ICAO ENVIRONMENT



ICAO ACT-SAF Assistance Programme

ACT-SAF Information Session on Sustainable Aviation Fuels (SAF)

Module II: An introduction to SAF

Contents

- **Session 1:** SAF: Key concepts and international trends
  - **Decarbonization of aviation**
  - **What are SAF?**
  - **The concept of life cycle assessment**
  - **Sustainability framework and certification**
  - **Main SAF Production pathways**
  - **Global SAF market (trends, outlook)**

Why SAF are needed?

The role and benefits of SAF in the aviation decarbonization



LTAG Decision



ICAO Long Term Global Aspirational Goal For International Aviation (LTAG)

Adopted by ICAO Assembly Resolution A41-21 (2022)

https://www.icao.int/environmental-protection/Documents/Assembly/Resolution_A41-21_Climate_change.pdf

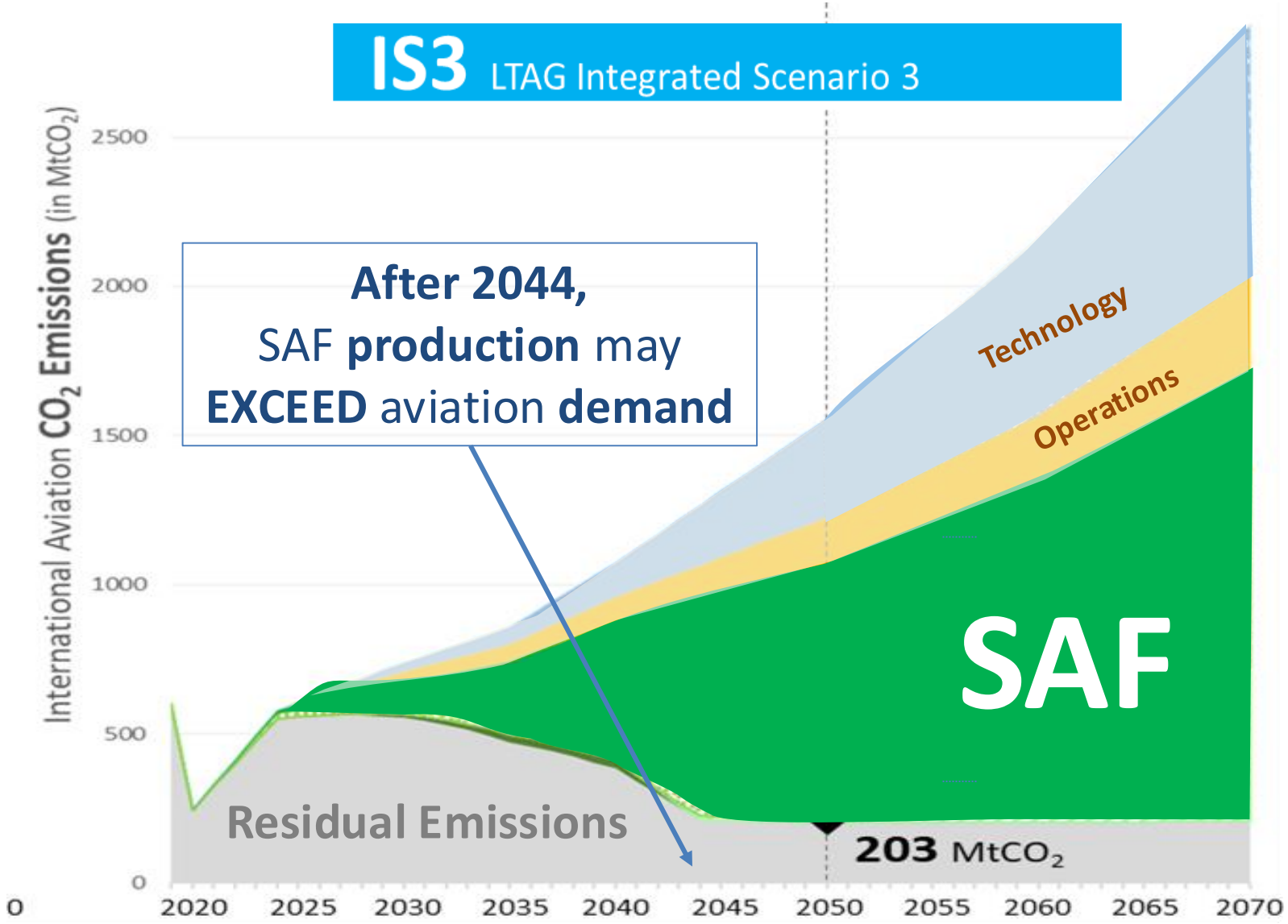


States will contribute **according to its national circumstances and capabilities**

LTAG Report

SAF will play a key role in aviation decarbonization efforts

LTAG report and SAF



2022: 0.15 Billion Liters of SAF being produced

2045: 636 billion liters needed to replace all fossil fuels

Need for immediate action to fully realize SAF potentials

References:
https://www.icao.int/environmental-protection/LTAG/Pages/LTAG-data-spreadsheet.aspx
https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---alternative-fuels/

CAAF/3 and the Global Framework



CAAF/3 DUBAI

- ICAO Member States adopted a new **ICAO Global Framework for Sustainable Aviation Fuels (SAF), Low-Carbon Aviation Fuels (LCAF) and other cleaner aviation fuels**.
- **An aspirational global collective vision to reduce CO2 emissions from international aviation by 5% by 2030**, through the use of cleaner energy in aviation, compared to the use of fossil fuels.
- Support the aviation sector's transition to clean energy necessary to achieve the current goal of net-zero carbon emissions by 2050

Benefits of SAF

- ✓ **The nature of SAF makes it ready for immediate use, compatible and interchangeable with conventional aviation fuels.**
  - Currently, SAFs can be blended with up to 50% conventional jet fuel and recertified; they are handled in the same way as conventional aviation fuels.
  - No changes are required to aircraft or their engines, nor to the infrastructure, which would otherwise entail significant logistical, safety and cost issues.
- ✓ **The SAF industry can provide opportunities for economic growth and employment**
- ✓ **The SAF industry can reduce energy dependence**

What are sustainable aviation fuels?

Definition and characteristics of SAF



What are Sustainable Aviation Fuels (SAF)?

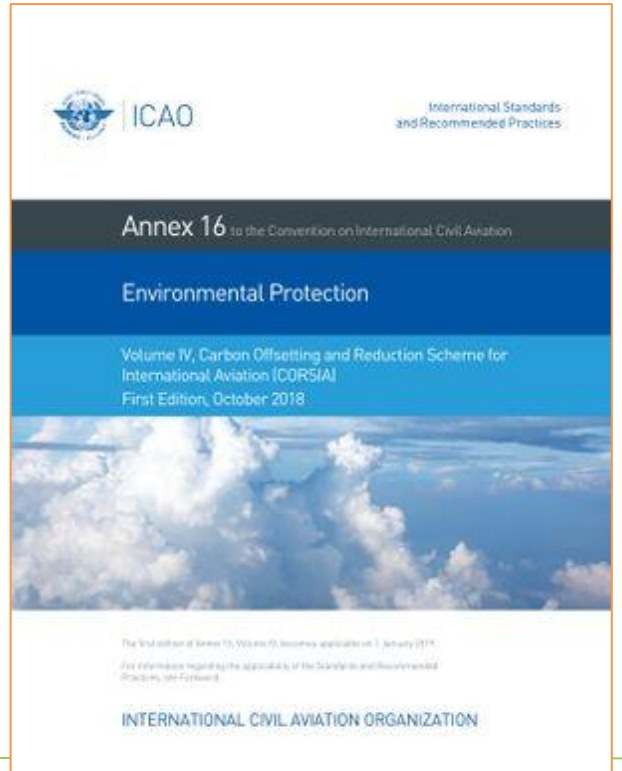
Not a single definition > linked to the applicable regulatory frameworks

CORSIA

Only one applies globally:

ICAO Annex 16 Vol IV (CORSIA)

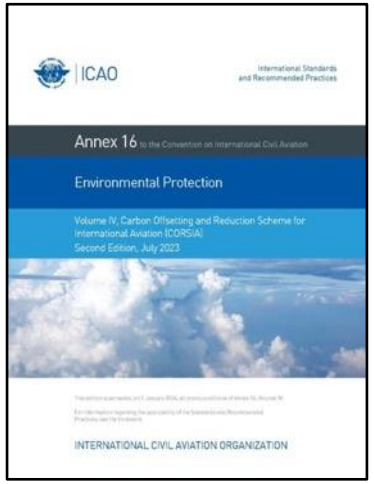
- SAF is defined as a ***renewable or waste-derived aviation fuel that meets the CORSIA Sustainability Criteria***

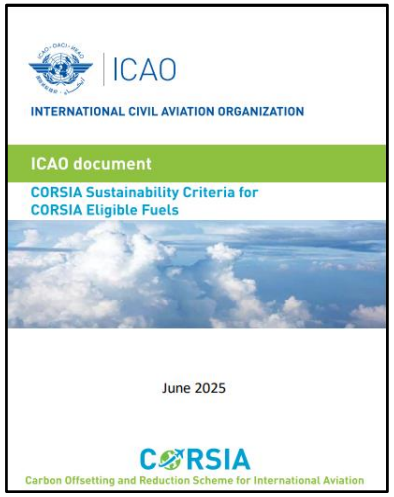


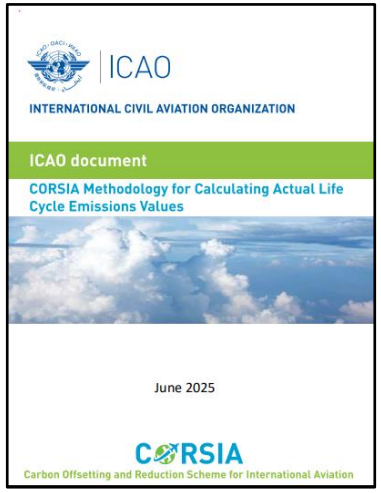
Basic definitions of SAF

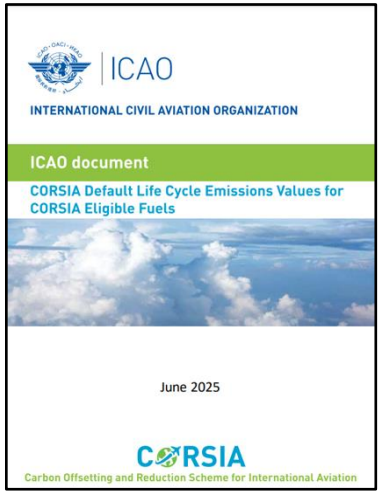
What are sustainable aviation fuels (SAF)?

Definition	What sustainability criteria?	What is waste?
SAF is defined as a *renewable or waste-derived aviation fuel* that meets sustainability criteria. ***Reference: Annex 16 Volume IV – CORSIA***	**Sustainability criteria** are defined in the ICAO document *"CORSIA Sustainability Criteria for CORSIA-eligible fuels"*	Waste is a raw material with an inelastic supply and no economic value (e.g. municipal solid waste, used cooking oil, waste gases, etc.) ***Reference:* ICAO document *"CORSIA Methodology for Calculating Actual Life-Cycle Emissions"***









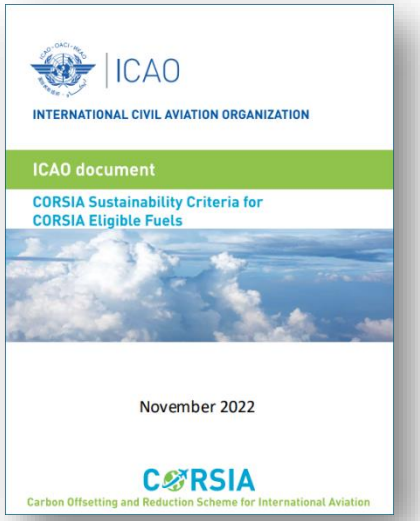
Documents available at https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-Eligible-Fuels.aspx

CORSIA Sustainability Criteria

Sustainability criteria for fuels eligible under CORSIA (CEF)
First comprehensive sustainability approach for an industrial sector

A **set of Sustainability Criteria** was approved by the ICAO Council, in the context of consideration of Sustainable Aviation Fuels and Lower Carbon Aviation Fuels under CORSIA. These Criteria are registered in the ICAO document "CORSIA sustainability criteria for CORSIA eligible fuels".

https://www.icao.int/CORSIA/corsia-eligible-fuels



Sustainability themes	
1. Greenhouse Gases (GHG)	Carbon-reduction themes
2. Carbon Stock	
3. GHG emissions reduction permanence	Environmental themes
4. Water	
5. Soil	
6. Air	
7. Conservation	
8. Waste and chemicals	
9. Seismic and vibrational impacts (only for LCAF)	
10. Human and labour Rights	Socio-economic themes
11. Land Use Rights and Land Use	
12. Water use rights	
13. Local and social development	
14. Food security	

All themes applicable for batches of CEF produced by certified fuel producer **on or after 1 January 2024**

Challenges and Need for Policy Action

- **Cleaner energy production is limited by a number of barriers**
  - Higher costs
  - Limited feedstock and fuel production infrastructure
  - Perceived financial risks

- **In the presence of such barriers, policy intervention is required to develop cleaner energy production.**
  - In general, a supporting policy framework is in place in those states where cleaner energy production has initiated

- **Constraints and opportunities are specific to each State**
  - Specific climates, agricultural systems, available resources, economic factors, political contexts, regulatory structures, etc.

The concept of life-cycle assessment and methodologies for calculating GHG savings



Life cycle assessment

CORSIA Sustainability Theme 1 requires lower carbon emissions on a **life cycle basis.**

CORSIA Sustainability Criterion 1.1 requires net greenhouse gas emissions **reductions of at least 10%** compared to a baseline.

These requirements are met based on **a Life cycle assessment of the SAF:**

SAF Life cycle emission value (LSf)
Unit – gCO2e/MJ

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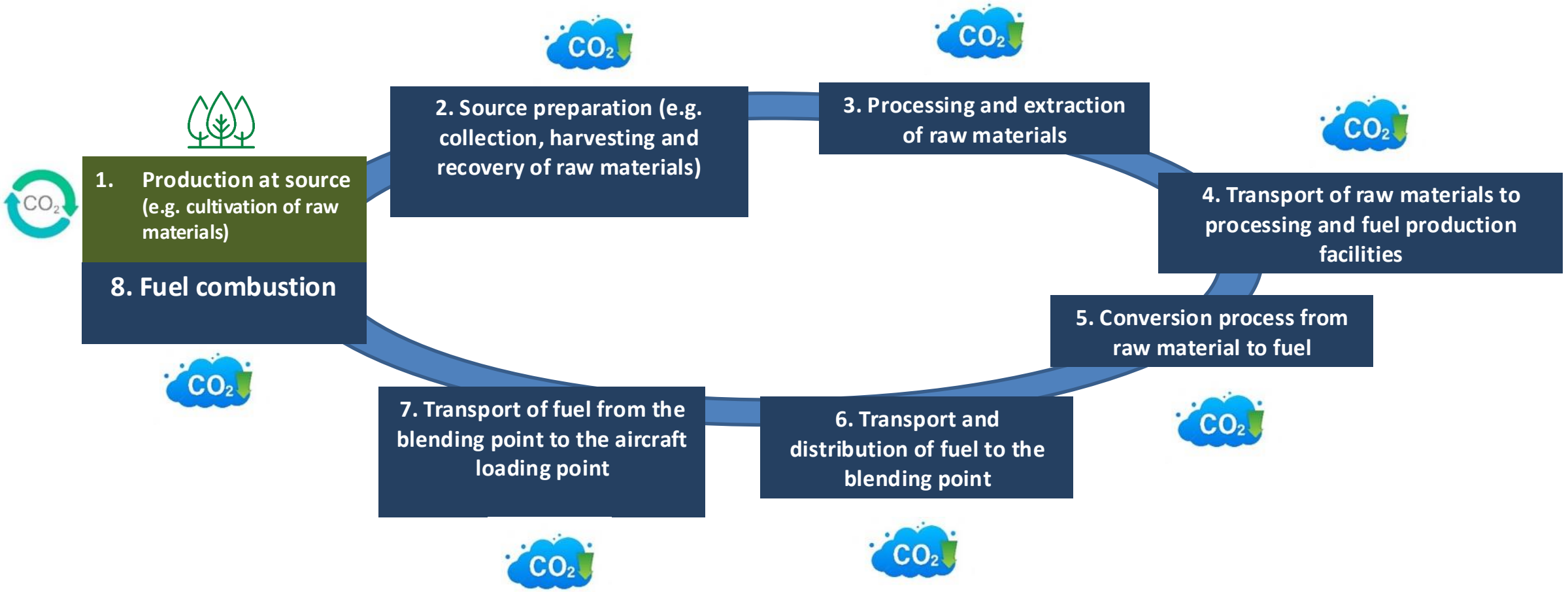
Core Life cycle assessment (core LCA value)
emissions associated with all steps of SAF production and use

+

Induced Land use Change (ILUC value)
Emissions associated with possible land use change generated by SAF feedstock production

Basic life cycle assessment (basic LCA value)

Emissions associated with the 8 stages of SAF production and use



Example: Life-cycle emissions from ATJ sugarcane ethanol in Brazil

Production stage	Associated emissions (gCO2e/MJ)
Raw material growth	-74
Raw material cultivation Processing, harvesting and recovery of raw materials Processing and extraction of raw materials	16.9
Transport of raw materials to fuel processing and production facilities	1.6
Conversion of raw materials into fuel	5.2
Transport and distribution of fuel	0.4
Fuel combustion in an aircraft engine	74
Total (basic LCA value)	24.1
Induced land-use change (ILUC value)	**8.7**
SAF life cycle emission value (LSF) = Basic LCA + ILUC	**32.8**



ACT-SAF #2 SERIES

63% reduction in emissions
Based on the life cycle
(Compared to the reference emission value of 89 gCO2e/MJ)

Calculation of emissions' reductions

CORSIA approach to calculate GHG savings: SAF Life Cycle Assessment

DEFAULT Life Cycle Emissions

ICAO document "CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels"

Default emission values, as a function of the feedstocks and conversion processes.



ACTUAL Life Cycle Emissions

ICAO document "CORSIA Methodology for Calculating Actual Life Cycle Emissions Values"

Allows calculation of specific emissions values to a given SAF or LCAF



First Global Approach to life cycle assessment

(ICAO ACT-SAF Series)

The sustainability framework for CORSIA eligible fuels



CORSIA Eligible Fuels

- CORSIA allows aircraft operators to **reduce its offsetting requirements through the use of CORSIA eligible fuels,** which include CORSIA sustainable aviation fuels and CORSIA lower carbon aviation fuels
- 5 ICAO documents containing the information needed to claim emissions reductions from the use of CORSIA Eligible Fuels

Current editions:



CORSIA Eligibility Framework and Requirements for Sustainability Certification Schemes	CORSIA Approved Sustainability Certification Schemes*	CORSIA Sustainability Criteria for CORSIA Eligible Fuels**	CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels***	CORSIA Methodology for Calculating Actual Life Cycle Emissions Values
Fourth Edition, June 2025	Third Edition, October 2024	Fourth Edition, June 2025	Eighth Edition, November 2025	Seventh Edition, November 2025

For more details, please visit ICAO CEF site:

Default life cycle emissions values

Table 1. CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels produced with the Fischer-Tropsch Fuel Conversion Process

Region	Fuel Feedstock	Pathway Specifications	Core LCA Value	ILUC LCA Value	LS_f (gCO_2e/MJ)
Global	Agricultural residues	Residue removal does not necessitate additional nutrient replacement on the primary crop	7.7	0.0	7.7
Global	Forestry residues		8.3		8.3
Global	Municipal solid waste (MSW), 0% non-biogenic carbon (NBC)		5.2		5.2
Global	Municipal solid waste (MSW) (NBC given as a percentage of the non-biogenic carbon content)		NBC*170.5 + 5.2		NBC*170.5 + 5.2
USA	Poplar (short-rotation woody crops)		12.2	-5.2	7.0
Global	Poplar (short-rotation woody crops)		12.2	8.6	20.8
USA	Miscanthus (herbaceous energy crops)		10.4	-32.9	-22.5
EU	Miscanthus (herbaceous energy crops)		10.4	-22.0	-11.6
Global	Miscanthus (herbaceous energy crops)		10.4	-12.6	-2.2



For more details, please refer to ICAO document 06 - Default Life Cycle Emissions - June 2022.pdf

Default life cycle emissions values

Table 2. CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels produced with the Hydroprocessed Esters and Fatty Acids (HEFA) Fuel Conversion Process

Region	Fuel Feedstock	Pathway Specifications	Core LCA Value	ILUC LCA Value	LSr (gCO_2e/MJ)
Global	Tallow		22.5	0.0	22.5
Global	Used cooking oil		13.9		13.9
Global	Palm fatty acid distillate		20.7		20.7
Global	Corn oil	Oil from dry mill ethanol plant	17.2		17.2
USA	Soybean oil		40.4	24.5	64.9
Brazil	Soybean oil		40.4	27.0	67.4
Global	Soybean oil		40.4	25.8	66.2
EU	Rapeseed oil		47.4	24.1	71.5
Global	Rapeseed oil		47.4	26.0	73.4
Malaysia & Indonesia	Palm oil	At the oil extraction step, at least 85% of the biogas released from the Palm Oil Mill Effluent (POME) treated in anaerobic ponds is captured and oxidized.	37.4	39.1	76.5
Malaysia & Indonesia	Palm oil	At the oil extraction step, less than 85% of the biogas released from the Palm Oil Mill Effluent (POME) treated in anaerobic ponds is captured and oxidized.	60.0	39.1	99.1



For more details, please refer to ICAO document 06 - Default Life Cycle Emissions - June 2022.pdf

Default life cycle emissions values

Table 3. CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels produced with the Alcohol (isobutanol) to jet (ATJ) Fuel Conversion Process

Region	Fuel Feedstock	Pathway Specifications	Core LCA Value	ILUC LCA Value	LSr (gCO_2e/MJ)
Global	Agricultural residues	Residue removal does not necessitate additional nutrient replacement on the primary crop.	29.3	0.0	29.3
Global	Forestry residues		23.8		23.8
Brazil	Sugarcane	Standalone or integrated conversion design	24.0	7.3	31.3
Global	Sugarcane	Standalone or integrated conversion design	24.0	9.1	33.1
USA	Corn grain	Standalone or integrated conversion design	55.8	22.1	77.9
Global	Corn grain	Standalone or integrated conversion design	55.8	29.7	85.5
USA	Miscanthus (herbaceous energy crops)		43.4	-54.1	-10.7
EU	Miscanthus (herbaceous energy crops)		43.4	-31.0	12.4
Global	Miscanthus (herbaceous energy crops)		43.4	-23.6	19.8
USA	Switchgrass (herbaceous energy crops)		43.4	-14.5	28.9
Global	Switchgrass (herbaceous energy crops)		43.4	5.4	48.8
Brazil	Molasses		27.0	7.3	34.3
Global	Molasses		27.0	9.1	36.1



For more details, please refer to ICAO document 06 - Default Life Cycle Emissions - June 2022.pdf

Actual life cycle emissions values

ICAO Document "CORSIA Methodology for Calculating Actual Life Cycle Emissions Values" allow for the calculation of specific emissions values to a given CORSIA SAF

- **Document provides further details on the methodology, such as:**
  - Technical report requirements
  - Feedstock categories (wastes, residues, byproducts = zero ILUC),
  - Low land use change risk practices (zero ILUC)
  - Emissions credits



For more details, please refer to ICAO document 07 - Methodology for Actual Life Cycle Emissions - June 2022.pdf

Sustainability certification



Sustainability certification

ICAO-approved 'Sustainability Certification Schemes (SCS)' are responsible for

- Ensuring compliance with the sustainability criteria for CORSIA eligible fuels (including CORSIA SAF)
- Ensuring that the life cycle emissions values of the fuel have been applied/calculated correctly
- To date, the International Sustainability and Carbon Certification (ISCC) and Roundtable on Sustainable Biomaterials (RSB) are the two CORSIA approved SCSs



SCS currently approved by ICAO

- ICAO Council approves Sustainability Certification Schemes (SCS) to Certify Fuels Eligible under CORSIA (CEF)



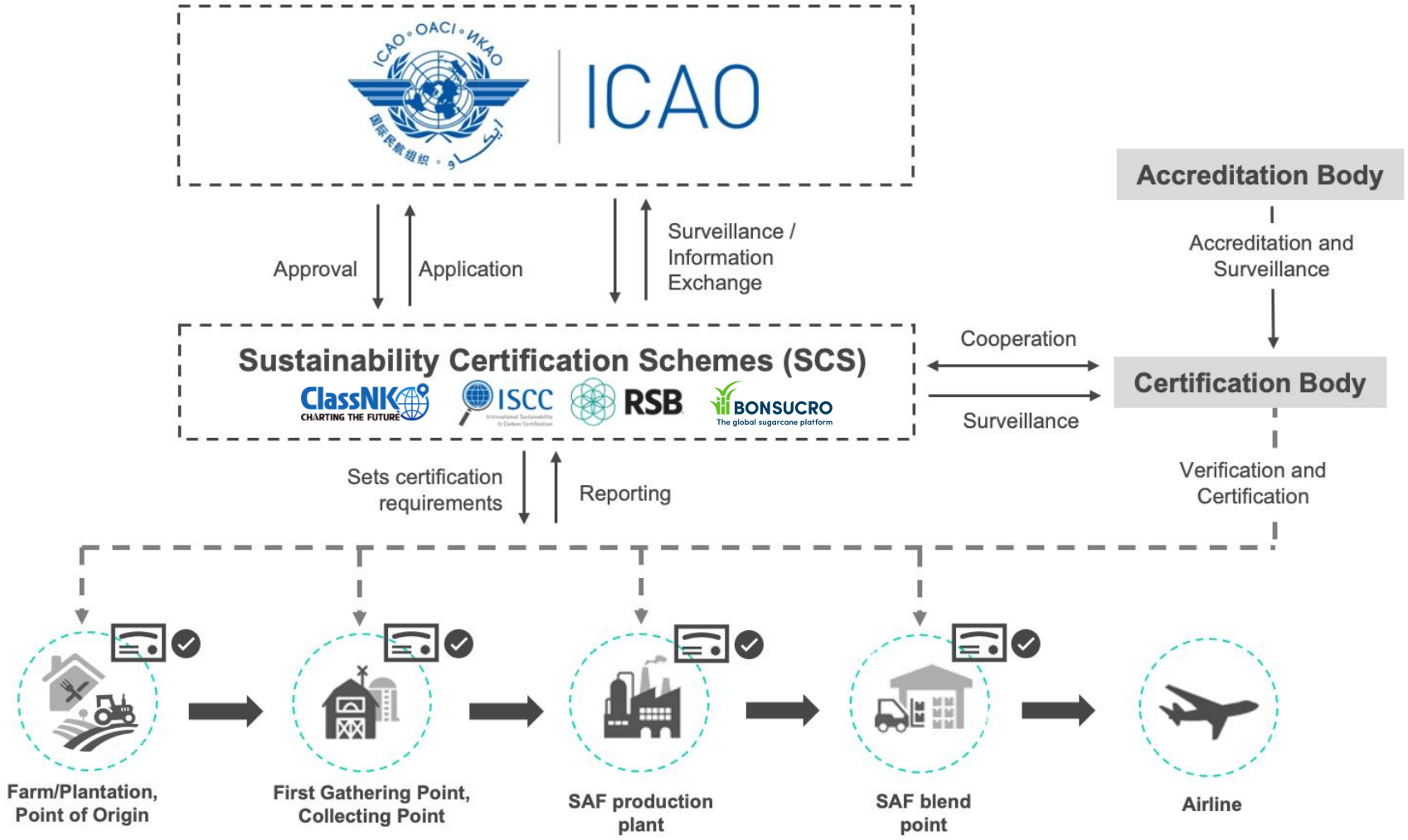
Name of the Sustainability Certification Scheme	Date of approval	Website	Scope of approval
International Sustainability and Carbon Certification (ISCC)	16 Jun. 2023	https://www.iscc-system.org/about/sustainable-aviation-fuels/corsia/	Certification of CORSIA Sustainable Aviation Fuels economic operators covered by Chapters 1 and 2 of the ICAO document "CORSIA Sustainability Criteria for CORSIA eligible fuels"
Roundtable on Sustainable Biomaterials (RSB)	16 Jun. 2023	https://rsb.org/rsb-corsia-certification/	Certification of CORSIA Sustainable Aviation Fuels economic operators covered by Chapters 1 and 2 of the ICAO document "CORSIA Sustainability Criteria for CORSIA eligible fuels"
ClassNK SCS	28 Oct. 2024	https://www.classnk.or.jp/hp/en/authentication/scs/index.html	Certification of CORSIA Sustainable Aviation Fuels economic operators covered by Chapter 2 of the ICAO document "CORSIA Sustainability Criteria for CORSIA eligible fuels"
Bonsucro	22 Jun. 2026	https://bonsucro.com	Certification of CORSIA Sustainable Aviation Fuels economic operators covered by Chapter 2 of the ICAO document "CORSIA Sustainability Criteria for CORSIA eligible fuels" and associated with the supply chain, production, and handling of sugarcane and its derivatives and associated CORSIA SAF production using ATJ and SIP processes.

For more details, please visit ICAO CEF site

✓ Economic operators **can demonstrate compliance with the CORSIA Sustainability Criteria for Eligible Fuels (CEFs),** by applying the ICAO approved Sustainability Schemes (SCS)

Role of SCS

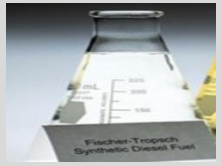
The certification "ecosystem" for CORSIA eligible fuels



Main SAF Production pathways



SAF processes come with different advantages & challenges

SAF Process	How feedstock is turned into SAF	Feedstock	CO_2eq % reduction*	Advantages	Current challenges
HEFA 	▪ **Upgrades natural oils and fats with hydrogen** (hydroprocessing of esters and fatty acids)	**Energy oil plants:** ▪ e.g. soybean or palm oil **Waste (biomass):** ▪ Used cooking oil ▪ Animal fats Other lipid-rich materials: ▪ E.g. algael	**~73-84%**	▪ Commercially available technology ▪ Ready to scale	▪ Limited scalability (sustainable feedstock scarcity) ▪ Competition with food production ▪ 50% blending mix (due to lack of aramatics)
Alcohol-to-Jet 	▪ **Converts alcohol through chemical steps** (dehydration, oligomerization, hydrogenation)	**Sugar plants:** • e.g. sugarcane, corn, sugar beets • Cellulosic energy crops (e.g. switchgrass) **Waste (biomass):** ▪ Agriculture residues (e.g. olive pits wheat or rice straws) ▪ Forestry residues (e.g. saw dust, wood chips) ▪ Municipal solid waste	**~85-94%**	▪ Commercial pilot stage technology ▪ Flexible feedstock options	▪ Limited commercial availability ▪ Expensive ▪ Competition with food production ▪ 50% blending mix
Gasification/ Fischer-Tropsch 	▪ **Converts carbon-rich waste into syngas, CO and H_2** (gasification) ▪ **Turns syngas into fuel** (esp. Fischer-Tropsch)	**Waste (biomass and general):** ▪ Municipal solid waste ▪ Biomass (e.g. agricultural residues, forest residues) **Other carbon-rich materials:** ▪ e.g. sewage sludge, plastic, paper	**~85-94%**	▪ Can use diverse feedstocks, particularly waste and residues ▪ 100% blending mx possible	▪ Expensive – energy intense and waste variation
E-fuels 	▪ **Combines hydrogen** (esp. electrolysis) **with captured carbon** (CCU/DAC) - both powered by renewable electricity ▪ **Turns this syngas into fuel** (esp. Fischer-Tropsch)	**Synthetic feedstock:** ▪ Hydrogen ▪ Captured carbon	**~99%**	▪ High scalability potential (does not compete with land & food resources)	▪ Low technology maturity ▪ Expensive ▪ Needs significant renewable energy ▪ 50-100% blending mix

Source: Clean Skies for Tomorrow (2021), *SAF Policy Toolkit;* Photos from MNT (2015), Britannica (2016), Cementis (2017), US DOE (2009)
Note: *over life cycle vs fossil jet fuel

Global SAF Market (trends, outlook)



ACT-SAF Platform

ACT SAF



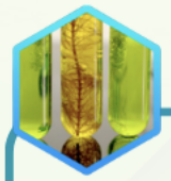
Policy and Planning

104
Policies adopted or under development

Production capacity (Kt/year)

1) Announced	25.616
2) FEED study	3.010
3) Under construction	1.922
4) Prod other fuels	0
5) Producing SAF	141
6) Prod CORSIA SAF	5.665

187
Airports distributing SAF



Regulatory Framework

CORSIA

57
Feedstocks recognized

135
Certified batches

794
Certified Economic Operators

422
kTonnes of certified SAF

11
Approved conversion processes
(11+ under evaluation)



Implementation Support

ACT SAF

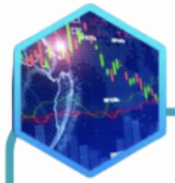
80
Feasibility Studies

294
Total partners

27
References and Reports

24
Total of Episodes

116
Events



Financing

55,4
Billion liters of SAF under offtake agreements

600
Announced SAF Facilities

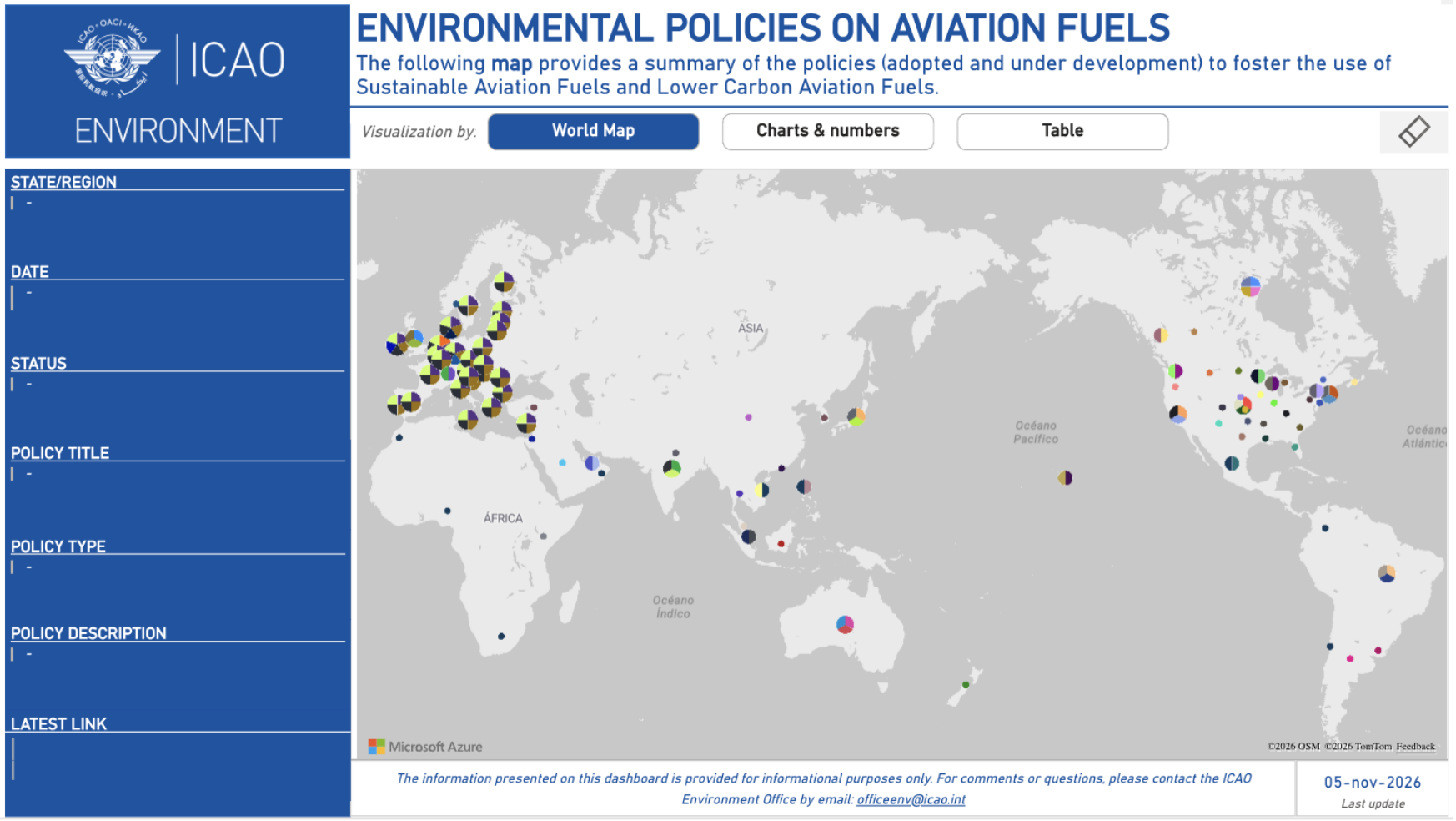
$75,6
Billion USD in announced investments

ICAO SAF monitoring tools to track progress and facilitate information sharing

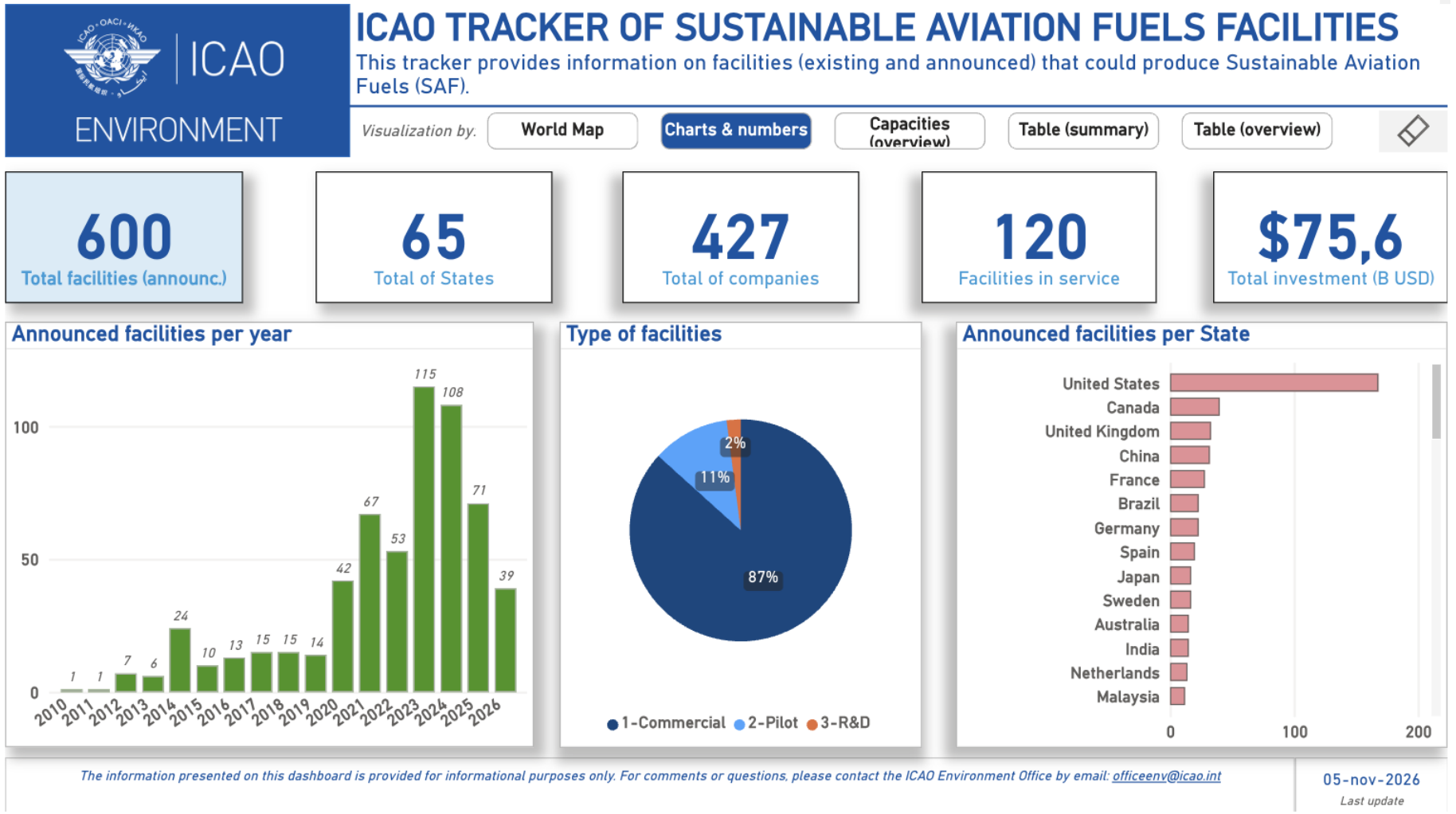
https://www.icao.int/icao-cleaner-energy-tracker-tools

ACT-SAF Platform

104 policies or regulations promoting SAF have been implemented or are currently being developed worldwide

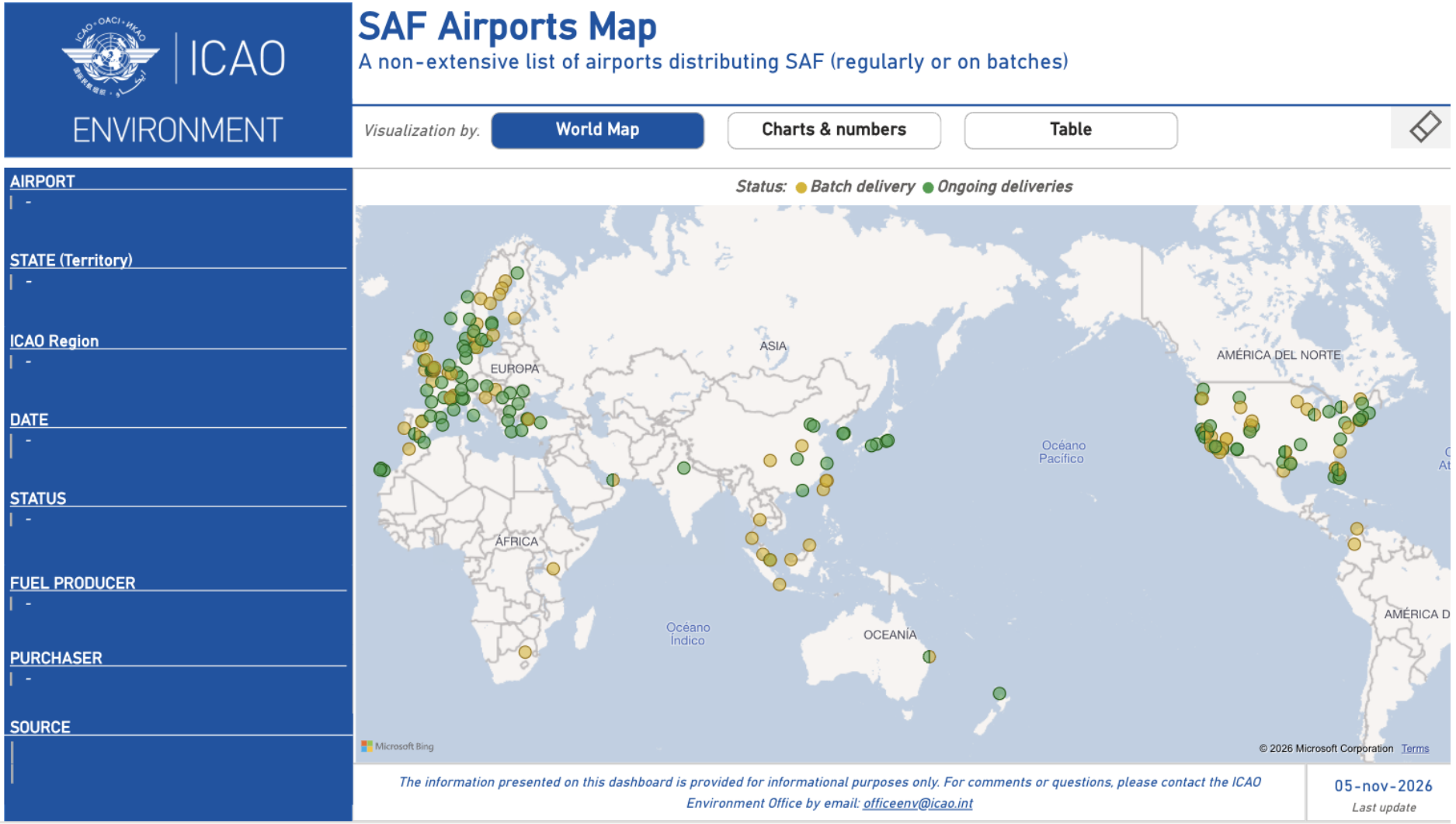


600 SAF production plants announced worldwide



ACT-SAF Platform

187 airports distribute SAF



Questions or comments?



ICAO

North American Central American and Caribbean (NACC) Office
Mexico City

South American (SAM) Office
Lima

ICAO Headquarters
Montréal

Western and Central African (WACAF) Office
Dakar

European and North Atlantic (EUR/NAT) Office
Paris

Middle East (MID) Office
Cairo

Eastern and Southern African (ESAF) Office
Nairobi

Asia and Pacific (APAC) Sub-office
Beijing

Asia and Pacific (APAC) Office
Bangkok



THANK YOU