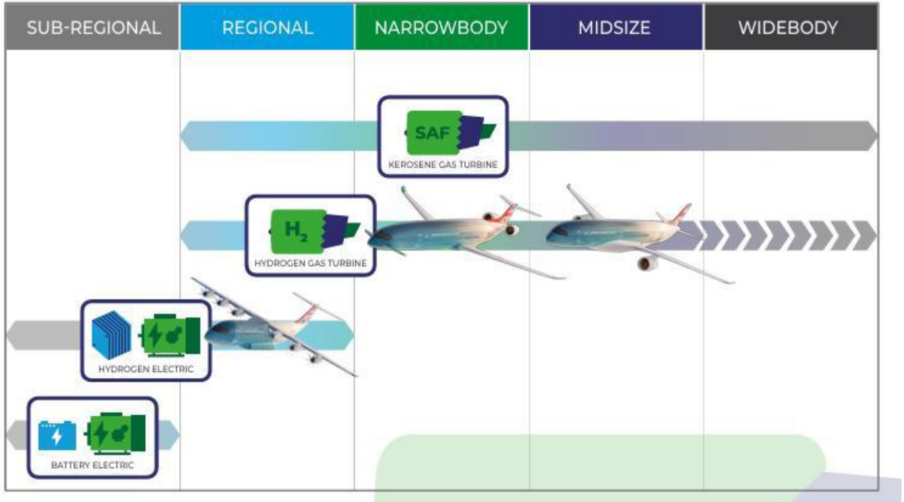
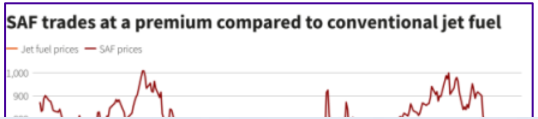
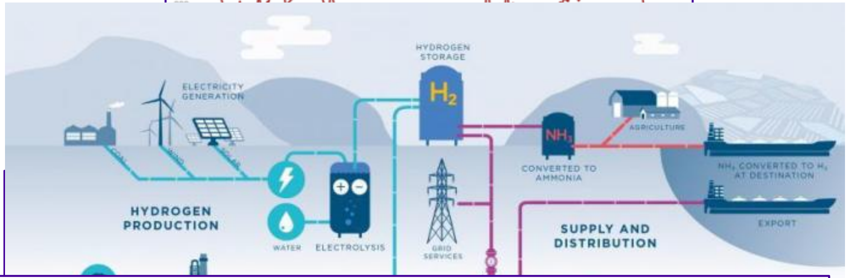


Image source: ATI FlyZero

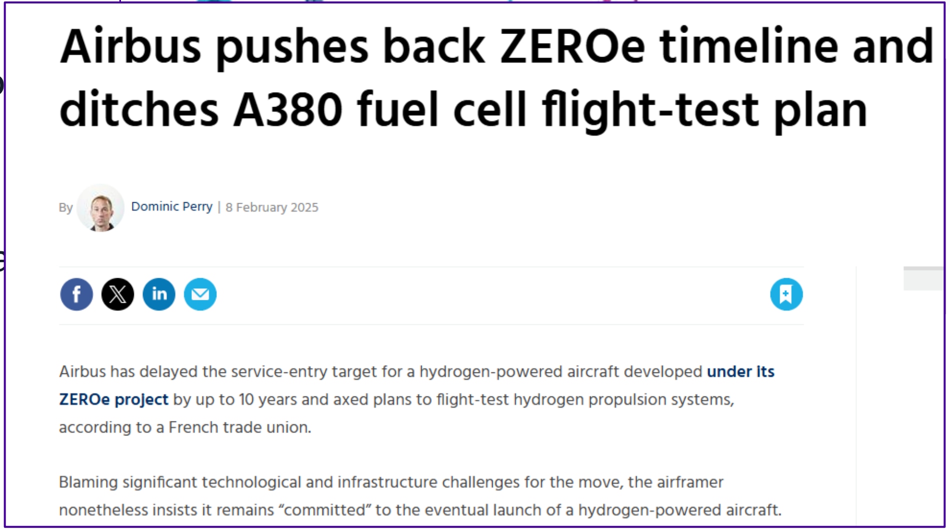
External factors

External factors and considerations





- Fuel prices
- Scalability of fuels
- Green energy, green hydrogen
- Global legislation and policy (USA oil & gas, cro
- Airport infrastructure - globally
- Supply chain: critical raw materials, carbon boa
- New platforms to install new technology
- Certification of new technology



Airbus pushes back ZEROe timeline and ditches A380 fuel cell flight-test plan

By Dominic Perry | 8 February 2025

Airbus has delayed the service-entry target for a hydrogen-powered aircraft developed **under its ZEROe project** by up to 10 years and axed plans to flight-test hydrogen propulsion systems, according to a French trade union.

Blaming significant technological and infrastructure challenges for the move, the airframer nonetheless insists it remains "committed" to the eventual launch of a hydrogen-powered aircraft.

University of Sheffield /AMRC

Summary

Future propulsion technologies: summary

Aircraft engines have massively improved efficiency since their introduction

Increasing passenger numbers and flights has led to increasing emissions

Aerospace is difficult to decarbonise, so the share of emissions is increasing

Various technologies are being considered to provide zero or net zero propulsion

Challenges remain

- Energy density of batteries
- Power of motors
- Thermal management
- Hydrogen storage
- Overall energy mix

Thank you.

For further information please contact or visit:

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TOMORROW.
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