The First Practical Zero Emission Aviation Powertrain

Q4 2020
$1.5T Aviation Market is Flying into Sustainability Crisis

Megatons

Net CO₂ Emissions = 3.67 X Fuel (Combustion Plus Production)

Contribution of Alternative Fuels Out to 2020

Minimum Net Life Cycle CO₂ Gap = 1,210 Mt

Today

5-10% Of total human Climate Impact

Useful life of a commercial aircraft

In 2050

25%

50%

No real, truly scalable solutions today
**Hydrogen is a Key Enabler of Future Aviation**

<table>
<thead>
<tr>
<th>Options</th>
<th>Primary issues (Blockers)</th>
<th>Secondary issues</th>
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</thead>
<tbody>
<tr>
<td>Battery electric</td>
<td>40x lower energy density compared to jet fuel; 5x+ higher kwh/kg required to start being relevant in aviation</td>
<td>High OPEX due to cycling costs (including recycling) - need at least 5x cycle life improvement</td>
</tr>
<tr>
<td>Turbine - electric</td>
<td>None</td>
<td>Marginal / zero benefit on any but the shortest routes (where turbine is primarily a reserve power source)</td>
</tr>
<tr>
<td>Biofuel</td>
<td>Not scalable to any meaningful % of aviation; Plants are 500x worse than solar+electrolysis at utilization of land</td>
<td>High costs; competition with food; environmental damage; water use problems; NOX / particulates</td>
</tr>
<tr>
<td>Synthetic fuel</td>
<td>None</td>
<td>Fundamentally higher cost of fuel than direct H2 approaches (green H2 is the required feedstock for synfuel); Fundamentally lower efficiency than H2 electric; NOX / particulates</td>
</tr>
<tr>
<td>H2 turbine</td>
<td>None</td>
<td>Fundamentally lower efficiency than H2 electric = more fuel required; volume of fuel storage system; NOX</td>
</tr>
<tr>
<td>Hydrogen - electric</td>
<td>None</td>
<td>Power density of fuel cell systems; volume and weight of fuel storage system</td>
</tr>
</tbody>
</table>

**Hydrogen-electric powertrains have advantage over all other alternative propulsion types, with no blockers and fixable secondary issues**
Why Hydrogen?*

- 4x+ Range even with gas H2
- Addtl 3x Range by going to Liquid H2
- 50% Lower emissions
- 30% Lower OPEX

True Zero Emission solution that can credibly scale to 100+ seat aircraft within 10-15 years

* compared to battery
Our Vision: Renewably-Powered Hydrogen-Electric Aviation

Long range, Lower costs & Zero Emission
We Made the Right Choice; Momentum Accelerating

Hydrogen is now considered the fuel of choice for any serious decarbonization of aviation.

France Plans To Make Airbus A320 Successor By 2030

by Joanna Bailey  ·  June 9, 2020  ·  3 minute read

The French government has today revealed plans to invest heavily in developing the plane of the future. France's ambitions for a zero carbon plane include a reworking of the popular Airbus A320 product line by 2030 and the move to hydrogen fuel by 2035. Altogether, €15bn ($17bn) will be poured into the aerospace sector over the coming years.
Step 1 (ZA-600): 19 Seats, 500 miles by 2023

Lower fuel, maintenance costs; lower noise; zero emissions end-to-end
500-mile 19-Seat is Just the Beginning...

2023 - First commercial offering

- 10-20 seats
- 500 mile range

2027
- 50-100 seats
- UAM

2030
- 100-200 seats
- 3,000 nm

2035
- >200 seats

2040
- >200 seats
- 5,000+ nm range

R&D roadmap

- R&D 6-seater: Completed, >10 flights
- $7M UK grant program

We are here now

Optimization & mile flight
- Sep 2019 - End of 2020

R&D 19-seater flights
- 2H 2020 - 2021

Certification of ZA600 for commercial 9-19-seat ops
- 2H 2021 - 2023
Phase 1 Flight Tests 2019-2020 (USA, UK)

2017 - 2019
A number of flight tests in California, starting in Q1 2019, proving the initial powertrain design, paving the way to further, longer-distance configurations.

2020 (Q1)
UK facility in Cranfield. Installation and test of the ZA250 hydrogen-electric powertrain in a 6 seat Piper Malibu. Extensive UK flight testing & demonstrations later this year.

2020 (Q2 - Q4)
Orkney - Edinburgh
Demo up to 300 NM range by the end of the year. Orkney - Edinburgh
$7M UK Gov grant

200+ NM
World’s Largest Hydrogen-Electric Aircraft

Historic flight on Sep 24, 2020
Green H2 Supply - On Track to Beat Jet Fuel

Projects cite $3 / kg today, path to $1 / kg

Shell unveils world's largest offshore wind plan to power green hydrogen
Oil giant links with Gasunie for NorthH2 initiative off Netherlands that aims to have 10GW of turbines in place by 2040

Green hydrogen 'cheaper than unabated fossil-fuel H2 by 2030': Hydrogen Council
Clean hydrogen derived from renewable energy will be cost-competitive with highly polluting grey hydrogen by 2030, and consultant McKinsey.

“Within five to ten years — driven by steeper than 80% and falling renewables' levelised costs — hydrogen could drop to about $1.50 per kg in operation, average conditions,” says the report. Price.

Renewable H2 could even compete with the cost of natural gas
Levelized cost of hydrogen production from large projects

<table>
<thead>
<tr>
<th>Yearly kg</th>
<th>$/MMBtu</th>
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<tbody>
<tr>
<td>2018</td>
<td>14.9</td>
</tr>
<tr>
<td>2019</td>
<td>7.4</td>
</tr>
<tr>
<td>2020</td>
<td>0.0</td>
</tr>
<tr>
<td>2030</td>
<td>0.0</td>
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Key inputs in ZA model
- $500 / kW Electrolysis CAPEX, 15-20 year depreciation
- Electrolysis OPEX at 2-3% / yr
- Fueling system is ~10% adder
- PV energy input, with optimally sized high-cycle buffer battery

$2.5 / kg in 2023 - equivalent to $1.5 / gallon jet fuel
ZeroAvia HARE (H2 Airport Refueling Ecosystem)

On / Near-site Renewables → On-site Electrolysis → On-site storage & mobile airport refueling

Hydrogen fueling support for multi-modal transport
ZeroAvia - a Market Leader in Clean Aviation

Strong business development traction

Confidential discussions:
- 25+ Operators
  - 12 signed / committed to sign
  - Many are interested in replacing larger vehicles with our entry product

- 7 Aerospace majors
  - Engine OEMs
  - Airframe OEMs

- 5 New vehicle manufacturers

- Governments in 5 regions
  - Funding secured in UK
Thank You!

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