The aviation industry is committed to reaching carbon-neutrality by 2050.

Several solutions are being explored by key stakeholders (airlines, IATA, government agencies, NGOs, engine and airframe OEMs, oil producers, fuel suppliers, researchers).

Pathways include improved technology and air traffic management, market-based measures (EU-ETS, CORSIA) and *sustainable aviation fuel* (SAF).

"SAF is a game-changer for aviation when it comes to reaching carbon neutrality. The requirement of driving production up and costs down is similar to what we witnessed happening in the wind energy industry a couple of decades ago. The wind energy industry, supported in the past by government collaborations, delivers today at a lower cost than its fossil equivalent. SAF will undergo a similar journey during the next decade or two."

Jan Melgaard
Executive Chairman, FPG Amentum

SUSTAINABLE AVIATION FUEL (SAF)

SAF is emerging as the most viable way to reach carbon neutrality for aviation. It is seen as the only feasible solution for mid to long-haul flights responsible for >70% of the aviation CO_2 emissions. Depending on the production pathway and the feedstock used, SAF can produce approximately 80% fewer CO_2 emissions than conventional jet fuel on a lifecycle basis (i.e., at all stages of production, distribution, and usage). The development of electric and hydrogen-powered aircraft is essential, although not expected to play a significant part for decades, given that such propulsion is feasible for short-haul and regional flights only.

SAF PRODUCTION

SAF in aviation has been researched, produced, and utilised for many years. New initiatives to derive SAF are proposed and developed in many parts of the world (US, European countries, China, India, Japan, and Indonesia). The technology is shared and co-developed across multiple regions. Two main SAF categories have emerged. Both can be used as "drop-in", mixed with A-1 jet fuel without the need to modify the aircraft design or the supply infrastructure.

Biofuels (advanced stage development; available today)

- 7 certified pathways approved by ASTM*, of these, the HEFA† fuel is the only one commercially available at an industrial scale so far
- Currently, the maximum approved blend for commercial aviation is 50%, but higher blend limits are being tested
- Diverse biomass: sugarcane, wood residue, algae, but no palm oil
- In advanced biofuels, biomass must not compete with food crops
- Some pathways can use inorganic substances instead of biomass (e.g., LanzaTech recycles steel mill emissions to produce ethanol)

E-fuels (early-stage development; long-term solution)

- Power-to-Liquid (PtL) technologies require only **renewable electricity**, **water**, and **CO_2**
- PtL is scalable with few limitations, contrary to biofuels where biomass may represent a constraint
- Derived through Fischer–Tropsch synthesis‡ – an already ASTM certified pathway for biofuels, e-fuels produce up to 100% less CO_2 emissions

Upscaling production

- >300,000 SAF flights to date [1]
- 190,000 tonnes SAF produced in 2020; SAF<0.1% of annual jet fuel consumption in commercial aviation
- 7 billion litres of SAF are in offtake agreements spanning 2021-2030. Airlines signed forward purchase agreements with the SAF producers; some airlines are also equity investors in SAF refineries.

* ASTM International (ex-American Society for Testing and Materials)

† Hydrotreated Esters and Fatty Acids

‡ The process that converts synthesis gas (a mix of CO and H_2 from the gasification of biomass) to synthetic jet fuel (synfuel/e-fuel/electrofuel/PtL)

- Ambitious self-imposed mandates by airlines and countries to increase SAF usage by 2030, for example:
  - Delta (10%), IAG (10%), Ryanair (12.5%)
  - Norway (30%), Sweden (27%), Finland (30%)
- Without government collaboration, SAF consumption cannot grow sufficiently fast. EU estimates that SAF demand will increase from 0.05% to 2.8% of airline fuel consumption by 2050 in the absence of additional EU intervention [2]. ReFuelEU Aviation, the pending EU initiative, will propose new legislation to incentivise SAF use in Europe. The proposal is expected to be published in mid-June 2021.
- In the US, the SAF market is growing, supported by credits from the federal legislature and state policies.
  - Federal level: biodiesel tax credit of 1 USD/gallon extended to producers/blenders of SAF
  - State level: low carbon fuel standard credit (LCFS) trading programmes adopted by the Pacific coast states. Similar proposals under assessment by other states. Californian LCFS credits trade close to 1 USD/gallon.

SAF COST

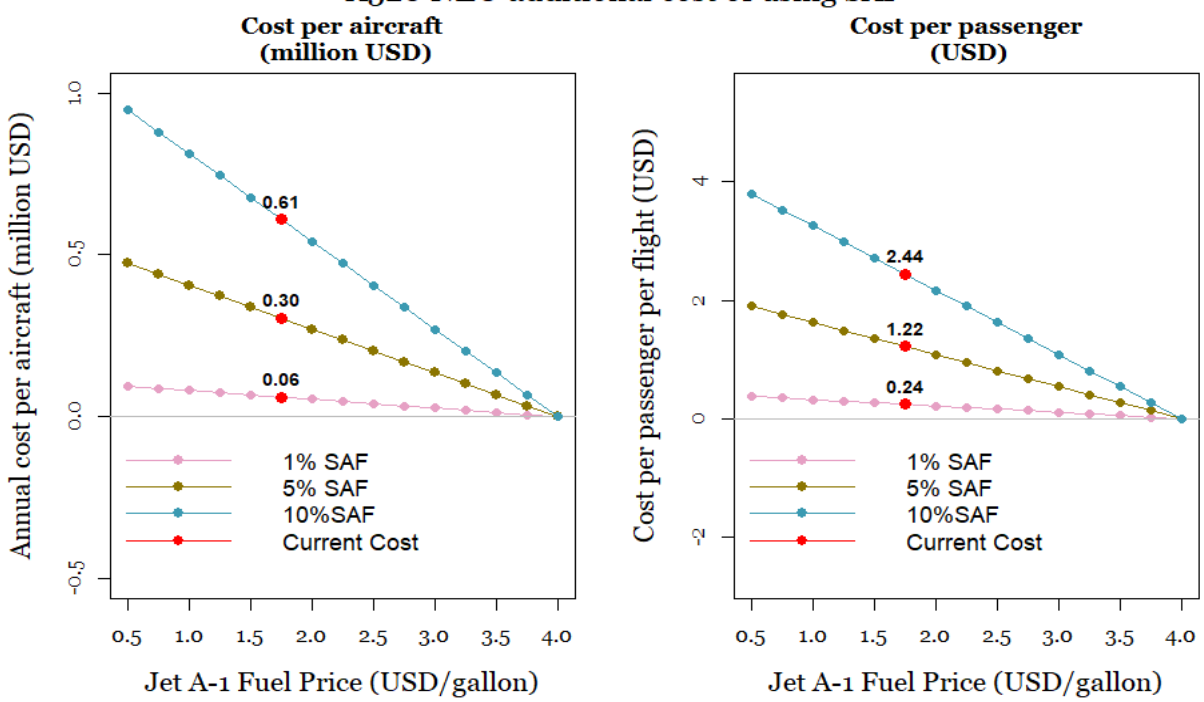
- SAF is an emerging market; SAF prices are between 2x and 5x that of Jet A-1 fuel.
- SAF prices are projected to drop with increased production volumes, market competition, and supporting policies to prices less than 2x the unsubsidised price of Jet A-1 fuel.
- SAF prices are expected to be less volatile than standard jet fuel. At present, there is insufficient evidence to point out a direct correlation between feedstock and traditional jet fuel prices. [3]

SIMULATION: Actual cost of using SAF for operators

For a 2018 built A320 NEO aircraft, assuming an average utilisation rate of 9 flight hours per day and SAF blending rates of 1%, 5%, and 10%, at today's fuel price (SAF~4.00USD/gallon, Jet A-1~1.75 USD/gallon), the additional annual costs for the airline are estimated at:

- 60,000 USD (1% blend), 300,000 USD (5% blend) and 600,000 USD (10% blend) per aircraft per year
- 0.24 USD (1% blend), 1.22 USD (5% blend) and 2.44 USD (10% blend) per passenger per flight at 80% load factors Comparatively, the average passenger ticket fare in Europe for low-cost carriers is below 60 USD.

A320 NEO additional cost of using SAF



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Contact Us

FPG Amentum
Ana Magdalina
Research Department
4th Floor, Mespil Court
Mespil Road, Dublin
D04 E516
Ireland

e-mail:
ana.magdalina@fpg-amentum.aero

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