



SAF MODULE

VOLUME 1

Introduction to Sustainable Aviation Fuel: Definitions, Benefits, and Global Relevance

- What is ATF?
- What is SAF?
- What is LCAF?
- Why SAF?
- SAF and UN SDGs
- Different Names of SAF
- Benefits of Using SAF
- SAF Required to Meet Mandates vs Current Capacity
- SAF Sustainability Criteria
- CORSIA
- ReFuelEU Aviation Regulation



What is Aviation Turbine Fuel?

- Aviation Turbine Fuel (ATF) is also known as **Jet Fuel**
- ATF is a liquid hydrocarbon in the **C9 to C16 range** (C=carbon)
- ATF has traditionally been produced from **petroleum crude oils**
- ATF combustion by aircraft emits **CO₂, NO_x, SO_x, water** and **particulate matter** into the atmosphere
- This can form persistent **contrail cirrus**, resulting in a net warming effect



What is Sustainable Aviation Fuel (SAF)

- The International Civil Aviation Organization (ICAO), a United Nations specialized agency, defines SAF as **'a renewable or waste-derived aviation fuel that meets the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) sustainability criteria'**
- SAF reduces carbon emissions (potentially by **up to 80 %**) and particulate emissions throughout its production route compared to traditional aviation fuel, making it a promising solution for the aviation industry to reduce emissions and mitigating environmental impacts
- SAF can be **directly blended and used interchangeably** without modifications to aircraft engines



Lower Carbon Aviation Fuels (LCAF)

- A **fossil-based aviation fuel that meets the CORSIA Sustainability Criteria**
- LCAF can **serve as a complementary measure** SAF in helping to reduce aviation greenhouse gas (GHG) lifecycle emissions
- A variety of technologies and processes can be used to produce CORSIA LCAF, such as **carbon capture and sequestration**, renewable and **low carbon intensity hydrogen**, and renewable and low carbon intensity **electricity**

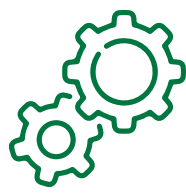


Why SAF?

- Aviation accounts for about 1 billion metric tons or about **3% of global CO₂ emissions annually**
- Every **metric ton of petroleum-based jet fuel** burned produces **3.15 tons of CO₂** in addition to other emissions such as nitrogen oxide, soot and other radiative-forcing mechanisms
- SAF offers a solution for the aviation industry to drastically reduce its carbon footprint by providing a **low-carbon alternative to traditional jet fuel**
- The use of SAF can reduce both **CO₂** and **non-CO₂** impacts at the same time
- SAF being a **drop-in alternative** can use **existing fuel supply and distribution infrastructure**, ensuring an energy transition can take place faster than other options



SAF Comparison with Other Alternatives

Comparison vs Fossil Kerosene	Battery-Electric 	H ₂ fuel Cell 	H ₂ fuel Turbine 	Sustainable Aviation Fuel 
Climate Impact 	100% Reduction ⁱⁱ	75%-90% Reduction	50%-75% Reduction	30%-60% Reduction ⁱⁱ
Aircraft Design 	Low-Battery Density Limits Ranges to 500km-1000km	Feasible only for Commuter to Short-Range Segments	Feasible for all Segments Except for Flights >10,000km	Only Minor Changes
Aircraft Operations 	Same or Shorter Turnaround Times	1-2X Longer Refuelling Times for up to Short Range	2-3X Longer Refuelling Times for Medium & Long Range	Same Turnaround Times
Airport Infrastructure 	Fast-Charging or Battery Exchange System Required	LH ₂ Distribution and Storage Required		Existing Infrastructure Can Be Used

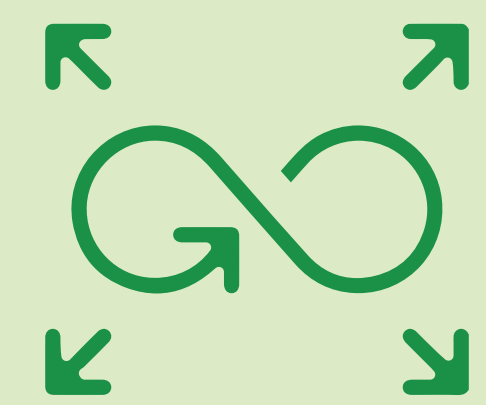
 Major Advantages
  Major Challenges

SAF Relation with UN SDGs

7 AFFORDABLE AND
CLEAN ENERGY



12 RESPONSIBLE
CONSUMPTION
AND PRODUCTION



13 CLIMATE
ACTION



Different Names of SAF

- Renewable Aviation Fuel
- Renewable Jet Fuel
- Biofuel
- Alternative Fuel
- Bio-jet Fuel
- Bio-Aviation Turbine fuel (Bio-ATF)



Global SAF Requirement to Meet Net-Zero Targets by 2050

- Between 330 – 445 million tonnes (412 – 556 billion litres) of SAF annually¹
- 520 million tonnes (650 billion litres) of SAF annually²



1. ATAG's Waypoint 2050, "Fueling net zero"

2. Sustainable aviation fuels as a pathway to net zero" (McKinsey, 2022)

SAF Production in 2024

- SAF production volumes were **1 million tonnes** (1.3 billion liters), double the 0.5 million tonnes (600 million liters) produced in 2023
- SAF accounted for **0.3% of global jet fuel production**
- In 2025, SAF production is expected to reach 2.1 million tonnes (2.7 billion liters) or **0.7% of total jet fuel production**



SAF Sustainability Criteria

Two Primary Frameworks:

- **ICAO** Carbon Offsetting and Reduction Scheme for International Aviation (**CORSIA**)
- **ReFuelEU** Aviation Regulation (Renewable Energy Directive, RED II)

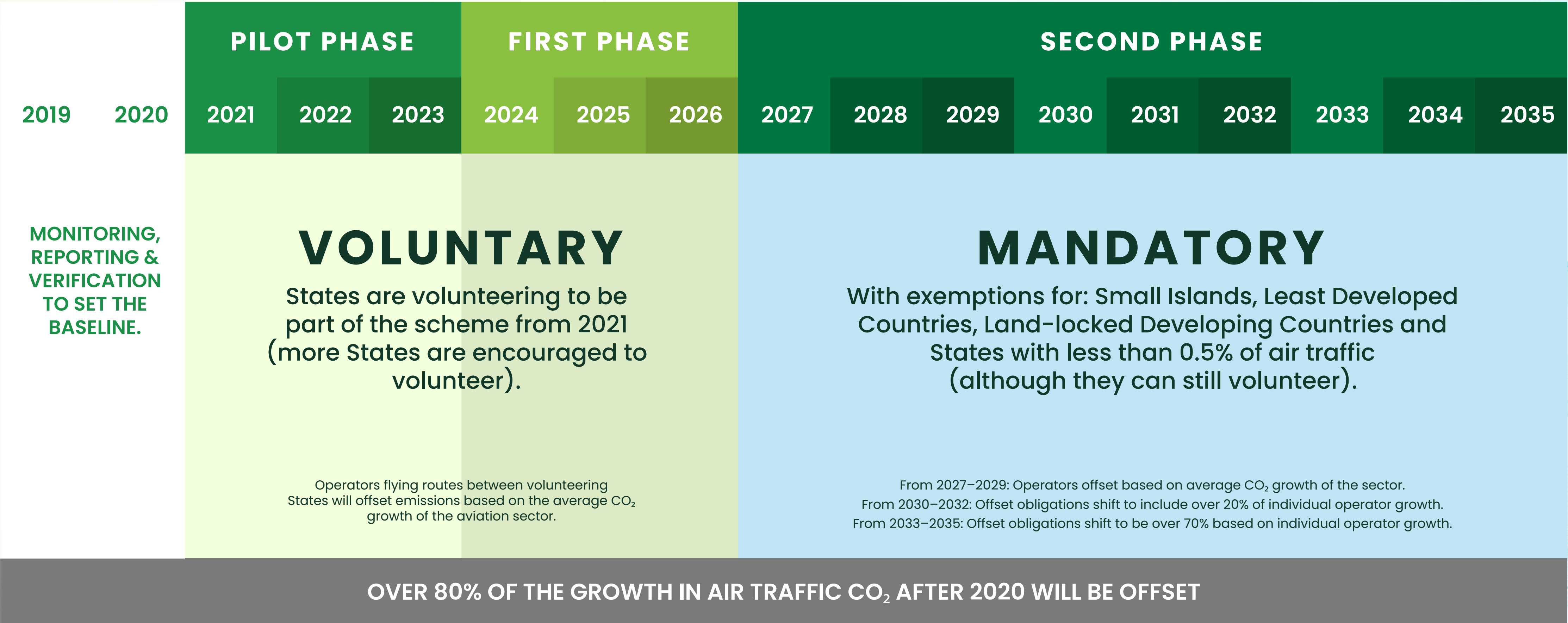


1. CORSIA

- Stands for **Carbon Offsetting and Reduction Scheme for International Aviation**
- In October 2016, the member states of **ICAO adopted this global market-based measure** to lessen aviation emissions
- CORSIA only applies to **international flights**. Domestic emissions fall under the scope of the UNFCCC and are covered by the Paris Agreement
- It is forecast that CORSIA will stabilize net CO₂ emissions from international aviation at between **550 and 600 million tons of CO₂ annually**, between 2024 and 2035
- As of 2025, **129 States** participate in CORSIA



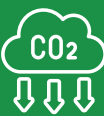
Phases of CORSIA



Voluntary Phase Participation



Sustainability Criteria under CORSIA

Sustainability Themes		Principle for Eligible Fuels
 Carbon Reduction	1. Greenhouse gases (GHG)	Should generate lower carbon emissions on a life cycle basis.
	2. Carbon stock	Should not be made from biomass obtained from land with high carbon stock.
	3. GHG reduction permanence	Should ensure carbon reductions are not reversed.
 Environment	4. Water	Production should not pollute waterways or impede availability.
	5. Soil	Production should maintain or enhance soil health.
	6. Air	Production should minimize negative effects on air quality.
	7. Conservation	Production should maintain biodiversity, conservation value, and ecosystems.
	8. Waste and chemicals	Production should promote responsible waste management and chemical use.
	9. Seismic and Vibrational Impacts	Not applicable
 Socio-Economic	10. Human and labor rights	Production should respect human and labor rights.
	11. Land use rights and land use	Production should respect land rights including indigenous and customary.
	12. Water use rights	Production should respect prior formal or customary water use rights.
	13. Local and social development	Production should contribute to localized socio-economic development.
	14. Food security	Production should not impede food-crop harvest and promote food security.

Carbon Reduction under CORSIA

Theme	Principle	Criteria
1. Greenhouse Gases (GHG)	CORSIA SAF should generate lower carbon emissions on a life cycle basis	Should generate lower carbon emissions on a life cycle basis.
2. Greenhouse Gas Emissions Reduction Permanence	Emissions reductions attributed to CORSIA SAF should be permanent	Criterion 2.1: Operational practices will be implemented to monitor, mitigate and compensate...

Sustainability Criteria under CORSIA

3. Carbon stock

CORSIA SAF should not be made from biomass obtained from land/aquatic systems with high biogenic carbon stock

Criterion 3.1: CORSIA SAF will not be made from biomass that is either obtained/extracted from land or aquatic ecosystems converted after 1 January 2008 that was primary forest, wetlands, peat lands, coral reefs, kelp forests, seagrass meadows, estuaries, tidal salt marshes or mangrove forests or contributes to degradation of the carbon stock in primary forests, wetlands, peat lands, coral reefs, kelp forests, seagrass meadows, estuaries, tidal salt marshes or mangrove forests as these systems all have high carbon stocks

Criterion 3.2: In the event of land use conversion after 1 January 2008, as defined based on the Intergovernmental Panel on Climate Change (IPCC) land categories, direct land use change (DLUC) emissions will be calculated. If DLUC greenhouse gas emissions exceed the default induced land use change (ILUC) value, the DLUC value will replace the default ILUC value

ReFuel EU Aviation Regulation & Sustainability Criteria

- **Part of EU's "Fit for 55" package aim:** reduce emissions by 55% by 2030 (vs. 1990 levels)
- **SAF Supply Mandates:** 2% in 2025, 6% in 2030, 70% in 2050
- **Synthetic e-fuel sub-mandate:** 0.7% in 2030, 35% in 2050
- **SAF Definition:** Biofuels, synthetic fuels, or recycled carbon fuels drop-in solutions (compatible with existing aircraft & infrastructure)
- **GHG Reduction Requirements (vs. fossil baseline = 94 g CO₂e/MJ):**
 - ≥50% (installations before Oct 2015)
 - ≥60% (installations after Oct 2015)
 - ≥65% (installations after 2021)
 - ≥70% (renewable fuels of non-biological origin & recycled carbon fuels)
- **Land Use Restrictions:** No raw material from primary/protected forests, biodiverse grassland, wetlands or peatlands