What are Sustainable Aviation Fuels (SAF) exactly?

Sustainable Pilot Training Webinar
14-15 June 2022

Working for quieter and cleaner aviation.

Your safety is our mission.
The Challenge

By mid-century aviation could account for major part of global CO₂ emissions budget

Projections prior Covid-19

International aviation and IPCC 1.5 degrees CO₂ emission data
Basket of Measures

→ Technology-Design, Operations, **Sustainable Aviation Fuels (SAF)** and Market Based Measures.

→ Expectation that drop-in SAF will play a significant role in the mitigation of aviation CO$_2$ emissions using the existing global fleet.

→ But what are Sustainable Aviation Fuels?
What are Sustainable Aviation Fuels?

→ Sustainable aviation fuel (SAF) is the main term used by the aviation industry to describe a sustainable, non-conventional, alternative to fossil-based jet fuel.

→ SAF is the preferred ICAO term, but other terms often used to describe types of SAF (e.g. renewable jet fuel, biojet fuel, e-fuels)
Drop-in fuels

→ Current SAF focused on so-called ‘drop-in fuels’
   → Physical and chemical characteristics are almost identical to conventional fossil based jet fuel and can therefore be safely mixed (at various blend ratios).
   → Uses the same fuel supply infrastructure and doesn’t require adaptation of current global fleet.

→ Drop-in fuels need to comply with international jet fuel specifications (e.g. ASTM D1655 and Def Stan 91-91)
   → Contain requirements for composition, volatility, fluidity, combustion, corrosion, thermal stability, contaminants, additives etc.
## Approved SAF pathways

<table>
<thead>
<tr>
<th>Production pathway</th>
<th>Feedstocks</th>
<th>Certification name</th>
<th>Blending limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass Gasification + Fischer-Tropsch (Gas+FT)</td>
<td>Energy crops, lignocellulosic biomass, solid waste</td>
<td>FT-SPK</td>
<td>Up to 50%</td>
</tr>
<tr>
<td>Hydroprocessed Esters and Fatty Acids (HEFA)</td>
<td>Vegetable and animal fat</td>
<td>HEFA-SPK (up to 50%)</td>
<td>Up to 50%</td>
</tr>
<tr>
<td>Direct Sugars to Hydrocarbons (DSHC)</td>
<td>Conventional sugars, lignocellulosic sugars</td>
<td>HFS-SIP</td>
<td>Up to 10%</td>
</tr>
<tr>
<td>Biomass Gasification + FT with Aromatics</td>
<td>Energy crops, lignocellulosic biomass, solid waste</td>
<td>FT-SPK/A</td>
<td>Up to 50%</td>
</tr>
<tr>
<td>Alcohols to Jet (AtJ)</td>
<td>Sugar, starch crops, lignocellulosic biomass</td>
<td>ATJ-SPK</td>
<td>Up to 50%</td>
</tr>
<tr>
<td>Catalytic Hydrothermolysis Jet (CHJ)</td>
<td>Vegetable and animal fat</td>
<td>CHJ or CH-SK</td>
<td>Up to 50%</td>
</tr>
<tr>
<td>HEFA from algae</td>
<td>Microalgae oils</td>
<td>HC-HEFA-SPK</td>
<td>Up to 10%</td>
</tr>
<tr>
<td>FOG Co-processing</td>
<td>Fats, oils, and greases</td>
<td>FOG</td>
<td>Up to 5%</td>
</tr>
<tr>
<td>FT Co-processing</td>
<td>Fischer-Tropsch (FT) biocrude</td>
<td>FT</td>
<td>Up to 5%</td>
</tr>
</tbody>
</table>
Aviation Fuel Approval Tied to Aircraft/Engine Type Certificate

Therefore, D7566 Alternative Jet Fuels Meet Existing Operating Limitations

Aircraft/Engines Approved to Operate With Jet A and Jet A-1 Fuel

D1655 Conventional Jet Fuel Spec

ASTM D7566 Fuels Meet ASTM D1655 Spec

ASTM D4054 Process Compares Alternative Jet Fuels to Jet A/A-1

Drop-in Alternative Jet Fuels Added to ASTM D7566

Source: FAA
→ Power-to-Liquid (PtL) ‘e-fuels’ offer another alternative production pathway and feedstock

Source: [https://www.umweltbundesamt.de/sites/default/files/medien/377/publikationen/161005_uba_hintergrund_ptl_barrierrefrei.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/377/publikationen/161005_uba_hintergrund_ptl_barrierrefrei.pdf)
100 % SAF – Options, Open Questions

• Drop-in vs. Non Drop-in fuel

• Drop-in:
  • Has to have same composition and properties as conventional Jet A-1
  • Can be used on all aircraft without restrictions, no change to ground infrastructure
  • ASTM D4054 process applicable
  • Limits the pathways – e.g. 100% Synth. Paraffinic Kerosin (SPK) cannot be used (density too low, material compatibility issues due to lack of aromatics)

• Non Drop-in:
  • New fuel grade, new fuel specification, approval process not addressed in detail in current D4054
  • Only for new aircraft, separate infrastructure required
  • Not bound to the limitation of Jet A-1 → more flexibility regarding fuel production pathways

ASTM Task Force on 100% SAF standardization established in February 2021
SAF Sustainability

→ Achieving a **net CO₂ emissions reduction** is the main objective for using SAF in order to meet the aviation sector’s ambitious climate goals.

→ Various sustainability criteria (e.g. CORSIA, EU RED).

→ SAF must demonstrate a net carbon reduction through a **lifecycle analysis** (LCA).

→ Emissions from the combustion of drop-in SAF are comparable to fossil-based jet fuels, except for marginal efficiency gains, hence the majority of the reductions in GHG emissions originate from the production process.
SAF Lifecycle Assessment

Well-to-Wake Pathway for Conventional Jet Fuel

Life Cycle Analysis (LCA)

Well-to-Wake Pathway for Bio-Based Alternative Jet Fuel

Source: https://greet.es.anl.gov/files/aviation-lca
SAF Environmental Benefits

→ SAF can achieve CO₂ emission reductions of up to 80% on a lifecycle basis.

→ Fewer compounds (e.g. sulphur, aromatics) → improving air quality by reducing sulphur dioxide (SO₂) and particulate matter (PM) emissions.

→ Use of municipal waste biomass for SAF feedstock avoids it going to landfill.
SAF challenges

→ Challenges turning aspirational goal into reality, including:
  → Price competitiveness
  → Ensuring sustainability
  → Meeting technical requirements, i.e. fuel specification standards
  → Fragmented policy landscape
→ Legislative proposal to ensure a well-functioning aviation market while accelerating decarbonisation with a gradual ramp-up of SAF

→ **Ambitious binding SAF targets** focusing on innovative, sustainable and scalable fuel technologies:

<table>
<thead>
<tr>
<th>Total shares in the fuel mix (in %)</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
<th>2040</th>
<th>2045</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAF ramp up:</td>
<td>2</td>
<td>5</td>
<td>20</td>
<td>32</td>
<td>38</td>
<td>63</td>
</tr>
<tr>
<td>Of which: sub-mandate on e-fuels</td>
<td>-</td>
<td>0.7</td>
<td>5</td>
<td>8</td>
<td>11</td>
<td>28</td>
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</table>

→ Adoption expected in late 2022
Questions?

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Your safety is our mission.

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