

ACT-SAF Series #1:

Introduction to Sustainable Aviation Fuels

Virtual meeting 24 November 2022

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Purpose and agenda

Purpose

- Update participants on ACT-SAF developments
- Provide participants with a broad working knowledge of Sustainable Aviation Fuels (SAF)
- Form the basis for additional training on specific technical aspects of SAF

Agenda

- ACT-SAF Introduction and updates
- Role and benefits of SAF
- Definition of SAF and Sustainability Criteria
- SAF life cycle assessment
- SAF sustainability certification
- SAF specifications, feedstocks and conversion pathways
- Developments in the SAF market
- Additional ICAO SAF resources
- Conclusion: ACT-SAF next steps



ACT-SAF

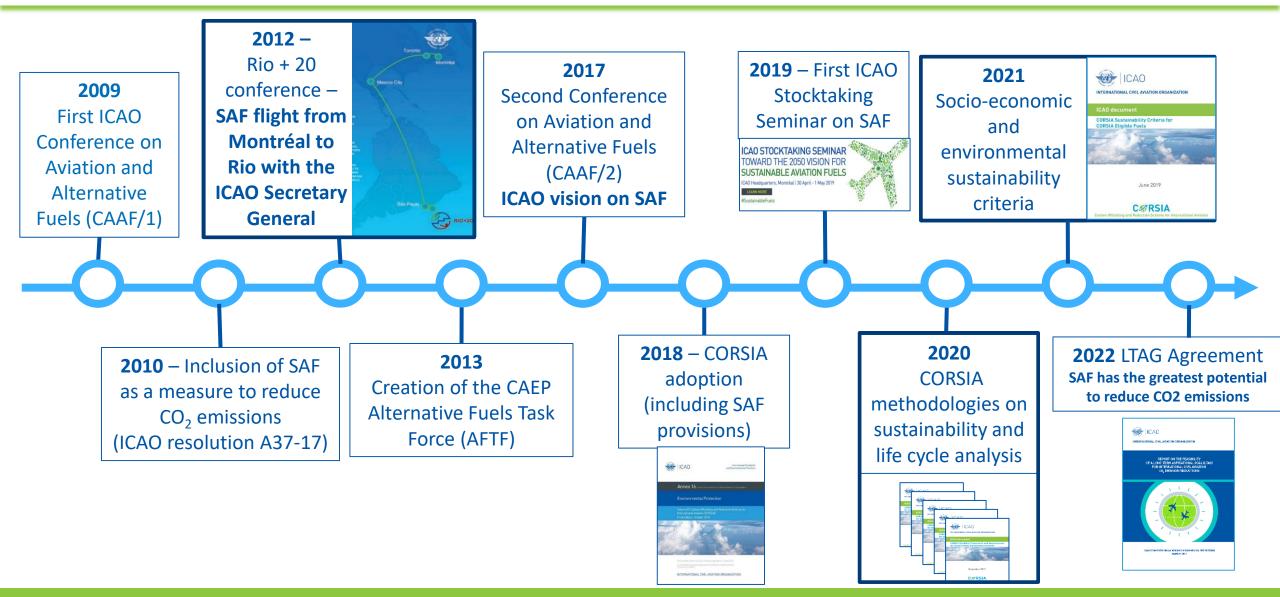
Introduction and updates



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ENVIRONMENT ICAO action on Sustainable Aviation Fuels (SAF)





ICAO ACT-SAF

ICAO Assistance, Capacity-building and Training for Sustainable Aviation Fuels



Launched on 1 June 2022, in an event Associated to the Stockholm+50 Conference



https://www.icao.int/environmentalprotection/Pages/act-saf.aspx



What is ICAO ACT-SAF?

- An ICAO initiative to facilitate the development and deployment of SAF
- Tailored support for States
- Facilitate cooperation under ICAO coordination
- A Platform to facilitate knowledge sharing and progress monitoring

Why ICAO ACT-SAF programme?

- Builds on existing ICAO "ACT" experience, through partnerships and cooperation amongst States
- ICAO LTAG report foresees largest CO2 reductions coming from fuels/cleaner energy sources
- Need for immediate action to fully realize SAF potentials





How does ACT-SAF work

1) Interested party* expresses interest in becoming an ACT-SAF Partner	2) ICAO coordinates with the interested party to detail the offers and requests, and suggest possible projects	3) ICAO connects ACT- SAF Participants	4) Agreement is signed and projects defined
Supporting State / Organization can participate by providing experts and/or resources Requesting State can participate by providing a focal point for coordination	Possible projects: •Feasibility Studies •Training programmes •Support for SAF certification •Support for Policy implementation	 Criteria for connection: Matching expertise Language, cultural and geographical aspects Resources availability 	Agreement will contain: Details on the cooperation terms, including the roles and responsibilities of ICAO and each participant



ACT-SAF updates

ACT-SAF platform provides most recent information

- States and International Organizations that are on ACT-SAF
- Latest news
- ACT-SAF Terms and Conditions (available to any State or Organization)





Atlantio

MERICA

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States

Microsoft Bing

Acceptance to ...
Pending
Yes

NORTH AMERIC

ICAO ACT-SAF Platform

Here you will find more information on our ACT-SAF Participants*



International Organizations



Latest news on ACT-SAF

		Ц	
Date	Latest news	Link	^
11/17/2022	ICAO launches the ACT-SAF Series of training events on SAF	୍ତ	
10/20/2022	Argentina signs the ACT-SAF Terms and Conditions	®	
10/7/2022	Equatorial Guinea signs the ACT-SAF Terms and Conditions	୍ତ	
10/4/2022	Brazil signs the ACT-SAF Terms and Conditions	୍ତ	
10/4/2022	Singapore signs the ACT-SAF Terms and Conditions	®	~

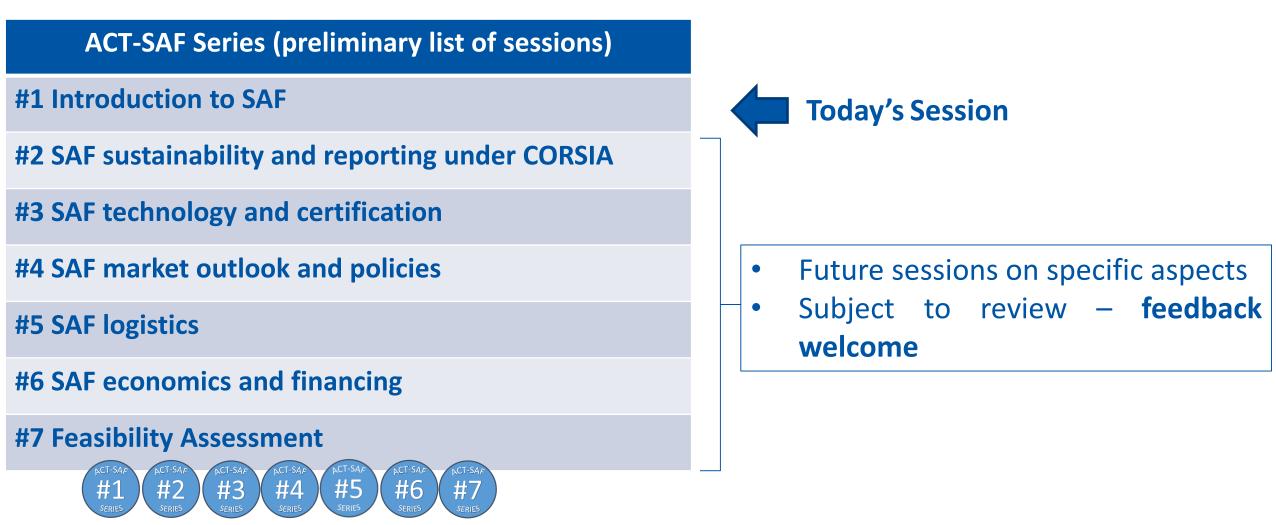
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Key request - conceptual training on SAF





The role and benefits of SAF in the aviation decarbonization





LTAG Decision

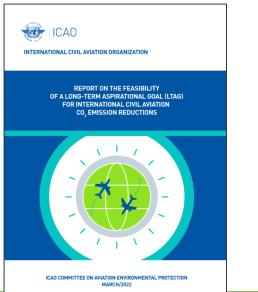


ICAO Long Term Global Aspirational Goal For International Aviation (LTAG) Adopted by ICAO Assembly Resolution A41-21

(2022)

https://www.icao.int/environmental-

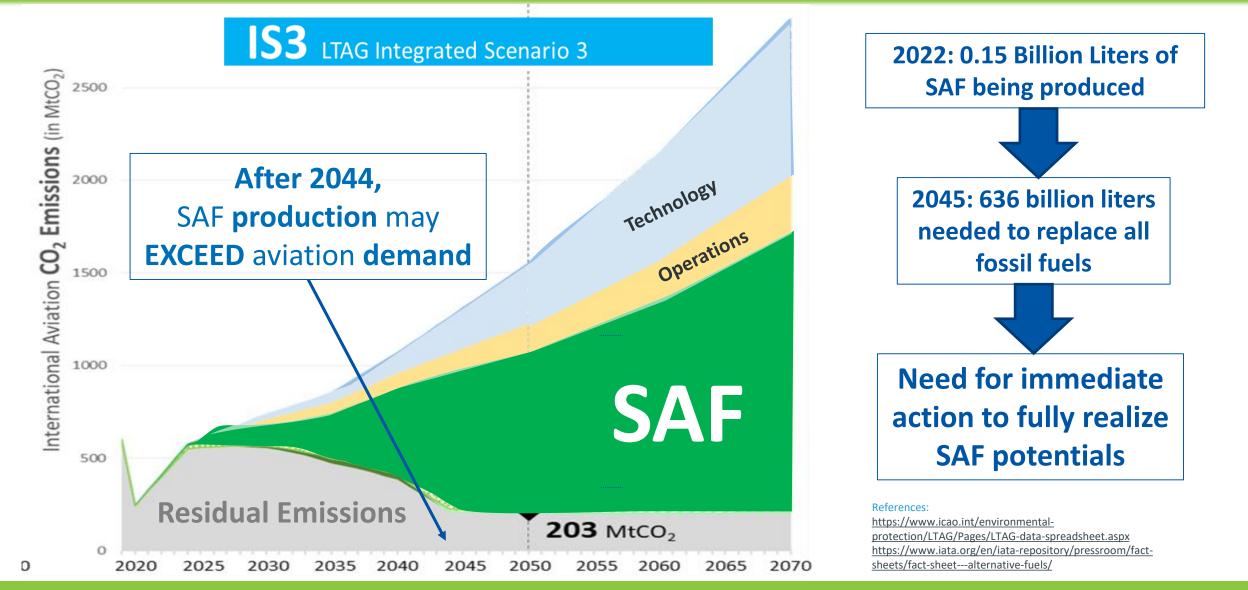
protection/Documents/Assembly/Resolution_A41-21_Climate_change.pdf



LTAG Report SAF will play a key role in aviation decarbonization efforts



LTAG report and SAF





ICAO 2050 Vision for SAF

adopted at the Second ICAO Conference on Aviation and Alternative Fuels (CAAF/2 - 2017)



- Calls on States, industry and other stakeholders to <u>substitute a significant proportion of</u> <u>conventional aviation fuels with sustainable aviation fuels</u> by 2050.
- 2050 Vision to be revised in 2023 (CAAF/3 Conference)
- Stocktaking process supporting these goals yearly events held since 2019



Benefits of SAF

Drop-in nature of SAF makes it interchangeable and compatible with conventional aviation fuels

- SAFs can currently be blended at up to 50% with conventional jet fuel, and recertified – it is handled in the same way as conventional aviation fuels
- No changes in aircraft or its engines, nor in infrastructure, which would imply major logistical, safety and cost issues

SAF industry can provide opportunities for economic growth and employment





Definition of SAF

And Sustainability Criteria





What are Sustainable Aviation Fuels (SAF)?

Definition	Which Sustainability Criteria?	What is a waste?
SAF is defined as a renewable or waste-derived aviation fuel that meets sustainability criteria. reference: Annex 16 Vol IV – CORSIA	Sustainability Criteria are defined in the ICAO document "CORSIA Sustainability Criteria for CORSIA Eligible Fuels"	Waste is a feedstock with inelastic supply and no economic value (e.g. municipal solid waste, used cooking oil, waste gases etc.) <i>reference:</i> ICAO document "CORSIA Methodology For Calculating Actual Life Cycle Emissions Values"







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





CORSIA sustainability criteria for CORSIA eligible fuels First global approach to sustainability for an industry sector



ICAO document





June 2019



Suctainability Thomas		
Sustainability Themes		
1. Greenhouse Gases (GHG)		Carbon-reduction themes
2. Carbon stock	\int	(CORSIA pilot phase, 2021-2023)
3. Water		
4. Soil		
5. Air		
6. Conservation		
7. Waste and Chemicals		Environmental and socio-economic
8. Human and labour rights		Themes for SAF
9. Land use rights and land use		(After CORSIA pilot phase, from 2024)
10. Water use rights		Sustainability criteria for LCAF is
11. Local and social development		under consideration by Council
12. Food security		17



Carbon Reduction Themes



Theme 1: Greenhouse gases

• CORSIA eligible fuel should generate lower carbon emissions on a life cycle basis

Theme 2: Carbon stock

• CORSIA eligible fuel should not be made from biomass obtained from land with high carbon stock



For more details, please refer to CORSIA Sustainability Criteria for CORSIA Eligible Fuels (icao.int)



Environmental themes



Theme 3: Water

Production of CORSIA SAFs should maintain or enhance water quality and availability

Theme 4: Soil

• Production of CORSIA SAFs should maintain or enhance soil health

Theme 5: Air

• Production of CORSIA SAF should minimize negative effects on air quality

Theme 6: Conservation

• Production of CORSIA SAF should maintain biodiversity, conservation value and ecosystem services

Theme 7: Waste and chemicals

 Production of CORSIA SAF should promote responsible management of waste and use of chemicals



Socio-economic themes



Theme 8: Human and labour rights

• Production of CORSIA SAF should respect human and labour rights

Theme 9: Land use rights and land use

• Production of CORSIA SAF should respect land and land use rights including indigenous and/or customary rights

Theme 10: Water use rights

 Production of CORSIA SAF should respect prior formal or customary water use rights

Theme 11: Local and social development

• Production of CORSIA SAF should contribute to social and economic development in regions of poverty

Theme 12: Food security

• Production of CORSIA SAF should promote food security in food insecure regions



SAF life cycle assessment



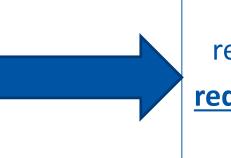






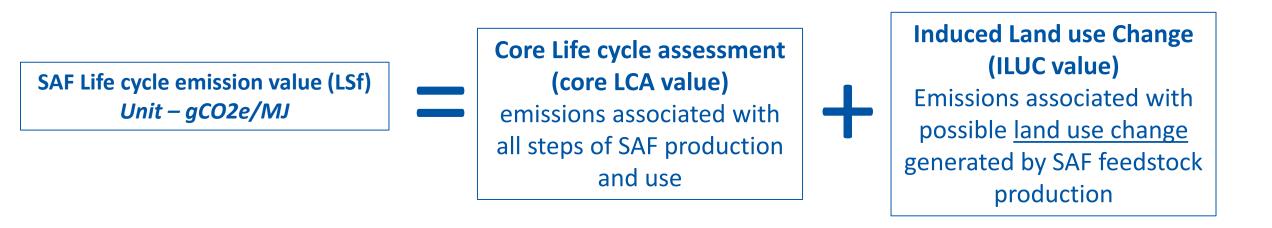


CORSIA Sustainability Theme 1 requires lower carbon emissions on a <u>life cycle basis.</u>



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

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



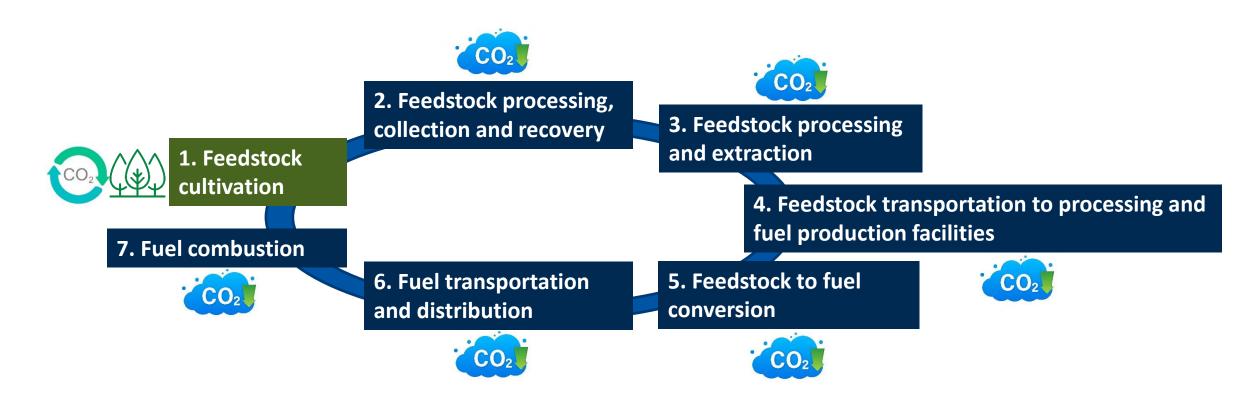




PCT-SAF #2 SERIES

Core Life cycle assessment (core LCA value)

Emissions associated with all steps of SAF production and use







Example: life cycle emissions of sugarcane ethanol ATJ in Brazil

Production step	Associated emissions (gCO2e/MJ)
Feedstock growth	-74
Feedstock cultivation Feedstock processing, collection and recovery Feedstock processing and extraction	16.9
Feedstock transportation to processing and fuel production facilities	1.6
Feedstock to fuel conversion	5.2
Fuel transportation and distribution	0.4
fuel combustion on aircraft engine	74
total (core LCA value)	24.1
Induced Land use Change (ILUC value)	8.7
SAF Life cycle emission value (LSf) = core LCA + ILUC	32.8



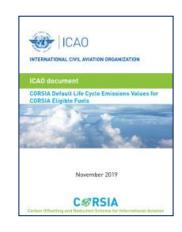




CORSIA allows two options to obtain the life cycle emissions of SAF

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



Default life cycle emissions values

pct-saf #2 series

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 ₂ e/MJ)
Global	Agricultural residues	Residue removal does not necessitate additional nutrient replacement on the primary crop	7.7		7.7
Global	Forestry residues		8.3		8.3
Global	Municipal solid waste (MSW), 0% non-biogenic carbon (NBC)		5.2	0.0	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 <u>ICAO</u> document 06 - Default <u>Life Cycle Emissions -</u> <u>June 2022.pdf</u>



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 ₂ e/MJ)
Global	Tallow		22.5		22.5
Global	Used cooking oil		13.9		13.9
Global	Palm fatty acid distillate		20.7	0.0	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 <u>ICAO</u> document 06 - Default <u>Life Cycle Emissions -</u> <u>June 2022.pdf</u>



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 ₂ e/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



ICAO ENVIRONMENT Actual life cycle emissions values

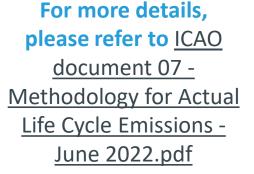
ICAO Document "CORSIA Methodology for Calculating <u>Actual</u> Life Cycle Emissions Values" allow for the calculation of specific emissions values to a given CORSIA SAF

- 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



#2







SAF 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









Questions?



SAF specifications, feedstocks and conversion pathways





SAF specifications

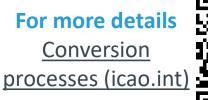
ASTM International defines technical specifications for SAF

Ensure SAF are safe for use in aircraft

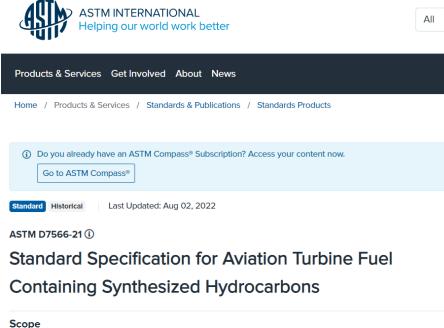
ENVIRONMENT

CAO

- **Specify necessary chemical properties**
- 9 conversion processes currently approved for SAF production (ASTM D7566 and D1655)
- **Other technical specifications include the UK DEF** STAN 91-091, China CTSO-2C701, among others.







1.1 This specification covers the manufacture of aviation turbine fuel that consists of conventional and synthetic blending components.

1.2 This specification applies only at the point of batch origination, as follows:



SAF – conversion pathways and feedstocks



SAF can be produced from a variety of feedstocks

Oils and fats





Lignocellulose

Examples of conversion pathways:

Sugars





Wastes

	Synthesized paraffinic kerosene from hydroprocessed esters and fatty acids (HEFA)	Fischer-Tropsch hydroprocessed synthesized paraffinic kerosene (FT)	Alcohol to jet synthetic paraffinic kerosene (ATJ-SPK)
Description	Conversion of oils/fats to hydrocarbons via deoxygenation with hydrogen and cracking	Gasification of carbon containing material to syngas, then converted to SAF through FT synthesis	Sugars (from syngas or cellulosic material) converted to SAF through alcohol intermediate
Blend ratio	50%	50%	50%
Possible feedstock	Animal tallow Used cooking oil	Municipal solid waste Miscanthus	Sugar cane Waste gases
Existing programs	Neste, WorldEnergy, Honeywell UOP, etc.	Fulcrum, Redrock, Sasol, Shell, etc.	Gevo, Lanzatech, Swedish biofuels, etc.

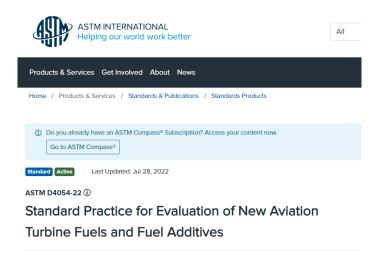


SAF – conversion processes and specifications



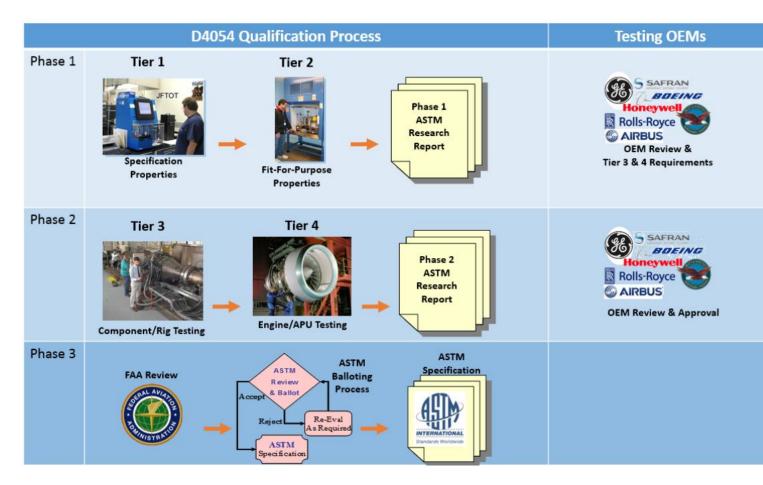
ASTM D4054 provides a framework for approval of new SAFs

- guidance on testing and necessary properties
- fast track process for fuel approval



Significance and Use

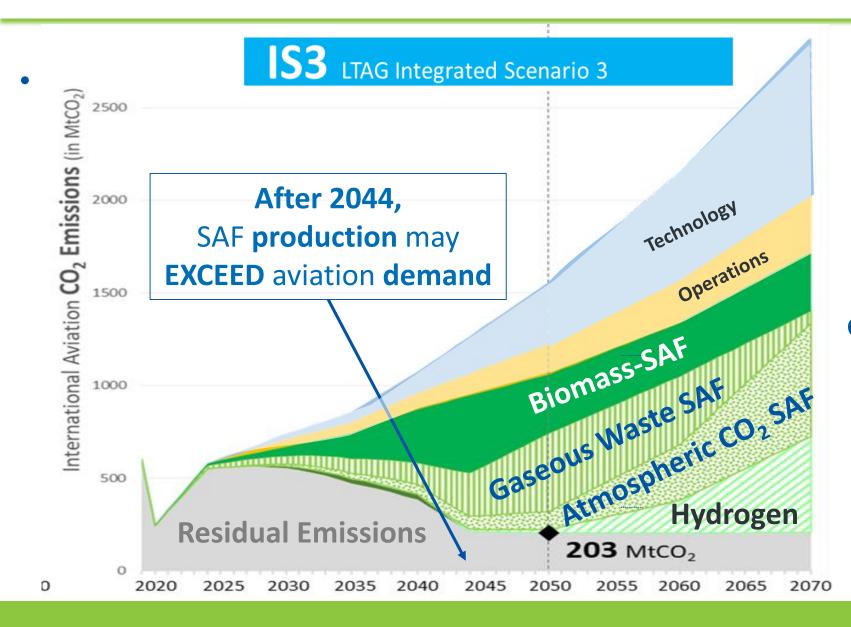
5.1 This practice is intended to describe the data requirements necessary to support the review of new aviation turbine fuels or additives by ASTM members for the developers or sponsors of these new products.



Source: https://www.caafi.org/focus_areas/fuel_qualification.html#streamlining



LTAG and SAF



All types of SAF will contribute to the LTAG of net zero CO₂ emissions by 2050



Developments in the SAF market



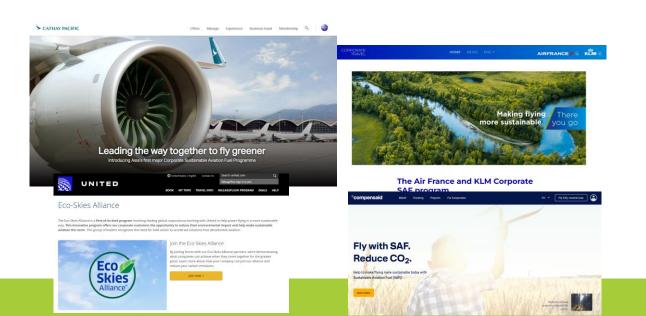


Developments in the SAF market demand

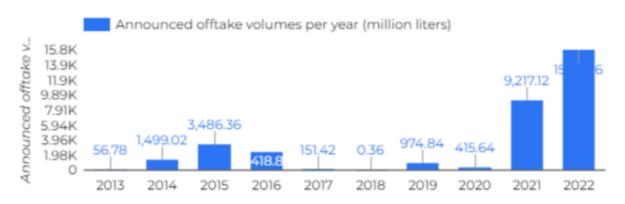


Demand for SAF is growing exponentially

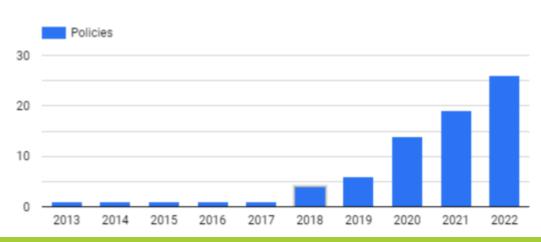
- Airlines signing multi year offtake agreements
- **States are implementing supporting policies**
- **Programmes allow corporates and travelers to** purchase SAF



Offtake agreements



Source: https://www.icao.int/environmental-protection/GFAAF/Pages/Offtake-Agreements.aspx



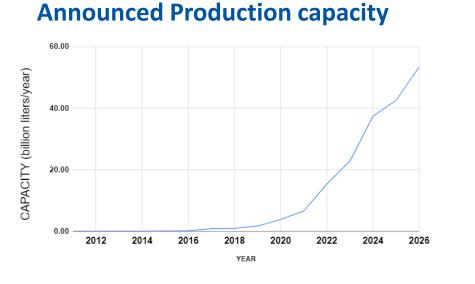
Policies



Developments in the SAF market supply



SAF production volumes and distribution also growing



ICAO SAF Tracking Tools provide regular updates on SAF market

Airports distributing SAF







Policy Examples



SAF policies are supporting supply and demand

United States SAF Grand Challenge

- Government wide effort to reduce cost, enhance sustainability, expand production and use of SAF
- Scale up SAF production to at least 3 billion gallons per year by 2030
- Sufficient SAF to meet 100% aviation fuel demand by 2050
- SAF Grand Challenge Roadmap
- Incentives (SAF blenders tax credit, Clean Fuel Production Credit, Grant Programs)

UK Jet Zero Strategy

- Vision and approach for aviation sector to reach net-zero by 2050
 - SAF is one of six core policy measures
- SAF mandate setting obligation on fuel suppliers for at least 10% SAF use by 2030
- Funding support to kickstart domestic SAF industry
- Joint industry/government work through Jet Zero Council SAF Delivery Group

Fit-for-55: ReFuelEU Aviation

- Regulatory proposal to transition from fossil fuels to SAF
- Proposal to introduce EU wide SAF blending mandate
 - Advanced biofuels and E-fuels
 - From 2% by 2025 to 63% by 2050
 - Sub-obligation on e-fuels (0.7% by 2030 to 28% by 2050)
- Legislative process is ongoing



Additional SAF resources from ICAO





ICAO provides guidance material to support SAF development and deployment

#4

SFRIFS

- Guidance on potential policies and coordinated approaches for the development of SAF
- Stimulate growth of SAF supply
- Create SAF demand
- Enable a SAF marketplace

For more details



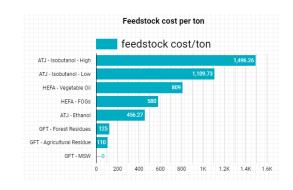


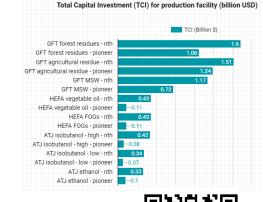
JUNE 2022

SAF Rules of Thumb – what does it take

to produce SAF?

- Estimations on SAF costs, investment needs and production potential
- Tradeoffs between variables





For more details





Additional resources

Four SAF feasibility studies are freely available on the ICAO website*







SAF tracker tools



SAF tracker tools are also available in the ICAO website

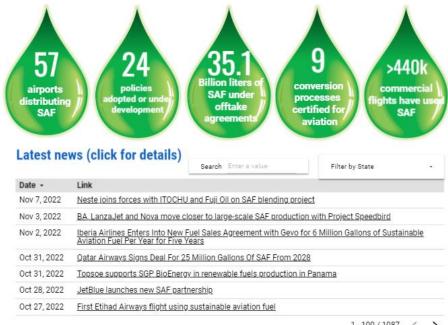
Provides updated information on

- SAF offtake agreements from airlines
- SAF production facilities
- Airports offering SAF
- Policies fostering SAF market developments
- Latest news



For more details, please refer to <u>ICAO SAF</u> <u>Tracking Tools</u> Sustainable Aviation Fuels (SAF)

SAF Tracking tools (click on the drops for details)



1-100/1087 < >

SAF facilities map see the facilities (existing and announced) that can produce SAF





Conclusion: ACT-SAF next steps





ACT-SAF next steps

1) Interested party* expresses interest in becoming an ACT- SAF Partner	2) ICAO coordinates with the interested party to detail the offers and requests, and suggest possible projects	3) ICAO connects ACT- SAF Participants	4) Agreement is signed and projects defined
Ongoing		Next steps	
 Identification of needs and offers Coordination calls being held European Commission offered €1.6m towards ACT-SAF Projects Various ACT-SAF partners offered technical support 		Facilitate the match of opportunities and needs from States	Coordination of specific ACT-SAF projects (Q1 2023)
Identification of financing opportunities 4 Informal Exchanges on SAF financing			



ACT-SAF Series



ACT-SAF Series (provisional list of next sessions)

#1 Introduction to SAF

#2 SAF sustainability and reporting under CORSIA

#3 SAF technology and certification

#4 SAF market outlook and policies

#5 SAF logistics

#6 SAF economics and financing

#7 Feasibility Assessment

ACTIONS FOR ACT-SAF Partners:

- Invite other States and Stakeholders to join ACT-SAF and participate on these events
 - Any State or Organization can fill out the ACT-SAF Terms and Conditions available on the ACT-SAF website)
- Provide feedback and suggest other subjects for the ACT-SAF Series (email officeenv@icao.int)



ACT-SAF next steps

ICAO ACT-SAF platform will consolidate the actions and results



ICAO ACT-SAF Platform Here you will find more information on our ACT-SAF Participants*



Outreach of Financing opportunities

- Assessment of SAF policy approaches
- 2023 Stocktaking (date TBC)
 - dedicated session on SAF policies and financing
- ICAO to continue to coordinate and get views from Member States and Stakeholders
- **Development of ICAO SAF Accounting and Reporting System**
 - Monitor progress on SAF implementation (Assembly Resolution A41-21)
 - Consolidate available information (e.g. Book and Claim systems; CORSIA CCR public information, State Action Plans).

All activities will support the CAAF/3 Conference in 2023 (date TBC)





