EASA
European Union Aviation Safety Agency

SAF Feedstock basics: Fundamental Know-how, CORSIA Eligibility and Sustainability Certifications

How to become SAF ready? How to make SAF happen?

SAF Training for ACI Africa & AFRAA

23.-25.04.2025, Arusha, Tanzania

Global Gateway

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Day 2 Section 3: Feedstock supply, preparation and certification

Topic

SAF Feedstock basics: Fundamental Know-how, CORSIA Eligibility and Sustainability Certifications

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CBR Sustainability Partners

Technology Expert

Dr. Fabian Schmitt is a professional in green chemicals such as sustainable aviation fuels with profound knowledge in chemical conversion technologies with expertise in electrochemical processes, electrochemical and thermochemical conversion of carbon dioxide to produce base chemicals, as well as methanol and FT-synthesis. Convinced, that green transition is an interdisciplinary and international effort that needs to be holistically and jointly addressed from technology, business and regulatory perspective.

Consulting Focus @ CBR Sustainability Partners

- Technology assessments, feasibility studies and techno-economic analysis in the field of renewable gases and liquids, hydrogen, Power-to-X, sustainable fuels (SAF) and green chemicals
- Expertise in regulatory policies with focus on renewable fuels, such as SAF
- Focus on renewable fuel production technologies, feedstock availabilities and CO2 reduction potentials

Education

- PhD in Chemical Engineering, TU Darmstadt, Germany
- Master in Chemical Engineering, TU Darmstadt, Germany / Aalto University Espoo, Finland
- Bachelor in Chemistry, TU Darmstadt, Germany

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SAF Feedstock basics: Fundamental Know-how, CORSIA Eligibility and Sustainability Certifications

Nipun Jagtap

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Technology Expert

Nipun Jagtap is a highly experienced professional in the field of sustainable aviation fuels, with a strong track record in process development and the techno-economic feasibility studies of sustainable technologies. His expertise extends to process designing and modelling, conducting feasibility studies and developing guidelines for the holistic assessment of sustainable technologies and consulting in private sector.

He is experienced in conducting experimental and simulation research of the production processes related to renewable chemicals, Power-to-X processes, sustainable aviation fuels (SAF), and green chemicals.

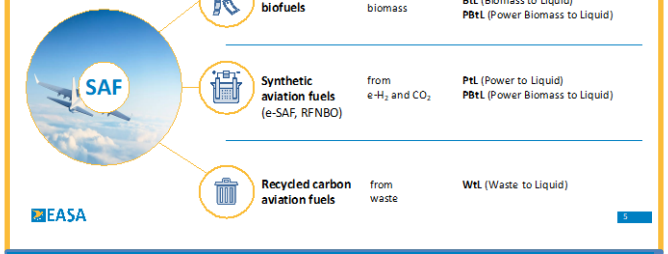
Consulting Focus @ CBR Sustainability Partners

- Conducting techno-economic evaluation of innovative green fuel and sustainable chemical production processes.
- Optimizing the viability and commercial feasibility of the project by critically addressing the bottlenecks.

Education

- Master in Process Engineering and Energy Technology, HS-Bremerhaven
- Bachelor in Chemical Engineering, ICT-Mumbai

Guiding questions



How are the different SAF categories, feedstocks and SAF production technologies linked?

RED III

CORSIA

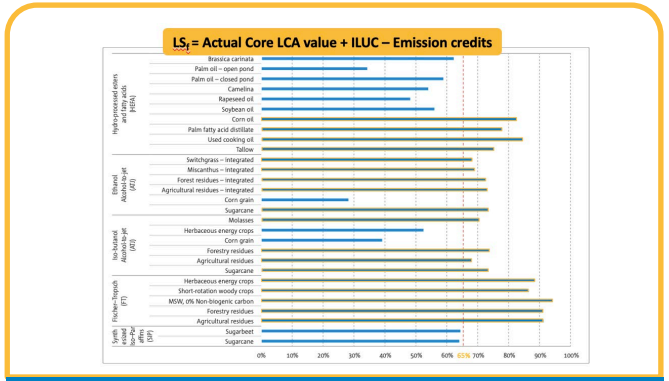
Sustainable Skies Act

ISCC International Sustainability & Carbon Certification

RSB CERTIFIED

What are feedstocks eligibility criteria? What are SAF sustainability certifications?

What are eligible feedstock according to CORSIA?



How GHG emissions are different for biomass and technology?

Step 1

How to add a new feedstock into the CORSIA framework

Step 2

How to add a new feedstock into the CORSIA framework

How new feedstocks can be added to the CORSIA eligible feedstocks?

SAF Categories and Feedstock Types

SAF as substitutes for fossil jet kerosene, are critical to decarbonising aviation as hard-to-abate sector.

SAF

Category	Feedstock	Technology pathway
Advanced biofuels	from biomass	**HEFA** (Hydrotreated Ester Fatty acid) **BtL** (Biomass to Liquid) **PBtL** (Power Biomass to Liquid)
Synthetic aviation fuels (e-SAF, RFNBO)	from e-H_2 and CO_2	**PtL** (Power to Liquid) **PBtL** (Power Biomass to Liquid)
Recycled carbon aviation fuels	from waste	**WtL** (Waste to Liquid)

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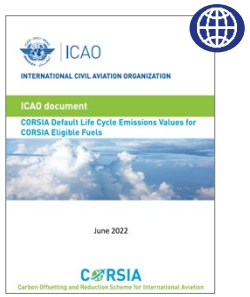
SAF Sustainability Certification and Feedstocks Eligibility Criteria

Feedstocks are subject to various regulatory schemes, resulting in additional complexity.

Feedstock philosophies according to RED III ANNEX IX A/B vs. examples of international schemes, e.g. CORSIA (ICAO)

CORSIA (ICAO)
Carbon Offsetting and Reduction Scheme for *International* Aviation



Eligible feedstock categories:
- Residues, Waste, By-Products, Co-Products
- Main Products: Sugarcane, Sugar beet, Soybean oil, Rapeseed oil, Palm oil, Corn, Primary biomass...

Minimum GHG saving
- >10 %

Renewable Energy Directive RED III
European Union

Eligible feedstock categories:
- Residues, Waste, By-Products
- No “Main Products”, especially no food and feed crops. Fuels from waste according to Annex IX/B are capped (1.7 % by energy).

Minimum GHG saving
- >70 % for RFNBO-SAF; >65 % for all other SAF

List of eligible feedstocks **determines their availability** and thus the **price developments**.
Sustainability criteria, especially regarding treatment of food and feed crops and regarding minimum GHG savings is currently highly region-dependent.

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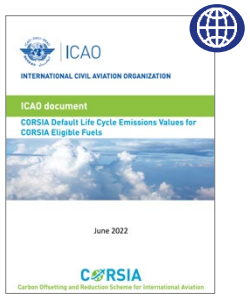

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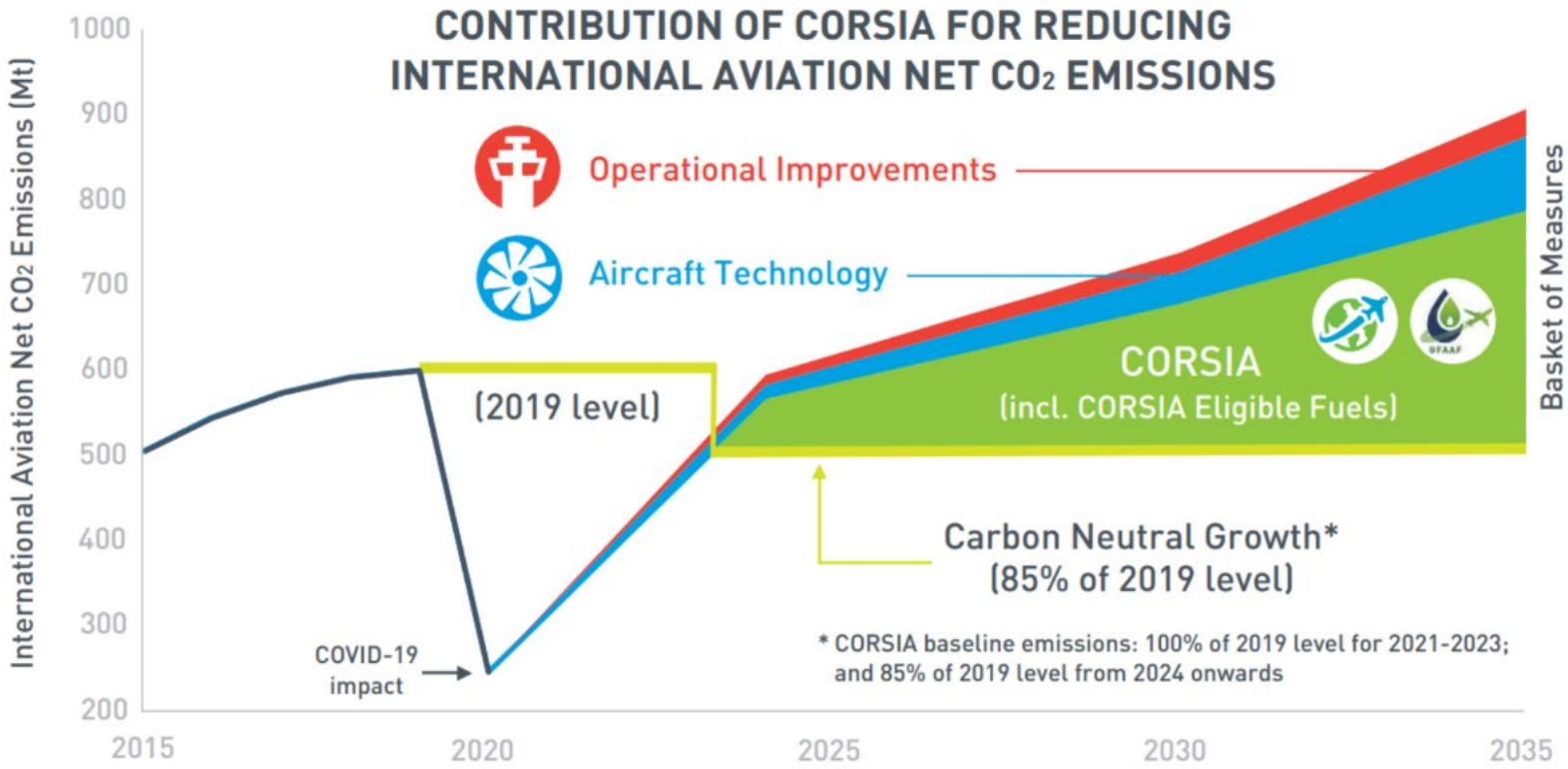
CORSIA is a global market-based measure designed to offset international CO_2 aviation emissions.

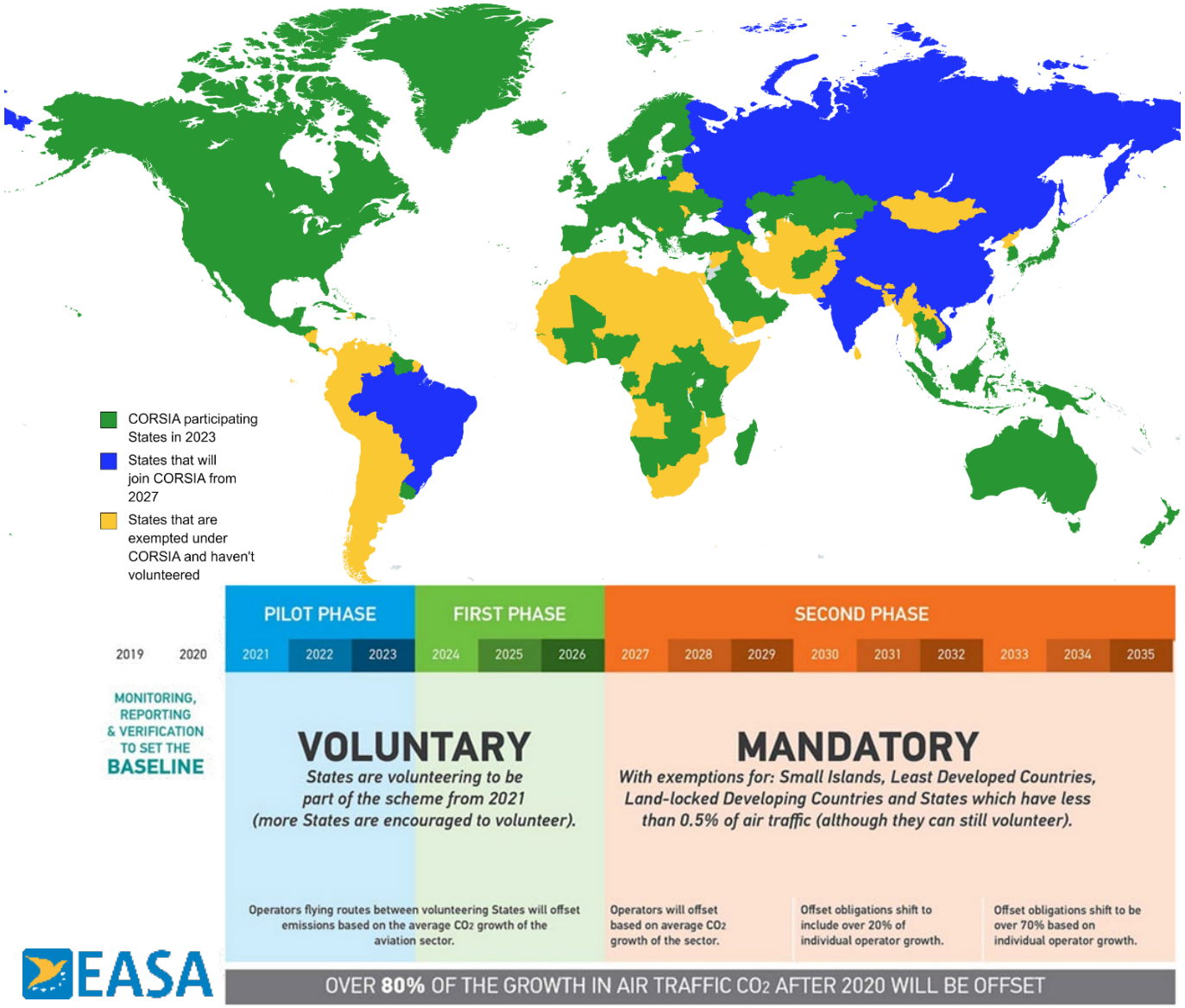
In 2016, the International Civil Aviation Organization (ICAO) adopted the **Carbon Offsetting and Reduction Scheme for International Aviation** (CORSIA) to address **CO2 emissions** from international aviation.

The target is to stabilise the levels of the GHG emissions from 2020 onwards with a baseline that is **85% of the emissions generated in 2019.**

Offsetting of CO2 emissions will be achieved through the **acquisition and cancellation of emissions units** from the global market by **aeroplane operators.**



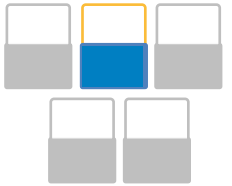
CORSIA at glance, a GHG reduction-targeted initiative for aviation



- Airlines and other aircraft operators will **offset any growth in CO2 emissions** above 2020 levels. CORSIA specifies the maximum CO2 emissions for airlines over the course of time as well as options to meet those targets. This means that aviation's net CO2 emissions will be stabilised, while **other emissions reduction measures, such as technology, sustainable aviation fuel, operations and infrastructure options, are pursued**.
- The use of **SAF is eligible for recognition as a GHG saving measure**, as well as **offsetting** by e.g., forestry projects, methane capture or deployment of renewable energy.
- Under CORSIA, all airline operators with annual emissions greater than 10,000 tonnes of CO2 are required to report their emissions from international flights on an annual basis since 1 January 2019. **Operators must keep track of their fuel use for each individual flight in order to calculate their CO2 emissions**.
- Offsetting requirements started from 2021. **Upon completion of each 3-year compliance period, operators will have to demonstrate that they have met their offsetting requirements by cancelling the appropriate number of emissions units**.

Source: IATA, ICAO, aviationbenefits.org

How offsetting requirements under CORSIA are met?



1. MRV

Monitoring, Reporting, and Verification

- Every airline (operating internationally) must **monitor and report CO_2 emissions** from eligible flights annually.
- **CO_2 Reports** are verified by accredited third parties.
- Submitted to the airline's national authority, then forwarded to ICAO.

CO_2 emissions

2. Calculate

Calculate Offset Obligations

- ICAO compares reported emissions to the **baseline** (average of 2019–2020 emissions).
- Airlines must **offset** the portion of **emissions** that **exceed** this baseline.

Obligation

CORSIA **baseline**

3. Reduce

Reduce Emissions with SAF

- Airlines can use CORSIA-eligible **SAF to reduce** their reported emissions.
- SAF must meet **lifecycle emission reduction thresholds** (minimum 10% below fossil fuel) and be certified under approved sustainability standards.
- The greater the emissions saving, the less they need to offset.

Reduced obligation

CORSIA eligible **SAF**

4. Offset

Offset Remaining Emissions

- After accounting for SAF use, airlines **purchase eligible carbon credits** from ICAO-approved schemes.
- These credits must come from projects that:
  - Are **additional** (not happening without funding)
  - **Avoid or remove emissions**
  - Are and not double-counted

Offsetting measures

CORSIA eligible **Carbon Credits**

5. Report

Compliance Reporting and Credit Retirement

- Airlines **submit proof** of:
  - SAF volumes used (with documentation)
  - Carbon credits purchased
- **Compliance is checked**
- Carbon credits are retired in a **central registry** to ensure no double use.

Compliance

Repeat annually

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Reference documentation for CORSIA eligible fuels

CORSIA Eligible Fuel – Reference Documentation

Five ICAO documents comprise the CORSIA Implementation Element for CEF, and they define the procedures and requirements needed for CEF consideration under CORSIA:

1. *CORSIA Eligibility Framework and Requirements for Sustainability Certification Schemes*
2. *CORSIA Approved Sustainability Certification Schemes*
3. *CORSIA Sustainability Criteria for CORSIA Eligible Fuels*
4. *CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels*
5. *CORSIA Methodology for Calculating Actual Life Cycle Emissions Values*

\+ *CORISA Annex 16 Volume 4: Environmental Protection*

Two types of CORSIA eligible fuels:

1 Sustainable Aviation Fuel

SAF

Renewable or waste-based fuel, meeting CORSIA criteria

2 Lower Carbon Aviation Fuel

CO_2

LCAF

Fossil feed
CORSIA criteria
Annex 16, Vol 4

+ Energy efficiency
+ Process gas management
+ Renewable/low carbon power, gas, H_2
+ Carbon capture and storage
↳ 10% GHG reduction

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Source: ICAO

Feedstock sustainability according to CORSIA: Sustainability key factors

Certification and Compliance in SAF Production

The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) by ICAO addresses CO_2 emissions from aviation. Sustainable biomass under CORSIA **must not negatively impact the environment, biodiversity, or local communities.**

Greenhouse Gases (GHG)

- Significant lifecycle GHG reduction.
- Includes emissions from production, processing, and combustion.
- Direct and indirect land-use changes considered.

Carbon Stock

- No biomass from high-carbon ecosystems (e.g., primary forests, wetlands).

GHG Emissions Permanence

- Ensure lasting emission reductions.
- Implement practices to monitor and mitigate non-permanence.

Water

- Maintain/enhance water quality and availability.
- Efficient water use and preventing depletion.

Soil

- Improve soil health

Air Quality

- Minimize air pollution and emissions.

Conservation

- Protect biodiversity and ecosystem services.
- Use low-risk feedstock to prevent the spread of invasive species.

Waste and Chemicals

- Promote responsible waste management.
- Handle production waste, pesticides, and harmful substances carefully.

Human and Labor Rights

- Respect human and labor rights.

Land Use Rights

- Honor indigenous and local land rights

Water Use Rights

- Respect formal and customary water rights.

Local and Social Development

- Support social and economic development.
- Uplift socio-economic conditions in impoverished regions.

Food Security

- Promote food security, especially in regions with scarcity.
- Ensure local food resources are not compromised.

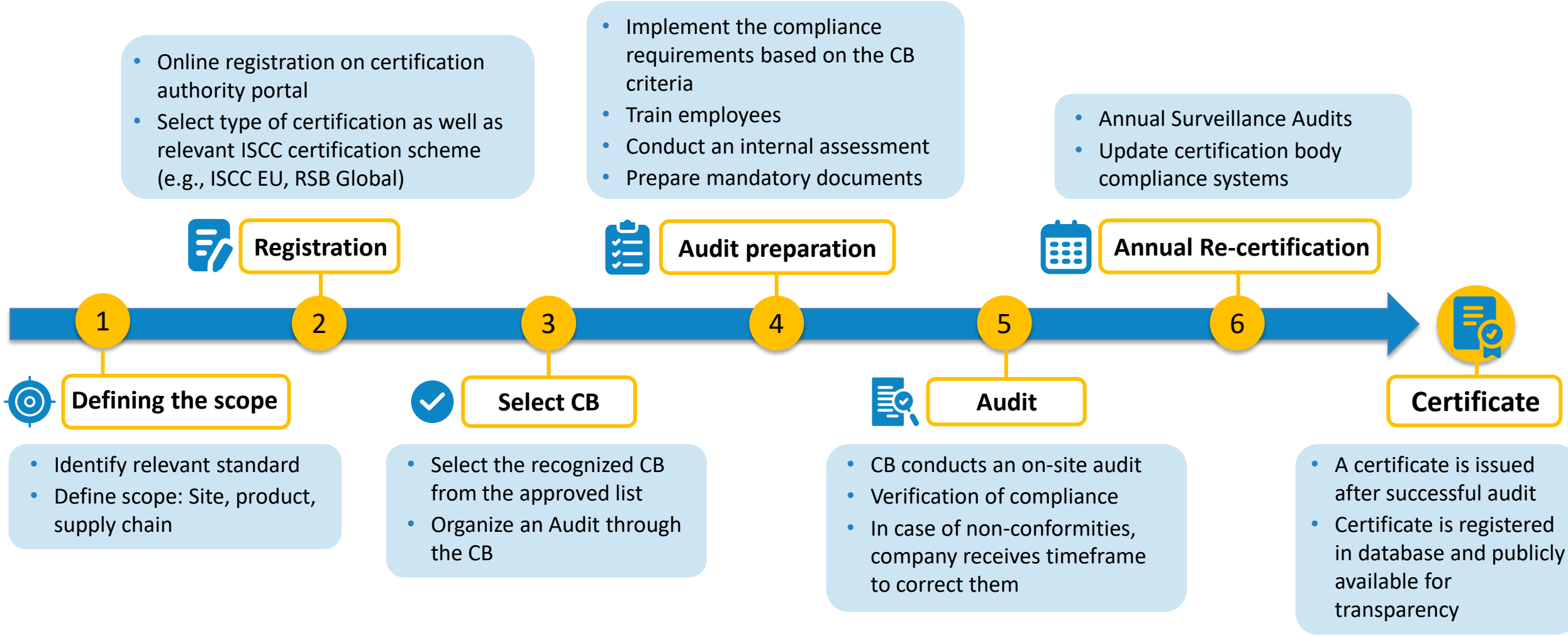
EASA Source: ICAO CORSIA

Status of deployment of certification schemes

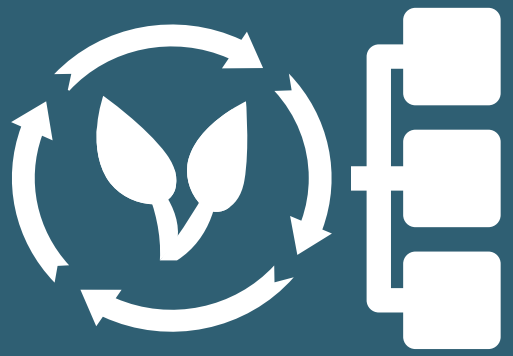
Aspect	ISCC	RSB
Global Reach	✓ Worldwide	✓ Worldwide
Certified Entities	✓ Companies like Wilmar International, with 34 mills and 29 downstream operations certified as of 2023	✓ Companies like Altair Paramount LLC, certified under RSB Global and RSB ICAO CORSIA standards
Accredited Certification Bodies	✓ Multiple certification bodies worldwide to conduct audits and issue certificates	✓ Multiple certification bodies worldwide to ensure compliance with RSB standards
Industry Adoption	✓ Adopted in sectors like biofuels, aviation fuels, chemicals, and packaging; companies such as Unilever and Neste	✓ Adopted by industries producing biofuels, aviation fuels, and biomaterials
Regulatory Recognition	✓ Approved by EU and ICAO	✓ Approved by the EU and ICAO
Digital Integration	✓ Offers an online platform (ISCC HUB) for managing registration and certification-related data	✓ Offers the RSB Academy's online courses to cover RSB sustainability certification system

EU: Europe Union, RED: Renewable Energy Directive; ICAO: International Civil Aviation Organisation

General process and provision of accreditation services

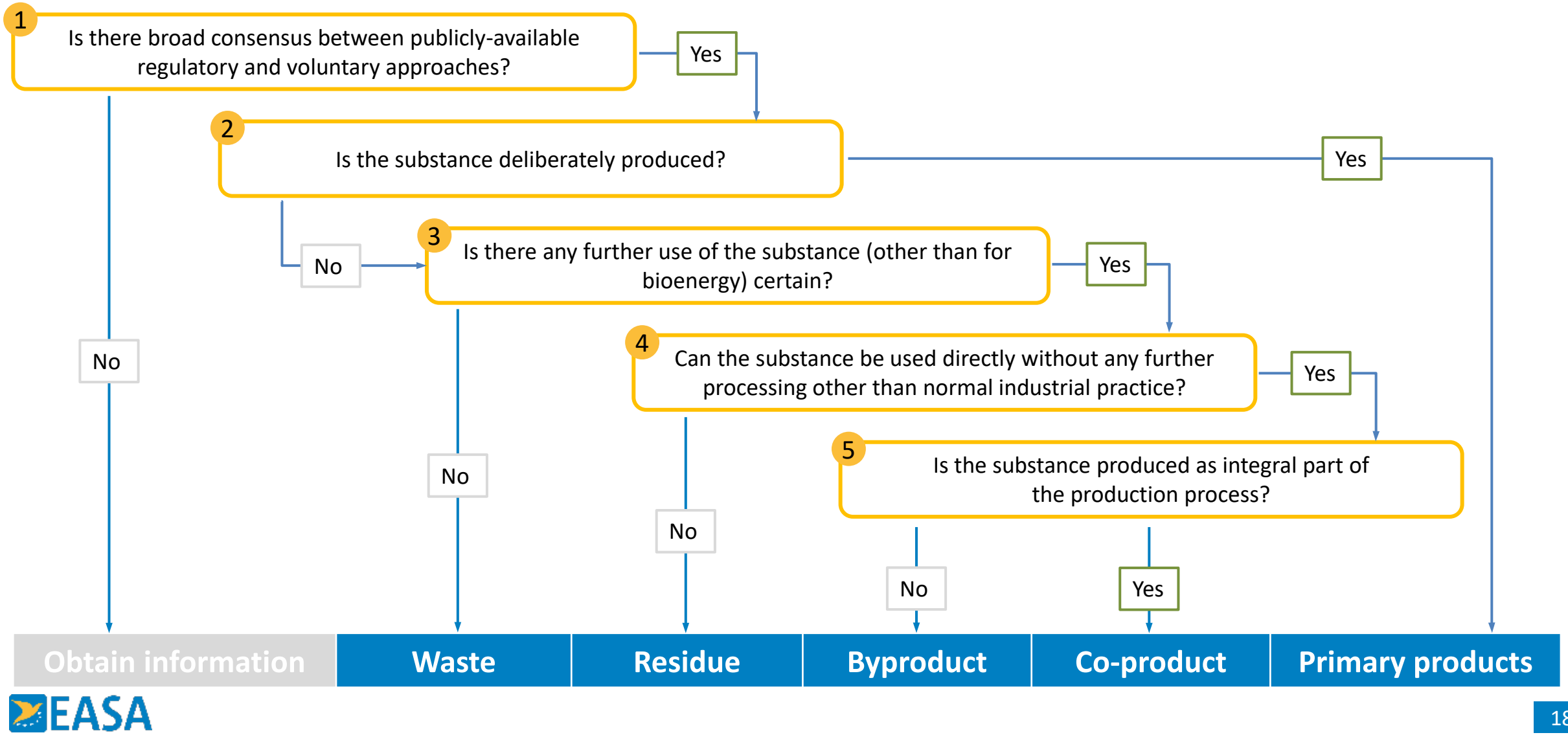


RSB: Roundtable on Sustainable Biomaterials; CB: Certification body



Categorization of the eligible feedstocks under CORSIA

Five feedstock categories and five step schema to determine them



CORSIA Eligible Feedstocks categorization on economic basis

Different type of feedstock can be used for CORSIA Eligible Fuels (GHG emission saving >10%).

Waste	Residues	By-products	Co-products	Primary products

A **by-product, residue, or waste** is a material that arises as a **secondary output** of a production process **without being deliberately produced for a specific use.**

- **Wastes** are materials with inelastic supply and no economic value. A waste is any substance or object which the holder discards or intends or is required to discard. Raw materials or substances that have been intentionally modified or contaminated to meet this definition are not covered by this definition.
- **Residues** are secondary materials with inelastic supply and little economic value.
- **By-products** are secondary products with inelastic supply and economic value.

Primary and co-products are the main products of a production process.

☑ significant economic value

☑ elastic supply

(i.e., there is evidence that there is a causal link between feedstock prices and the quantity of feedstock being produced)

Feedstock examples under CORSIA CEF categories

Agricultural residues (e.g. bagasse, nut shells, etc.)

Agricultural residues (e.g. corn cobs, straw, etc.)

Palm oil, Palm fatty acid distillate

Forestry residues (e.g. cutter shavings)

Soybean oil

Rapeseed oil

Municipal solid waste (MSW)

Corn oil, Corn grain

Sugar Cane

Molasses

Sugar beet

Switchgrass

Miscanthus

Used cooking oil (UCO)

Categories of the materials: Products, Co-products, By-products, Residues, Waste

Source: ICAO(2024)

CORSIA has recognized 48 feedstock types under five categories

Waste	Residues		By-products	Co-products	Primary products
Municipal solid waste (MSW)	Bagasse	Straw	Palm fatty acid distillate	Molasses	Brassica carinata oilseed
Waste gases	Cobs	Bark	Technical Corn oil		Camelina oilseed
Used cooking oil	Husks	Branches	Mixed Animals Fat		Corn grain
	Manure	Cutter shavings	Non-Standard Coconuts		Jatropha oilseed
	Nut shells	Leaves	Beef Tallow		Miscanthus (herbaceous energy crops)
	Stalks	Needles	Poultry Fat		Palm fresh fruit bunches
	Stover	Pre-commercial thinnings	Lard Fat		Poplar (short rotation woody crops)
	Slash	Crude tall oil	Tallow		Rapeseed oilseed
	Tree tops	Empty palm fruit bunches			Soybean oilseed
	Crude glycerine	Forestry processing residues			Sugar beet
	Palm oil mill effluent	Tall oil pitch			Sugar cane
	Sewage sludge	Wheat starch slurry			Switch grass (herbaceous energy crops)

48
Feedstocks recognized under ICAO CORSIA

Source: ICAO(2024)

Sustainability Criteria of CORSIA for Feedstocks

Life cycle emissions value of the feedstock is crucial for the sustainability criteria

Why the type of feedstock is important?

The amount of emissions reductions generated by the use of CEF depends on its life cycle emissions value (LS_f)

Actual Core LCA value + ILUC – Emission credits = **LS_f**

LS_f = Total Life Cycle emissions in gCO_2eq/MJ of fuel produced and combusted in an aircraft

Core LCA value = Core Life Cycle emissions value of a fuel pathway

ILUC = Induced Land Use Change value

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

Region	Feed Feedstock	Core LCA Value	ILUC LCA Value	Emission credits	LS_f (gCO_{2e}/ MJ)
Global	Tallow	22.5	0	0	22.5
Global	Used cooking oil	13.9	0	0	13.9

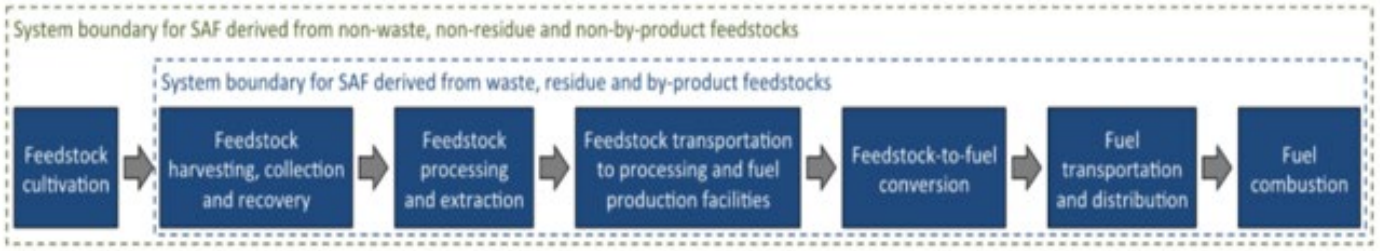
Source: CORSIA Methodology for Calculating Actual Life Cycle Emissions Values

Actual Core LCA value and ILUC

Actual Core LCA value

Applied to: Residues; Waste; By-products; Co-products; Main products

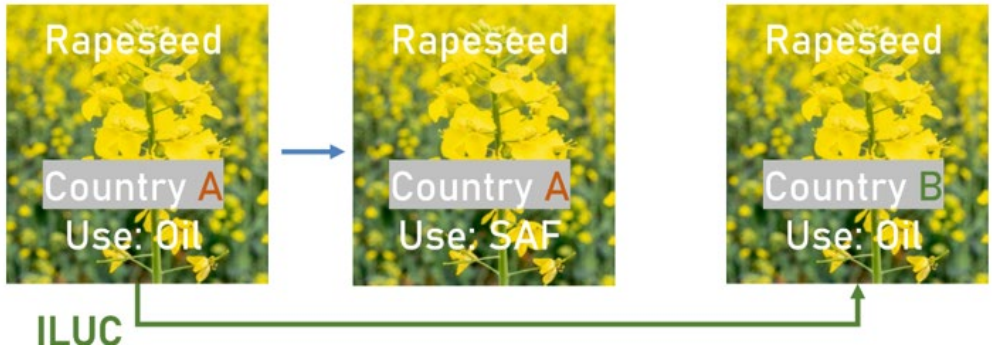
The system boundary of the core LCA value calculation will include the full supply chain of CEF production and use.



ILUC
(Induced Land Use Change value)

Applied to: Co-products; Main products

CORSIA Eligible Fuel production may require some additional land to be used, and generate land use change GHG emissions in other locations due to the displacement of crops or animals.



In general, as the Default Life Cycle Emissions values reflect:

- **The CEF that uses as a feedstock residues/wastes/by-products have better Life Cycle Emissions (LS_f)**
- The CORSIA scheme incentivizes the use of these CEFs by allowing them to reduce the Offsetting Requirements
- The classification of specific feedstocks is subject to later revisions as part of the regular CORSIA review process

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	LS_f (gCO_2e/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

Source: CORSIA Methodology for Calculating Actual Life Cycle Emissions Values

SAF must be preferentially produced from sustainable feedstocks that significantly reduce GHG emissions

LCA emissions reductions for CORSIA eligible SAF pathways and feedstock compared to a fossil fuel reference value (**89 g_{CO2e}/MJ**)

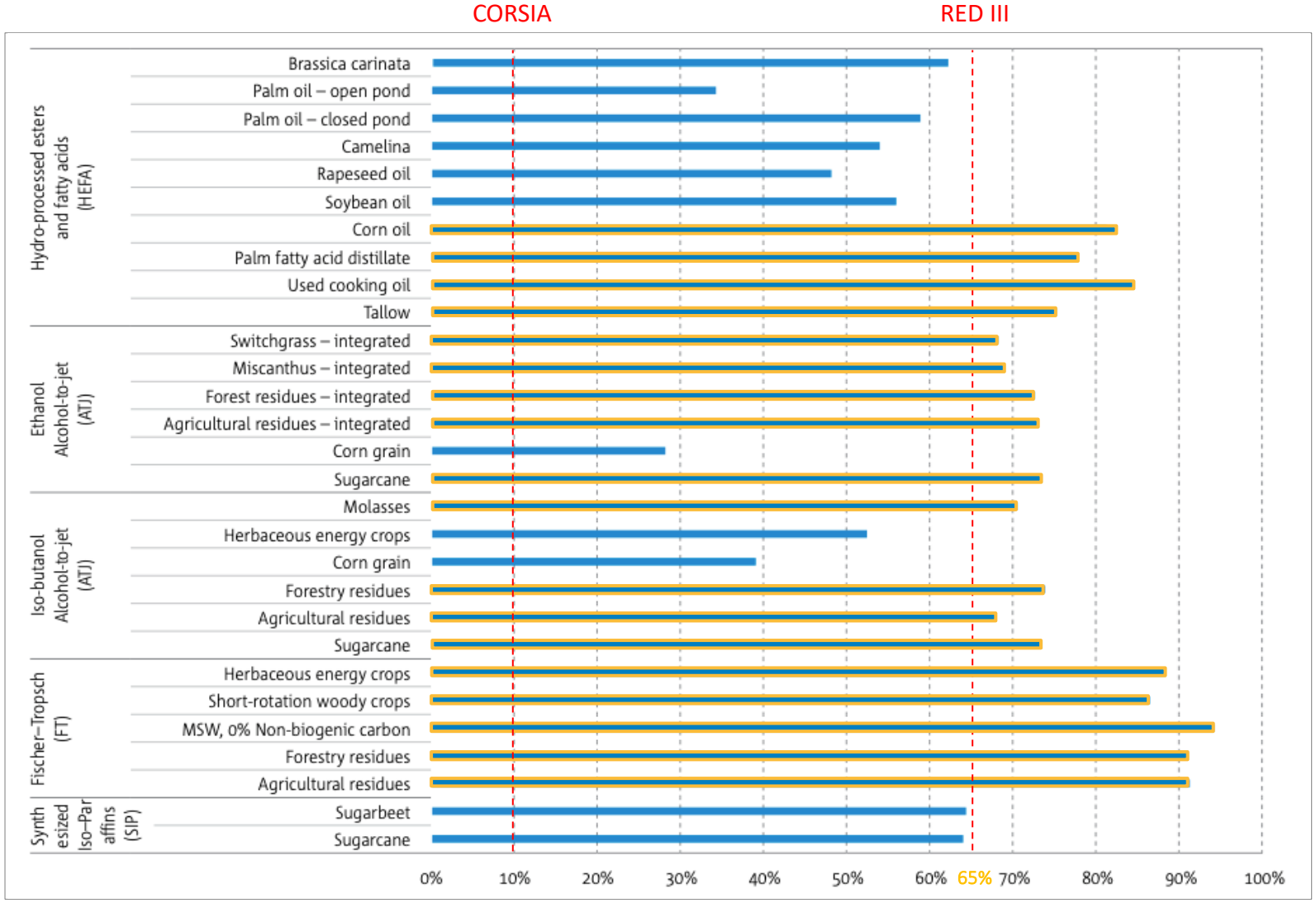
Reference Value (CORSIA)

89 g_{CO2e}/MJ

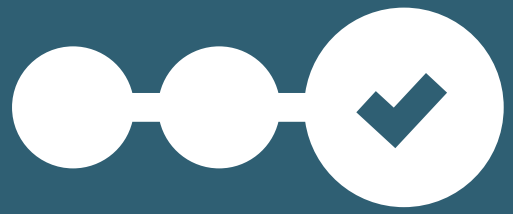
Reference Value (RED III)

94 g_{CO2e}/MJ

Feedstock with high mass potential (e.g., corn, vegetable oils) in tendency allow for **only moderate specific GHG savings** resulting in respectively **higher need to offset residual emissions** by other means.



Source: EASA, European Aviation Environmental Report, 2022



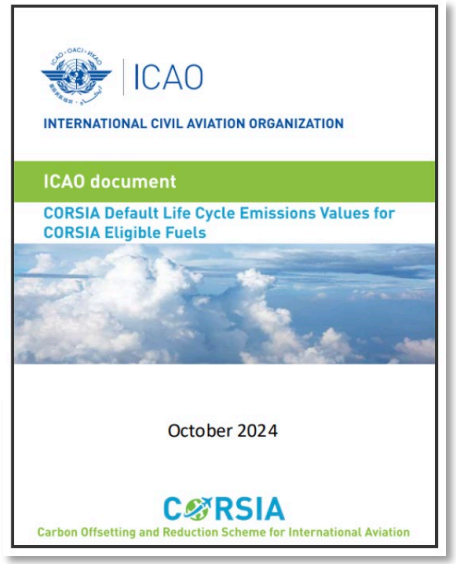
Steps to add new feedstock to the CORSIA eligible feedstock list

How new feedstock can be included in the CORSIA CEF list?

Step 1

Verify that the identified feedstock is truly out of the CORSIA eligible feedstock lists

Region	Fuel Feedstock	Pathway Specifications	Core LCA Value	ILUC LCA Value	L_{CEF} (gCO_2e/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 oilseed		40.4	24.5	64.9
Brazil	Soybean oilseed		40.4	27.0	67.4
Global	Soybean oilseed		40.4	25.8	66.2
EU	Rapeseed/Canola oilseed		47.4	24.1	71.5
Global	Rapeseed/Canola oilseed		47.4	26.0	73.4
Malaysia & Indonesia	Palm fresh fruit bunches	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 fresh fruit bunches	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
Brazil	Brassica carinata oilseed	Feedstock is grown as a secondary crop that avoids other crops displacement	34.4	-20.4	14.0
USA	Brassica carinata oilseed	Feedstock is grown as a secondary crop that avoids other crops displacement	34.4	-21.4	13.0
Global	Brassica carinata oilseed	Feedstock is grown as a secondary crop that avoids other crops displacement	34.4	-12.7	21.7
Global	Camelina oilseed	Feedstock is grown as a secondary crop that avoids other crops displacement	42.0	-13.4	28.6
India	Jatropha oilseed	Meal used as fertilizer or electricity input	46.9	-24.8	22.1
India	Jatropha oilseed	Meal used as animal feed after detoxification	46.8	-48.1	-1.3



Step 2

Engage with the ICAO Secretariat, and ultimately the Fuel Task Group

The **Fuels Task Group** addresses technical issues related to aviation fuels, including the methodologies for considering CORSIA Sustainable Aviation Fuels and CORSIA Lower Carbon Aviation Fuels under Annex 16, Vol IV.

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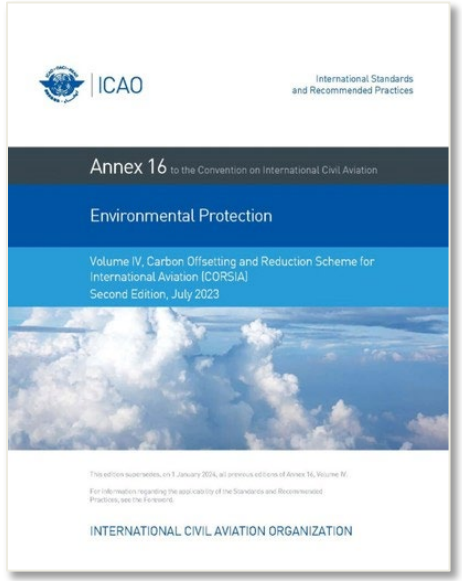
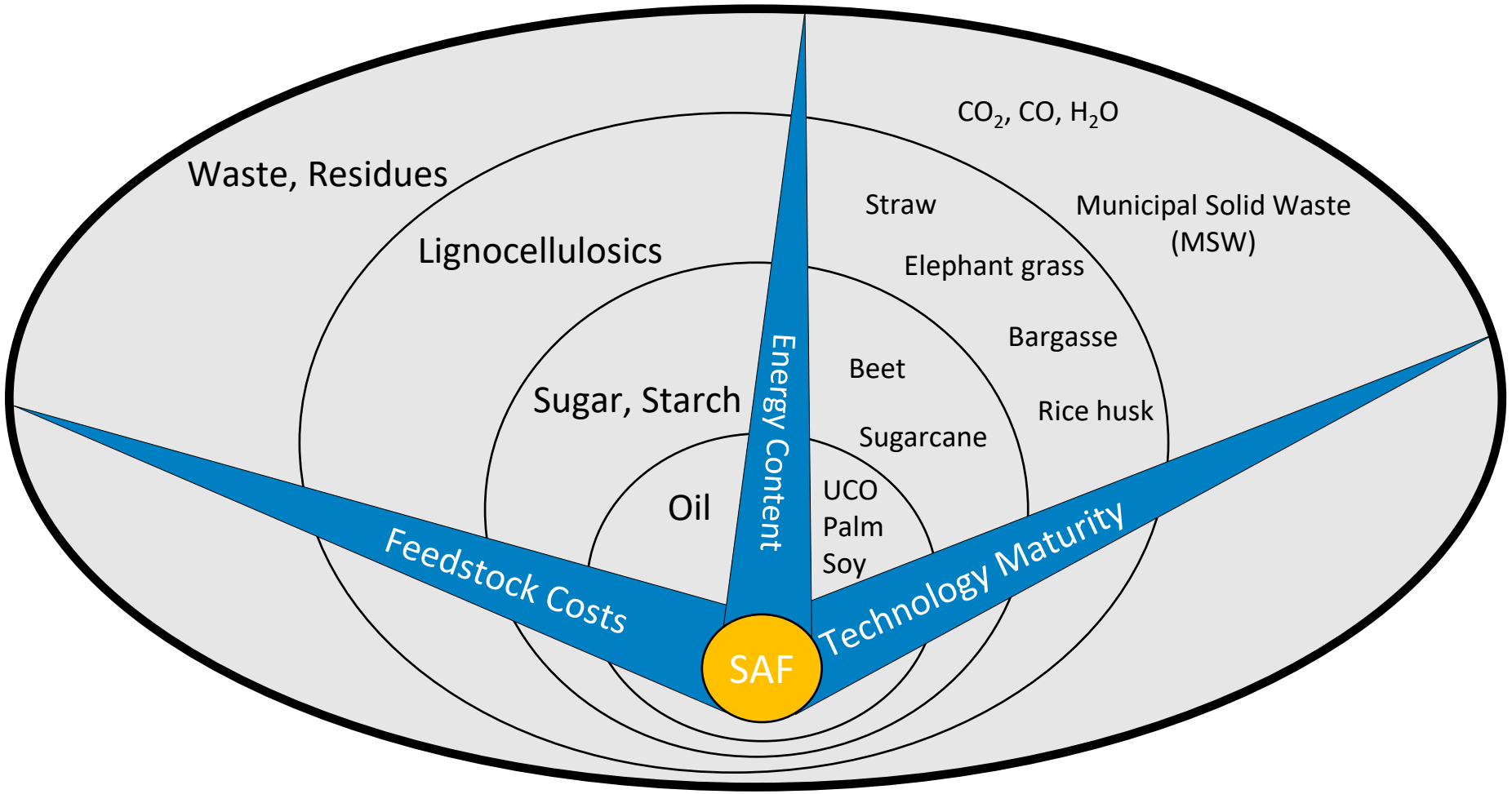


Source: ICAO(2024)

Role of Feedstock in the Production of SAF

Biomass availability and costs are inversely proportional to the intensity of the technical process



HEFA

- Feed molecule's chemical composition close to target

Fischer-Tropsch syn.

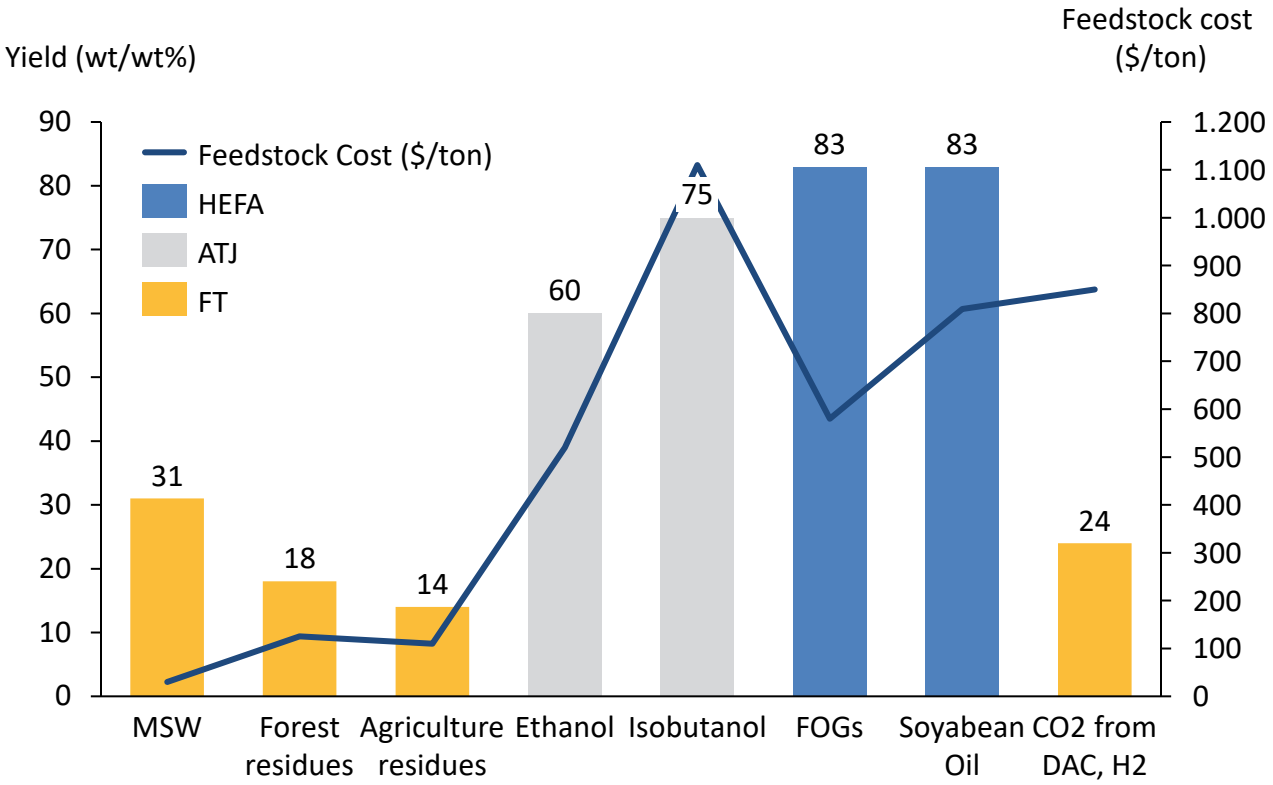
- Solid feed with broad composition, and
- Synthesis from C1 blocks (CO, CO_2)

Alcohol-to-Jet

- Usually starting from one selected alcohol
- C-chain build-up required

Source: Sustainable Alternatives for Aviation Fuels, Yousuf.

Yield comparison of various feedstocks and processing technologies for SAF production



Rule of thumb - ICAO

Rule of thumb are **only a qualitative indication**. **Use these numbers carefully!** In reality, the yield and price can highly vary depending on technology, feedstock composition and region!

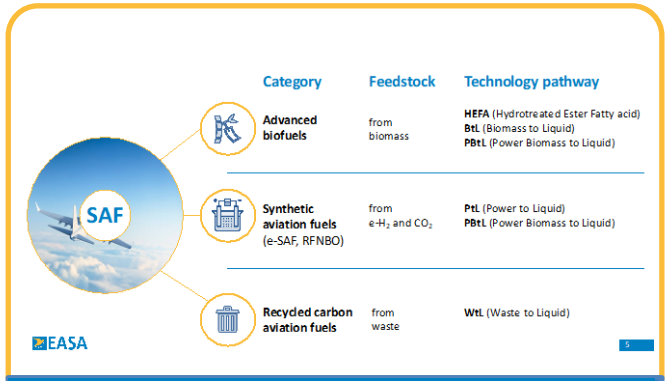
SAFs can be produced from multiple and diverse sources of feedstock.

- This is crucial to **develop regional value chains and promote the uptake of SAF**
- It's an opportunity to **valorize the feedstocks that are abundant in a region**
- An economic opportunity for using **secondary materials** that until now had little economic value
- **Different feedstocks will be processed with specific and appropriate technology**. The combination of feedstock and technology result in **different yields** (how much tons SAF are produced per tons of feedstock).

Source: ICAO rule of thumb

FT= Fischer-Tropsch, AtJ= Alcohol to Jet, HEFA hydroprocessed esters and fatty acids

Key take-aways



Potential feedstocks for SAF can be biomass, waste, CO_2 and H_2.

RED III

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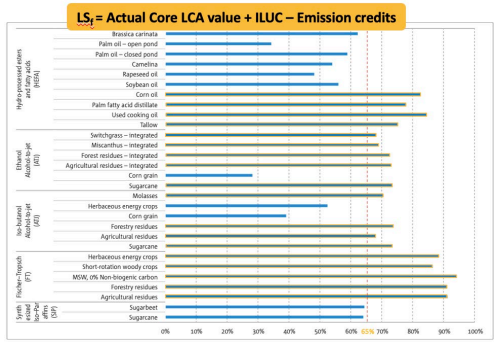
Not all the feedstocks are eligible. This depends on the regulations, and it need to meet specific target for GHG saving to be defined SAF.

There are five categories of feedstocks under the CORSIA Eligible Fuels: Residues, Wastes, By-products, Co-products and Primary products.



ICAO describes a specific methodology for the GHG emissions, considering Actual core LCA and ILUC

Step 1

How to add a new feedstock into the CORSIA framework

Step 2

How to add a new feedstock into the CORSIA framework

New feedstock can always be included in the CORSIA documentation taking contact with ICAO and following the defined procedure.

EASA
European Union Aviation Safety Agency

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