ICAO ENVIRONMENT

ACT-SAF
#10
SERIES

ICAO methodologies and tools for life cycle assessment

ACT SAF
Assistance, Capacity-building and Training for SAF

1. Opening

Dr. Bruno Silva
Environmental Officer, SAF and LTAG
ICAO Environment

Objectives

ACT-SAF
#10
SERIES

Provide participants with knowledge on ICAO’s methodologies and tools for life cycle assessment

ACT-SAF Series #10 Speakers

Matteo Prussi

Co-lead of FTG subgroup
on Core LCA

Politecnico di Torino

Michael Wang

Systems Assessment
Center Director

**Argonne National
Laboratory**

Uisung Lee

Principal Energy
Systems Analysis

**Argonne National
Laboratory**

ACT-SAF Series #10 Speakers

Mateus Chagas

Researcher

Brazilian Center for Research in Energy and Materials (CNPEM)

Alba Cánovas Creus

Sustainability Manager – Circular Bioeconomy

The Roundtable on Sustainable Biomaterials (RSB)

Dario Formenti

System Manager – Sustainable Fuels

ISCC – International Sustainability and Carbon Certification

Agenda

- Opening remarks
- ICAO Update on ACT-SAF activities
- Presentation by the ICAO Secretariat
- Presentation by co-lead of CAEP FTG subgroup on Core LCA
- Presentation by Argonne National Laboratory
- Presentation by Centro National de Pesquisa em Energia e Materiais
- Presentation by RSB
- Presentation by ISCC

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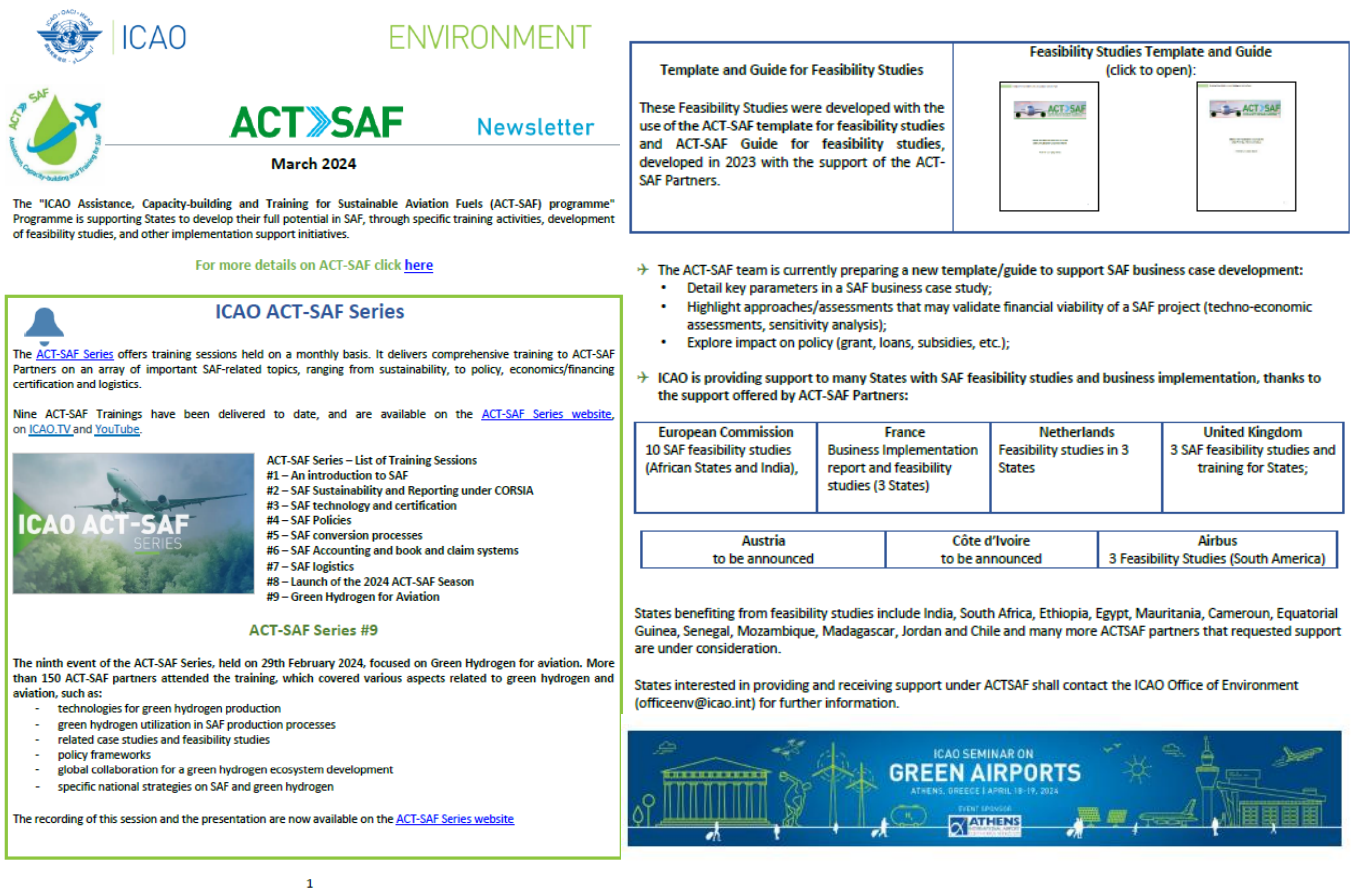
ACT SAF

ACT SAF

Assistance, Capacity-building and Training for SAF

ICAO update on ACT-SAF programme

ACT-SAF newsletter provides useful updates on SAF developments



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ACT SAF Newsletter

March 2024

The "ICAO Assistance, Capacity-building and Training for Sustainable Aviation Fuels (ACT-SAF) programme" Programme is supporting States to develop their full potential in SAF, through specific training activities, development of feasibility studies, and other implementation support initiatives.

For more details on ACT-SAF click here

ICAO ACT-SAF Series

The ACT-SAF Series offers training sessions held on a monthly basis. It delivers comprehensive training to ACT-SAF Partners on an array of important SAF-related topics, ranging from sustainability, to policy, economics/financing certification and logistics.

Nine ACT-SAF Trainings have been delivered to date, and are available on the ACT-SAF Series website, on ICAO.TV and YouTube.

ICAO ACT-SAF SERIES

ACT-SAF Series – List of Training Sessions
#1 – An introduction to SAF
#2 – SAF Sustainability and Reporting under CORSIA
#3 – SAF technology and certification
#4 – SAF Policies
#5 – SAF conversion processes
#6 – SAF Accounting and book and claim systems
#7 – SAF logistics
#8 – Launch of the 2024 ACT-SAF Season
#9 – Green Hydrogen for Aviation

ACT-SAF Series #9

The ninth event of the ACT-SAF Series, held on 29th February 2024, focused on Green Hydrogen for aviation. More than 150 ACT-SAF partners attended the training, which covered various aspects related to green hydrogen and aviation, such as:

- technologies for green hydrogen production
- green hydrogen utilization in SAF production processes
- related case studies and feasibility studies
- policy frameworks
- global collaboration for a green hydrogen ecosystem development
- specific national strategies on SAF and green hydrogen

The recording of this session and the presentation are now available on the ACT-SAF Series website

1

Template and Guide for Feasibility Studies	Feasibility Studies Template and Guide (click to open):
These Feasibility Studies were developed with the use of the ACT-SAF template for feasibility studies and ACT-SAF Guide for feasibility studies, developed in 2023 with the support of the ACT-SAF Partners.	ACT SAF ACT SAF

→ The ACT-SAF team is currently preparing a new template/guide to support SAF business case development:
- Detail key parameters in a SAF business case study;
- Highlight approaches/assessments that may validate financial viability of a SAF project (techno-economic assessments, sensitivity analysis);
- Explore impact on policy (grant, loans, subsidies, etc.);

→ **ICAO is providing support to many States with SAF feasibility studies and business implementation, thanks to the support offered by ACT-SAF Partners:**

European Commission	France	Netherlands	United Kingdom
10 SAF feasibility studies (African States and India),	Business Implementation report and feasibility studies (3 States)	Feasibility studies in 3 States	3 SAF feasibility studies and training for States;

Austria	Côte d'Ivoire	Airbus
to be announced	to be announced	3 Feasibility Studies (South America)

States benefiting from feasibility studies include India, South Africa, Ethiopia, Egypt, Mauritania, Cameroun, Equatorial Guinea, Senegal, Mozambique, Madagascar, Jordan and Chile and many more ACTSAF partners that requested support are under consideration.

States interested in providing and receiving support under ACTSAF shall contact the ICAO Office of Environment (officeenv@icao.int) for further information.

ICAO SEMINAR ON
GREEN AIRPORTS
ATHENS, GREECE | APRIL 18-19, 2024
EVENT SPONSOR
ATHENS

Links to access **past ACT-SAF training** material

Development of **template to support SAF business implementation**

Updates on support for **SAF feasibility studies / business implementation** from ACT-SAF partners

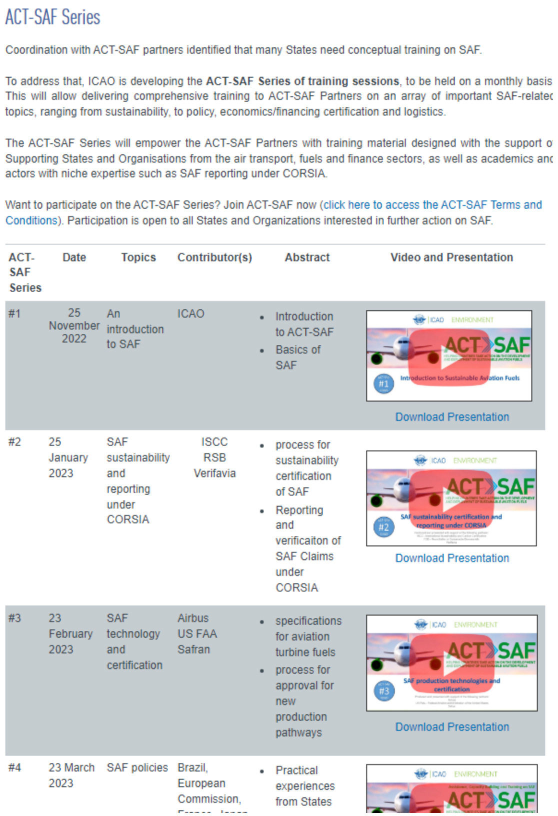
ACT-SAF platform updates
- ➢ Feasibility studies
- ➢ Training and outreach
- ➢ Events

ACT-SAF updates

ACT-SAF platform provides the most recent information:

- List of Partners constantly updated
- ACT-SAF series material available online

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



ACT-SAF Series

Coordination with ACT-SAF partners identified that many States need conceptual training on SAF.

To address that, ICAO is developing the **ACT-SAF Series of training sessions**, to be held on a monthly basis This will allow delivering comprehensive training to ACT-SAF Partners on an array of important SAF-relatec topics, ranging from sustainability, to policy, economics/financing certification and logistics.

The ACT-SAF Series will empower the ACT-SAF Partners with training material designed with the support o Supporting States and Organisations from the air transport, fuels and finance sectors, as well as academics anc actors with niche expertise such as SAF reporting under CORSIA.

Want to participate on the ACT-SAF Series? Join ACT-SAF now (click here to access the ACT-SAF Terms and Conditions). Participation is open to all States and Organizations interested in further action on SAF.

ACT-SAF Series	Date	Topics	Contributor(s)	Abstract	Video and Presentation
#1	25 November 2022	An introduction to SAF	ICAO	• Introduction to ACT-SAF • Basics of SAF	Introduction to Sustainable Aviation Fuels Download Presentation
#2	25 January 2023	SAF sustainability and reporting under CORSIA	ISCC RSB Verifavia	• process for sustainability certification of SAF • Reporting and verificaiton of SAF Claims under CORSIA	SAF sustainability certification and reporting under CORSIA Download Presentation
#3	23 February 2023	SAF technology and certification	Airbus US FAA Safran	• specifications for aviation turbine fuels • process for approval for new production pathways	SAF production technologies and certification Download Presentation
#4	23 March 2023	SAF policies	Brazil, European Commission,	• Practical experiences from States	

90
States
Name of State
Albania
Argentina
Australia
Austria
Bahamas

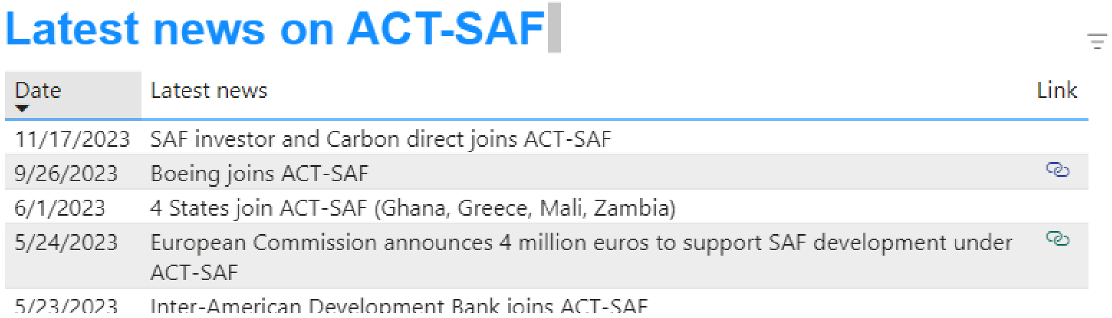
States

Acceptance to ... ● Pending ● Yes

60
Organizations
Name of Organization
WORLD TRAVEL & TOURISM COUNCIL
World Bank
Wizz Air
WEF - World Economic Forum
Verifavia
United Nations World

International Organizations

Acceptance T&C ● (Blank) ● Pending ● Yes



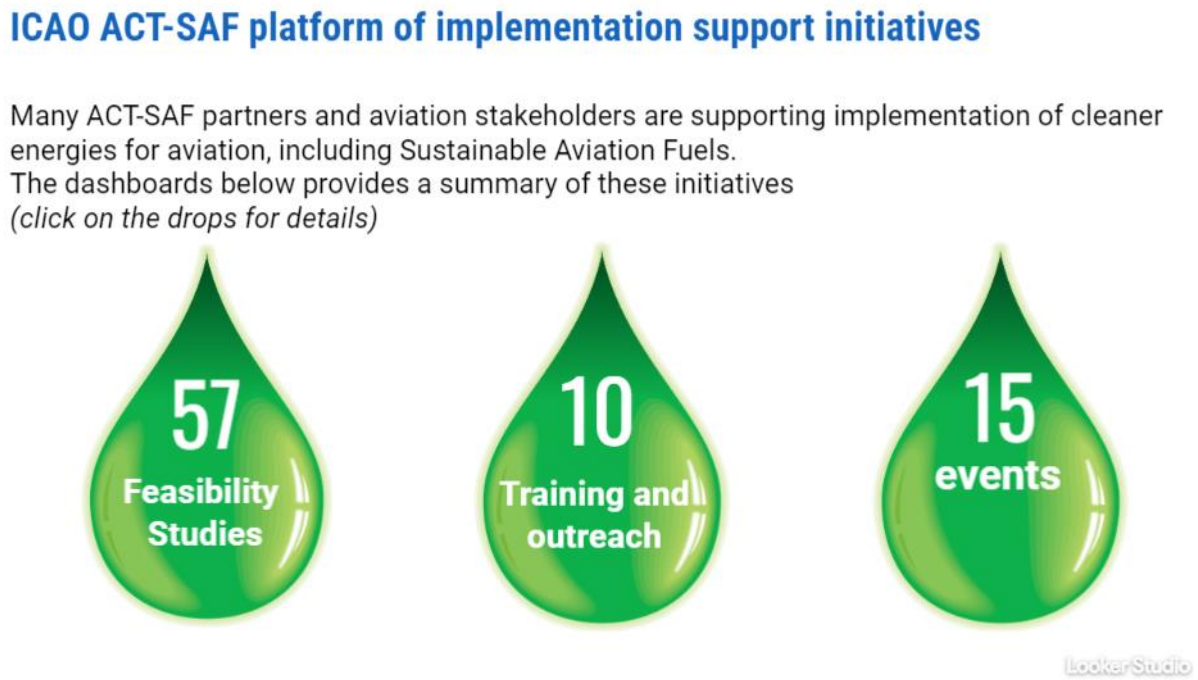
Latest news on ACT-SAF

Date	Latest news	Link
11/17/2023	SAF investor and Carbon direct joins ACT-SAF	
9/26/2023	Boeing joins ACT-SAF	🔗
6/1/2023	4 States join ACT-SAF (Ghana, Greece, Mali, Zambia)	
5/24/2023	European Commission announces 4 million euros to support SAF development under ACT-SAF	🔗
5/23/2023	Inter-American Development Bank joins ACT-SAF	

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

ACT-SAF platform of implementation support initiatives

- **ACT-SAF tracks implementation support initiatives from our partners**
  - ➢ Easy to access resource in ICAO ACT-SAF website, with information on feasibility studies, training/outreach, and events
  - ➢ Reduces duplication of efforts across partners/stakeholders
  - ➢ Reach out to ICAO to have your initiative reflected in the platform



ICAO ACT-SAF platform of implementation support initiatives

Many ACT-SAF partners and aviation stakeholders are supporting implementation of cleaner energies for aviation, including Sustainable Aviation Fuels.
The dashboards below provides a summary of these initiatives
(click on the drops for details)

Recently concluded/upcoming events by ACT-SAF Partners

UK ACT-SAF programme

Introductory training and SAF policy workshops

- Tanzania - 18 to 21 March 2024
- Equatorial Guinea – 25 to 28 March 2024
- Cameroon – 8 to 11 April 2024

Recently concluded/upcoming events by ACT-SAF Partners

ECAC – Training on SAF for North Macedonia

- 20 to 21 February 2024
- Platform for exploring and identifying opportunities and next steps to foster SAF in North Macedonia

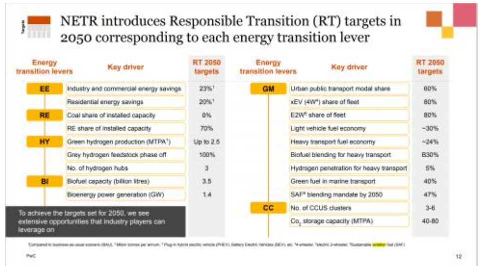
Recently concluded/upcoming events by ACT-SAF Partners

RSB

RSB - SAF Train the Trainer Workshop

- March 2024, at Ethiopian Aviation University
- Keys areas covered in SAF sustainability, technologies

Recently concluded policies / roadmaps from our partners



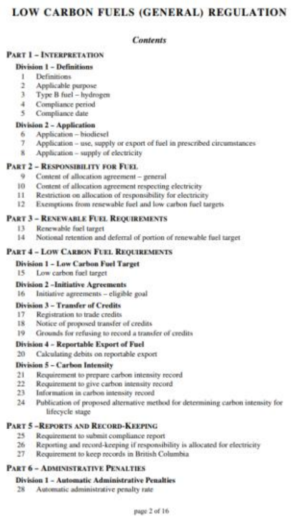
NETR introduces Responsible Transition (RT) targets in 2050 corresponding to each energy transition lever

Energy transition levers	Key driver	RT 2050 targets	Energy transition levers	Key driver	RT 2050 targets
EE	Industry and commercial energy savings	23%[1]	GM	Urban public transport modal share	60%
	Residential energy savings	20%[1]		xEV (4W[4]) share of fleet	80%
RE	Coal share of installed capacity	0%		E2W[5] share of fleet	80%
	RE share of installed capacity	70%		Light vehicle fuel economy	~30%
HY	Green hydrogen production (MTPA[1])	Up to 2.5		Heavy transport fuel economy	~24%
	Grey hydrogen feedstock phase off	100%		Biofuel blending for heavy transport	B30%
	No. of hydrogen hubs	3		Hydrogen penetration for heavy transport	5%
BI	Biofuel capacity (billion litres)	3.5		Green fuel in marine transport	40%
	Bioenergy power generation (GW)	1.4		SAF[6] blending mandate by 2050	47%
			CC	No. of CCUS clusters	3-6
				Co$_2$ storage capacity (MTPA)	40-80

To achieve the targets set for 2050, we see extensive opportunities that industry players can leverage on

PwC 12

- **National Energy Transition Roadmap in Malaysia**
  - ➢ Outlining efforts towards achieving a sustainable and inclusive energy system
  - ➢ Identified key challenges to green mobility in aviation
  - ➢ Identified SAF blending mandate as a potential energy transition lever
  - ➢ https://www.pwc.com/my/en/assets/publications/2023/PwC-my-Summary-of-the-National-Energy-Transition-Roadmap.pdf



LOW CARBON FUELS (GENERAL) REGULATION

Contents

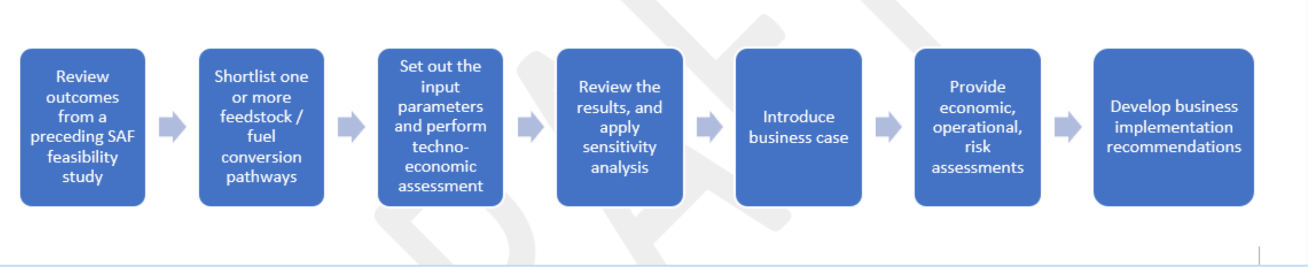
page 2 of 16

- **British Columbia introduces SAF mandate**
  - ➢ First jurisdiction in North America to require suppliers to incorporate low carbon jet fuel into fossil jet fuel
  - ➢ Revamped Low Carbon Fuel Regulation
    https://www.bclaws.gov.bc.ca/civix/document/id/oic/oic_cur/0699_2023

Request for support: Consultations on SAF business implementation template

- **As a follow up to the SAF feasibility study template/guide, ICAO has prepared a draft template to support SAF business implementation**
  - ➢ Highlight approaches that may validate viability of a SAF project (techno-economic assessments, sensitivity analysis, economic/operational/risk assessments)
  - ➢ Facilitate final investment decisions to drive the start of concrete SAF projects
  - ➢ Support ICAO Global Framework for SAF, LCAF and other Aviation Cleaner Energies (*Building Block 3 – Implementation Support*, and *Building Block 4 – Financing*)
  - ➢ Plan to publish in May 2024, to coincide with related capacity-building efforts
  - ➢ **Support needed**: Additional references, review of draft

- – Executive Summary
- – Section 1: Scenario and Assumptions
- – Section 2: Techno-economic assessment and results
- – Section 3: Economic and Operational Assessment of the project
- – Section 4: Risk assessment
- – Section 5: Business Implementation recommendations



Review outcomes from a preceding SAF feasibility study ➡ Shortlist one or more feedstock / fuel conversion pathways ➡ Set out the input parameters and perform techno-economic assessment ➡ Review the results, and apply sensitivity analysis ➡ Introduce business case ➡ Provide economic, operational, risk assessments ➡ Develop business implementation recommendations

ACT-SAF updates

ACT-SAF Series - SEASON 2
#9 Green Hydrogen for aviation
#10 ICAO methodologies and tools for life cycle assessment
#11 CAAF/3 Global Framework
#12 SAF in State Action Plans
#13 Multi-stakeholder SAF Alliances
#14 Feasibility assessments
#15 Economics and Financing (SAF projects)
#16 Updates on recent developments (policies)

Today's Session

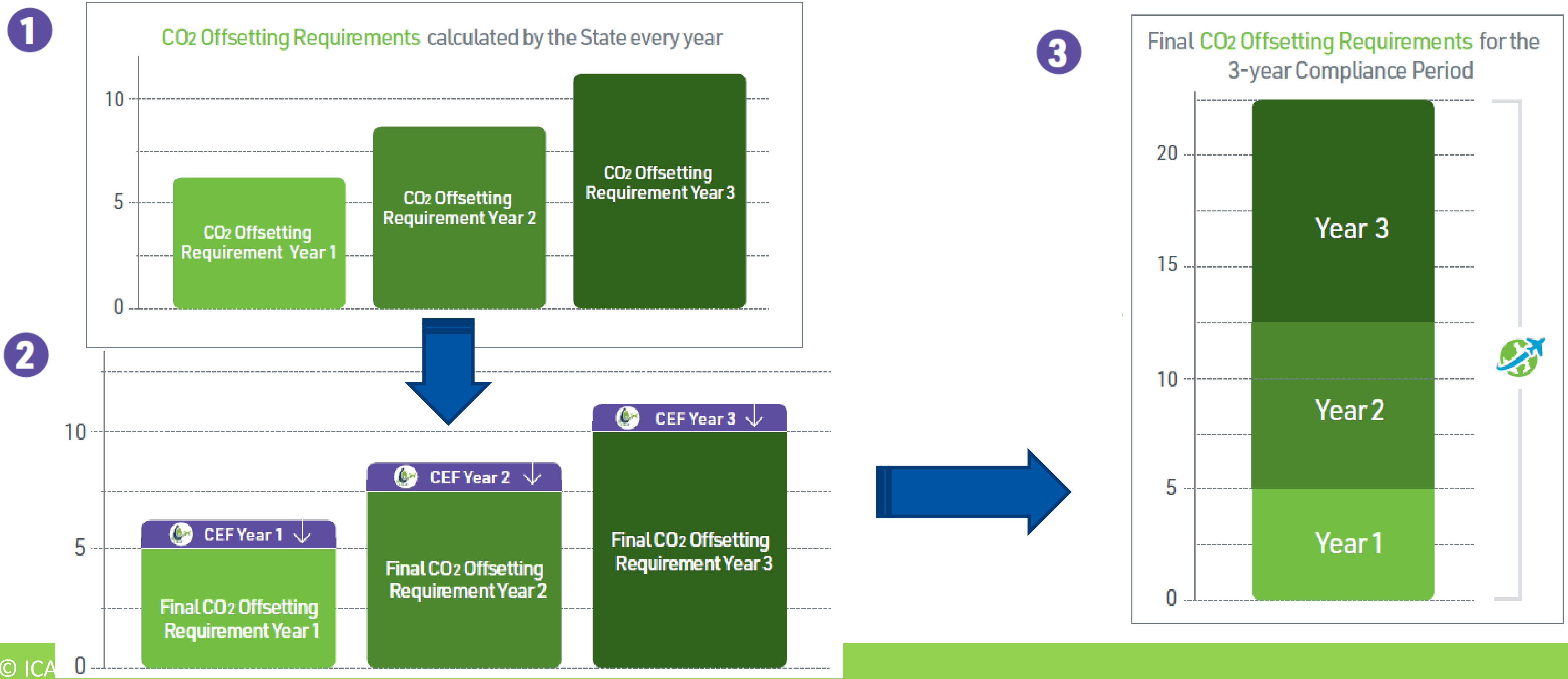
- Future sessions on specific aspects
- Subject to review – **feedback welcome**

https://www.icao.int/environmental-protection/Pages/ACT-SAF-Series.aspx

Introduction
CORSIA default LCA values

CEF and CORSIA Offsetting Requirements

An aeroplane operator can reduce its CORSIA offsetting requirements by claiming emissions reductions from the use of CEFs



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Claiming Emission Reductions from CEF

Emission reductions are related to the life cycle emissions value of the CEF

UPDATE: Second edition of Annex 16 Vol IV now uses the acronym "L_{CEF}" to represent the life cycle emissions of the CEF.

life cycle emissions value (~~LS_f~~ L_{CEF}) of the CEF.

Fuel Conversion Factor, fixed value,
3.16 for Jet-A/ Jet-A1 or 3.10 for AvGas/ Jet B
[kg CO_2/kg fuel]

$$\textbf{CEF emissions reductions } (ER_y) = FCF * \left[\sum_f MS_{f,y} * \left(1 - \frac{\overset{L_{CEF}}{\cancel{LS_f}}}{LC}\right)\right]$$

Total mass of CEF claimed
in the year y, by fuel type f [tonnes]

Baseline life cycle emissions,
fixed value, 89 for jet fuel or
95 for AvGas
[gCO2e/MJ]

Example: If, in 2021, an operator uses 10,000 tonnes of Jet-A fuel produced from Used Cooking Oil (default ~~LSf~~ L_{CEF} **=13.9 gCO2e/MJ***), the amount of emissions reductions will be:

$$ER_{2021} = 3.16 * \left[10{,}000 * \left(1 - \frac{13.9}{89}\right)\right] = \textbf{26,665 tonnes of } CO_2$$

Life Cycle Assessment of SAF

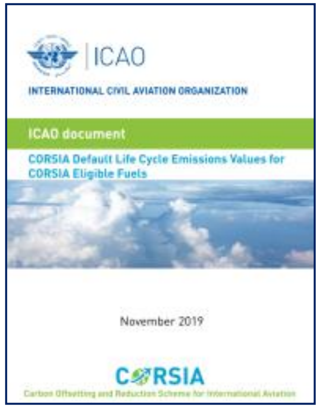
There are two options to obtain the life cycle emissions of SAF and LCAF

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.



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ICAO document

CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels

November 2019

CORSIA

Carbon Offsetting and Reduction Scheme for International Aviation

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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

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ICAO document

CORSIA Methodology for Calculating Actual Life Cycle Emissions Values

November 2019

CORSIA

Carbon Offsetting and Reduction Scheme for International Aviation

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 <u>Life cycle assessment of the SAF:</u>**

SAF Life cycle emission value (L_{CEF})
Unit – gCO2e/MJ

=

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 <u>land use change</u> generated by SAF feedstock production

+

Emission Credits
Reductions that can be obtained on MSW-based fuels, due to benefits associated with recycling and avoided waste on landfills

Default life cycle emissions values

Core Default LCA values depend on:

- **conversion process**
- **feedstock**
- **pathway specification**

Region is only relevant to ILUC values

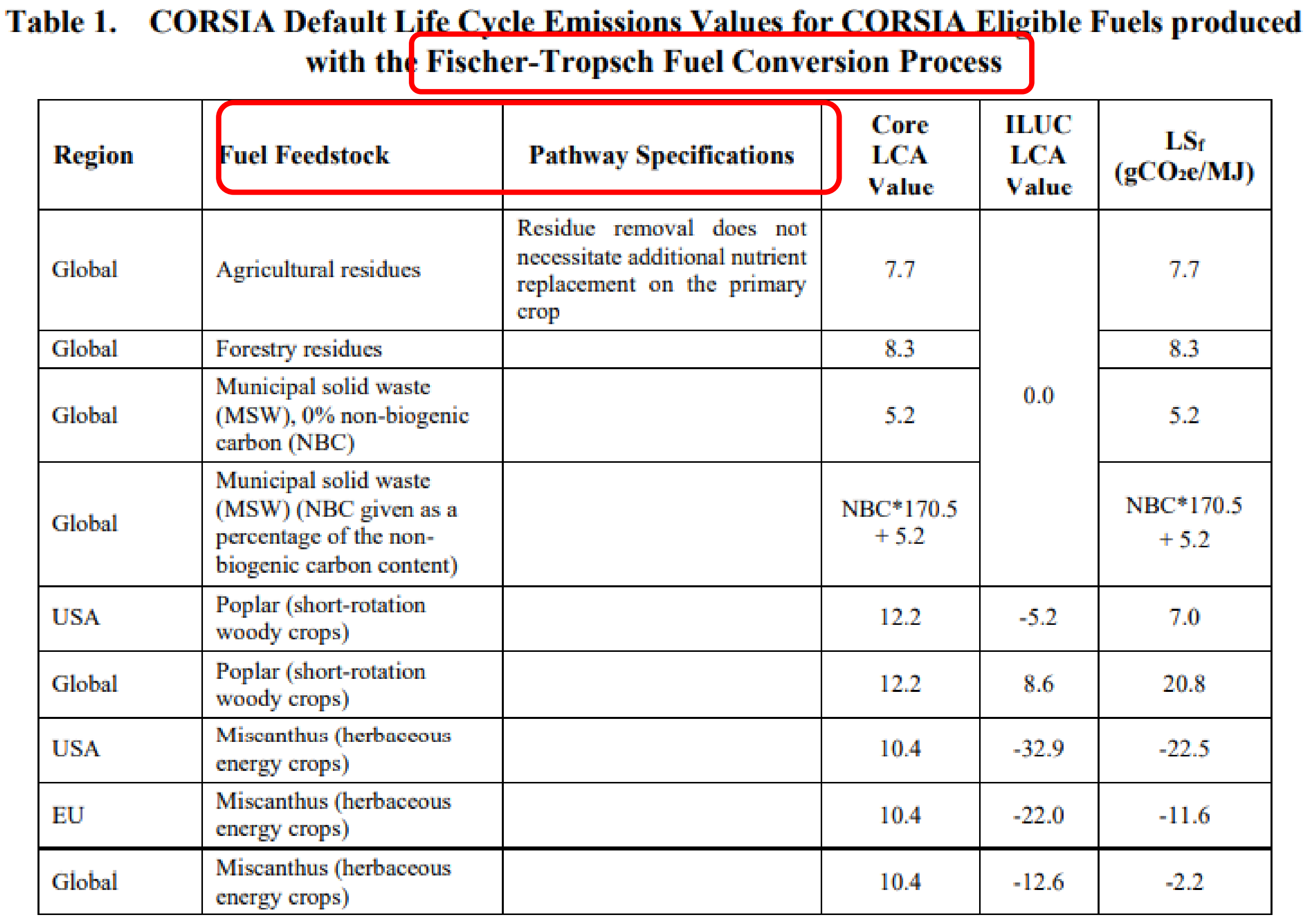

Table 1. CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels produced with the Fischer-Tropsch Fuel Conversion Process

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

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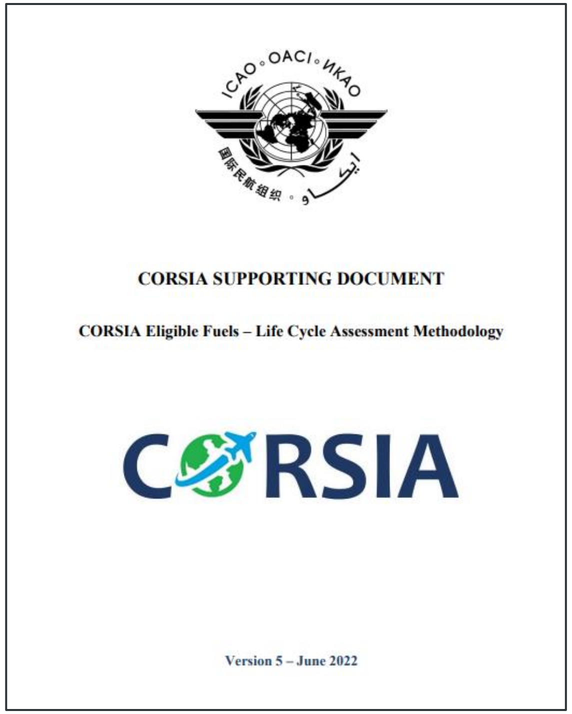
INTERNATIONAL CIVIL AVIATION ORGANIZATION
ICAO document
CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels
November 2019
CORSIA
Carbon Offsetting and Reduction Scheme for International Aviation

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

How to request a new default LCA value to ICAO

How to request a new default value to ICAO

Process defined in the CORSIA supporting document “CORSIA eligible fuels – Life Cycle Assessment Methodology”, Part I



CORSIA SUPPORTING DOCUMENT

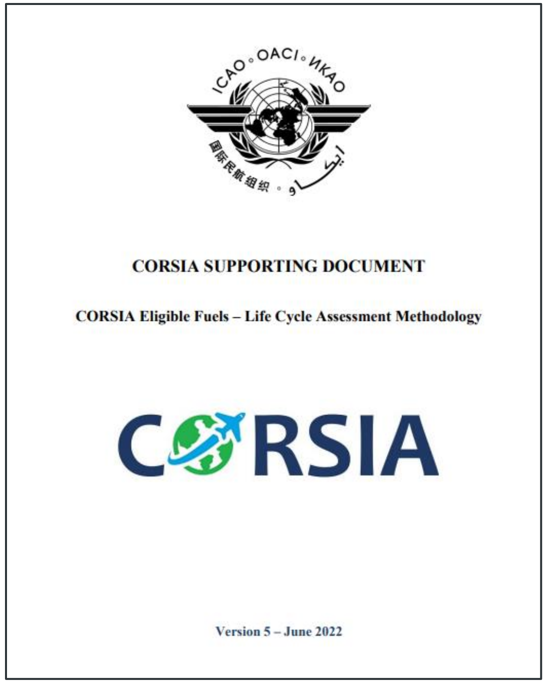
CORSIA Eligible Fuels – Life Cycle Assessment Methodology

CORSIA

Version 5 – June 2022

Requests for CAEP to consider a conversion process, feedstock, and/or region can be made by ICAO Member States, Observer Organizations, or an approved SCS to the CAEP Secretary in ICAO (caep@icao.int).

Criteria for consideration



CORSIA SUPPORTING DOCUMENT

CORSIA Eligible Fuels – Life Cycle Assessment Methodology

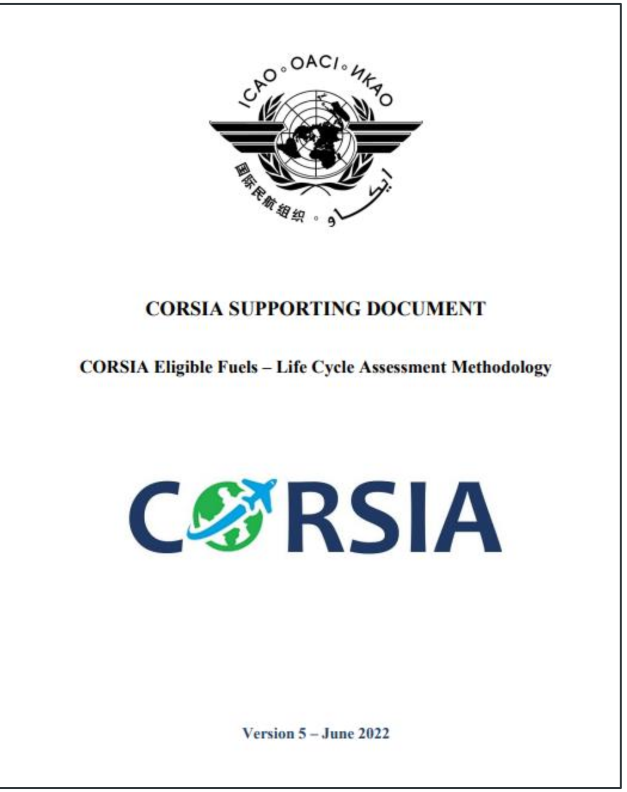
CORSIA

Version 5 – June 2022

The following criteria need to be met for a new feedstock to be considered:

1. The pathway uses an ASTM certified conversion process or, a conversion process for which the Phase 2 ASTM Research Report has been reviewed and approved by the OEMs
2. The conversion process has been validated at sufficient scale to establish a basis for facility design and operating parameters at commercial scale
3. There are sufficient data on the conversion process of interest to perform LCA modelling.
4. There are sufficient data on the feedstock of interest to perform LCA modelling.
5. There are sufficient data on the region of interest to perform ILUC modelling, where applicable to the pathway.

Data requirements

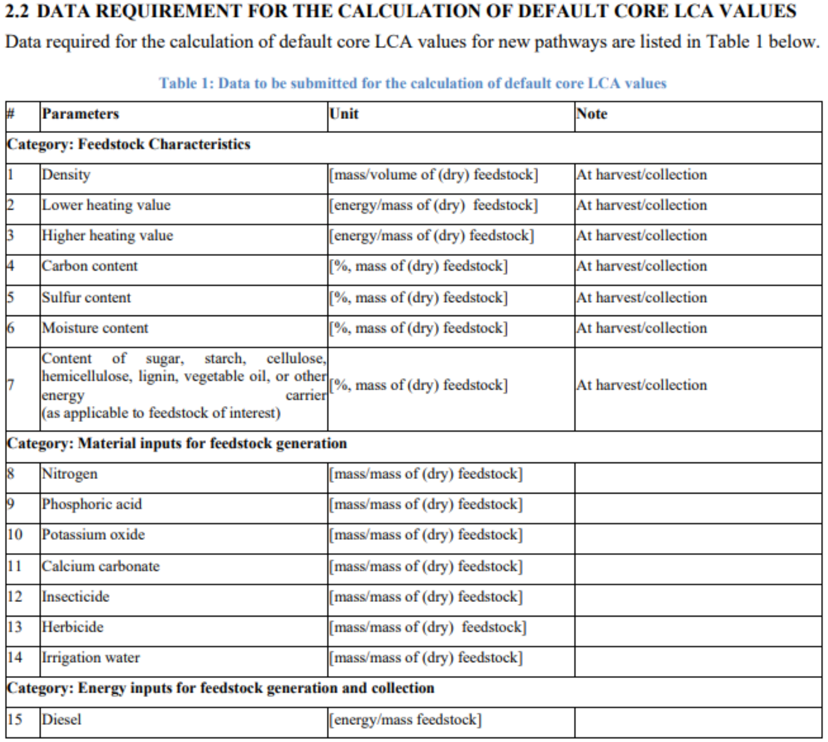


CORSIA SUPPORTING DOCUMENT

CORSIA Eligible Fuels – Life Cycle Assessment Methodology

CORSIA

Version 5 – June 2022

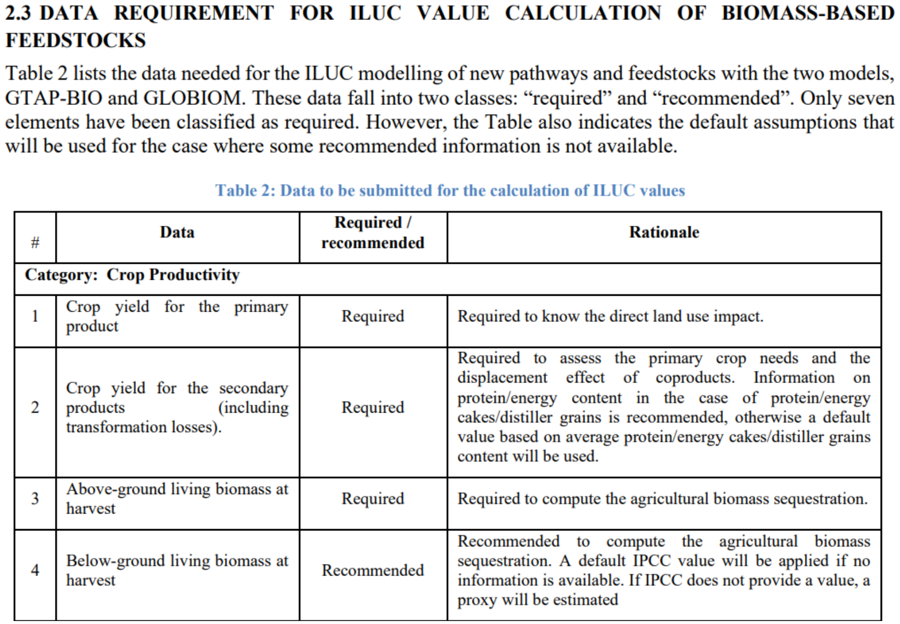


2.2 DATA REQUIREMENT FOR THE CALCULATION OF DEFAULT CORE LCA VALUES

Data required for the calculation of default core LCA values for new pathways are listed in Table 1 below.

Table 1: Data to be submitted for the calculation of default core LCA values

#	Parameters	Unit	Note
Category: Feedstock Characteristics			
1	Density	[mass/volume of (dry) feedstock]	At harvest/collection
2	Lower heating value	[energy/mass of (dry) feedstock]	At harvest/collection
3	Higher heating value	[energy/mass of (dry) feedstock]	At harvest/collection
4	Carbon content	[%, mass of (dry) feedstock]	At harvest/collection
5	Sulfur content	[%, mass of (dry) feedstock]	At harvest/collection
6	Moisture content	[%, mass of (dry) feedstock]	At harvest/collection
7	Content of sugar, starch, cellulose, hemicellulose, lignin, vegetable oil, or other energy carrier (as applicable to feedstock of interest)	[%, mass of (dry) feedstock]	At harvest/collection
Category: Material inputs for feedstock generation			
8	Nitrogen	[mass/mass of (dry) feedstock]	
9	Phosphoric acid	[mass/mass of (dry) feedstock]	
10	Potassium oxide	[mass/mass of (dry) feedstock]	
11	Calcium carbonate	[mass/mass of (dry) feedstock]	
12	Insecticide	[mass/mass of (dry) feedstock]	
13	Herbicide	[mass/mass of (dry) feedstock]	
14	Irrigation water	[mass/mass of (dry) feedstock]	
Category: Energy inputs for feedstock generation and collection			
15	Diesel	[energy/mass feedstock]	



2.3 DATA REQUIREMENT FOR ILUC VALUE CALCULATION OF BIOMASS-BASED FEEDSTOCKS

Table 2 lists the data needed for the ILUC modelling of new pathways and feedstocks with the two models, GTAP-BIO and GLOBIOM. These data fall into two classes: "required" and "recommended". Only seven elements have been classified as required. However, the Table also indicates the default assumptions that will be used for the case where some recommended information is not available.

Table 2: Data to be submitted for the calculation of ILUC values

#	Data	Required / recommended	Rationale
Category: Crop Productivity			
1	Crop yield for the primary product	Required	Required to know the direct land use impact.
2	Crop yield for the secondary products (including transformation losses).	Required	Required to assess the primary crop needs and the displacement effect of coproducts. Information on protein/energy content in the case of protein/energy cakes/distiller grains is recommended, otherwise a default value based on average protein/energy cakes/distiller grains content will be used.
3	Above-ground living biomass at harvest	Required	Required to compute the agricultural biomass sequestration.
4	Below-ground living biomass at harvest	Recommended	Recommended to compute the agricultural biomass sequestration. A default IPCC value will be applied if no information is available. If IPCC does not provide a value, a proxy will be estimated

An Excel template to provide this data available on the CORSIA eligible fuels website

ICAO processes and methodologies to calculate default core LCA values

Approach under CORSIA for life cycle assessment of fuels

Presented by FTG subgroup co-lead for Core LCA

Process and methodology for LCA values

- ICAO Document “CORSIA Methodology for Calculating Actual Life Cycle Emissions Values” allows fuel producers to obtain specific emissions values to a CORSIA SAF
- This methodology is also followed by ICAO to obtain the default LCA values

LCA methodologies

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ICAO document

CORSIA Methodology for Calculating Actual Life Cycle Emissions Values

November 2019

CORSIA

Carbon Offsetting and Reduction Scheme for International Aviation

Default LCA value calculated by at least two modelling teams

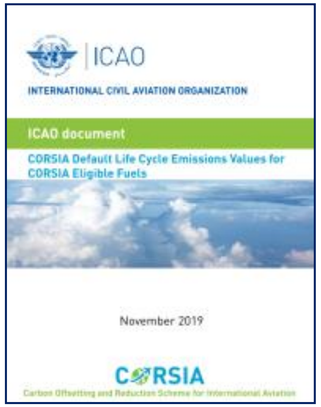
And verified by a third one

(ANL, CTBE, JRC MIT, Uhasselt,…)

Approvals by:

- CAEP FTG board
- CAEP
- Council

Publication on Default LCA document



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ICAO document

CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels

November 2019

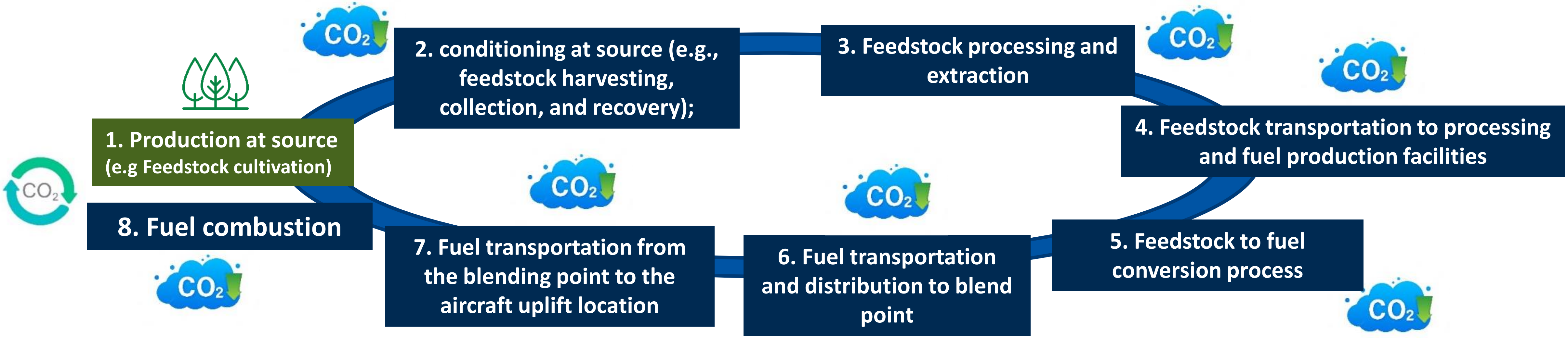
CORSIA

Carbon Offsetting and Reduction Scheme for International Aviation

Life cycle assessment

Core Life cycle assessment (core LCA value)

Emissions associated with 8 Stages of SAF production and use



1. Production at source (e.g Feedstock cultivation)

2. conditioning at source (e.g., feedstock harvesting, collection, and recovery);

3. Feedstock processing and extraction

4. Feedstock transportation to processing and fuel production facilities

5. Feedstock to fuel conversion process

6. Fuel transportation and distribution to blend point

7. Fuel transportation from the blending point to the aircraft uplift location

8. Fuel combustion

- CORSIA LCA considers emissions associated with material and utility inputs, such as processing chemicals, electricity, and natural gas.
- CORSIA LCA does not consider emissions generated from facility construction and equipment manufacturing *(these emissions are negligible for current technologies considered in CORSIA)*
- Wastes, residues and by-products have zero emissions for Life Cycle Stage 1 (Production at Source)

LCA metric

Life cycle values are measured in **gCO_2e/MJ**, which means:

grams of CO_2 equivalent per megajoule of fuel (calculated using the lower heating value)

CO_2 equivalent – considers the 100-Year Global Warming Potential (GWP) of other greenhouse gases generated during the fuel production.

CO_2e values used in CORSIA:

Greenhouse gas	CO2e Value
Methane (CH_4)	28
Nitrous oxide (N_20)	265

These values are based on the Fifth Assessment report of the IPCC.

Emissions related to energy content of each fuel type

Energy allocation

In many cases, the SAF production involves co-production of other commodities.

Examples:

- HEFA process – produces SAF together with renewable diesel
- Other co-products may include chemicals, electricity, steam, hydrogen, and/or animal feed

Energy allocation is used to assign emissions burdens to all co products in proportion to their contribution to the total energy content.

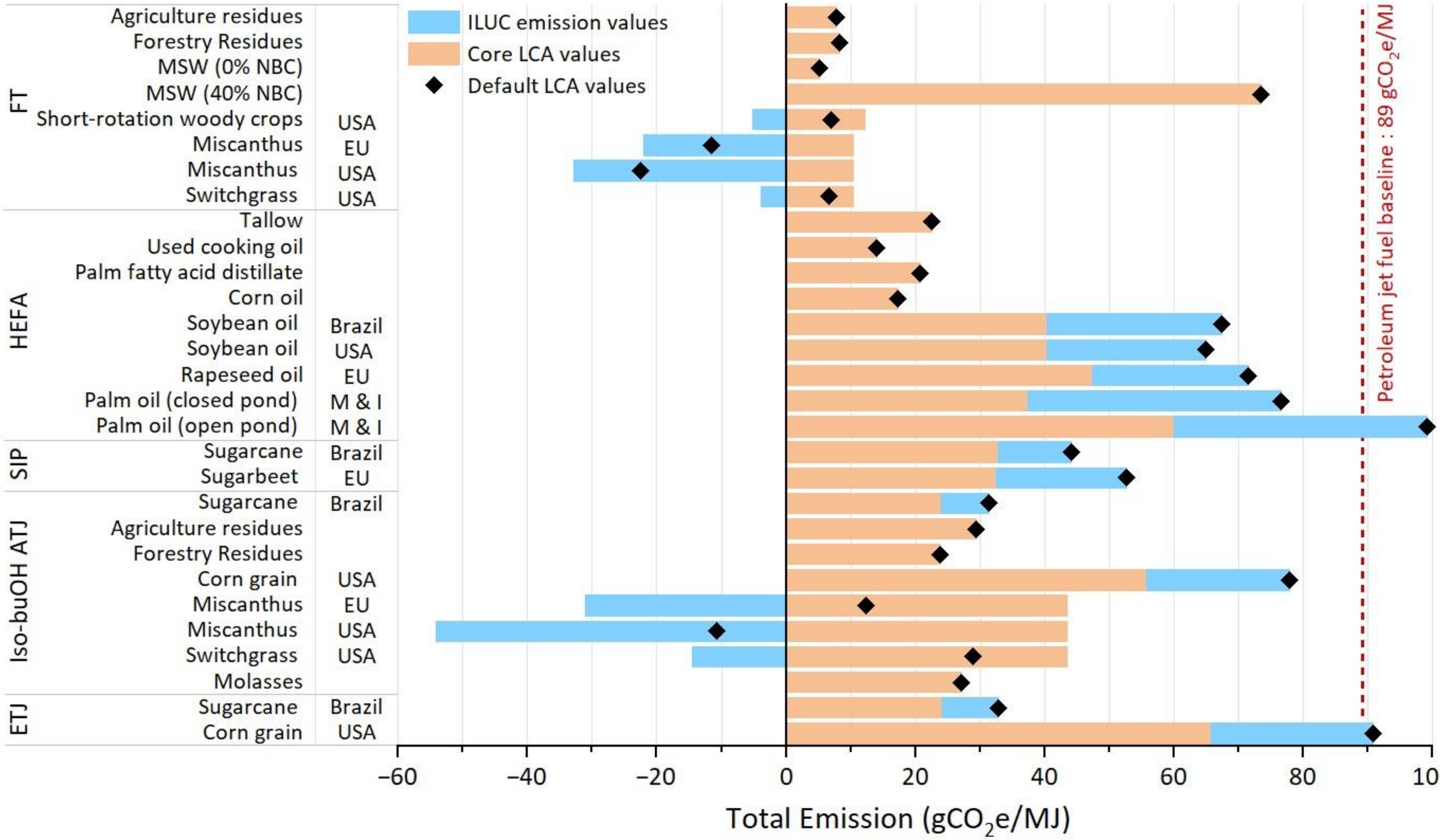
CO_2e emissions are not allocated to waste, residues and by-products that result from the SAF supply chain.

Default LC emission values in CORSIA

ICAO is working to establish default values for all relevant ASTM-approved SAF pathways (i.e. combinations of feedstock and conversion process).

Current core gaps:

CHJ
FT-coprocessing
HC-HEFA



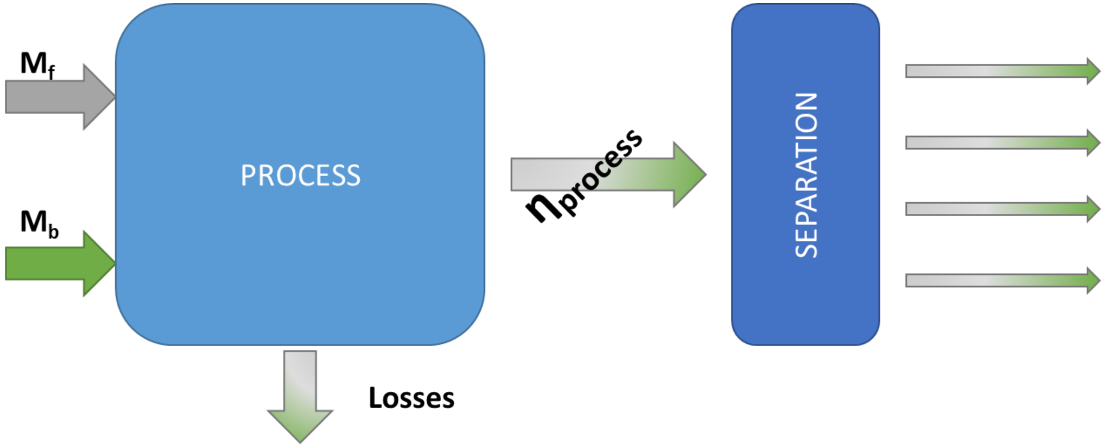
CoProcessing

Baseline definition:

For co-processing, a fuel producer will measure/estimate all inputs and outputs of the facility for scenarios both with and without co-processing operations.

Calculation:

- By **subtracting the base** (petroleum only) case **from** the **coprocessing case**, the fuel producer **calculates the changes** in inputs and outputs.
- First, the **changes in refinery emissions are allocated to the changes in fuel production** (MJ).
- The **upstream emissions** associated with the changes in energy inputs (estimated with an LCA tool) are then **allocated to the changes in fuel production** (MJ).
- Based on the calculated **bio-feedstock input allocated** to MJ fuel production, **emissions associated with bio-feedstock production and transportation can be calculated** using the LCA tool.



Sustainability certification schemes (SCS) may prescribe measurements techniques (e.g. 14C) and protocol **as a means to verify the modelled changes** in inputs and outputs.

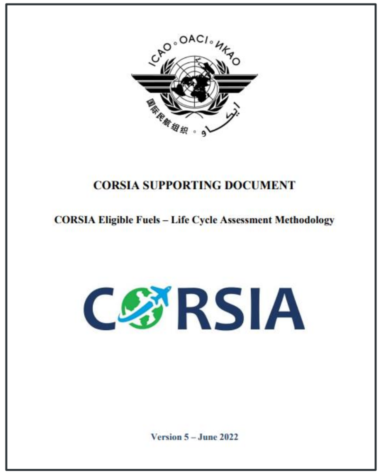
Life cycle assessment

Example: life cycle emissions of sugarcane ethanol ATJ in Brazil

Production step	Associated emissions (gCO2e/MJ)
1,2 3 - Feedstock cultivation Feedstock processing, collection and recovery Feedstock processing and extraction	**16.9**
4 - Feedstock transportation to processing and fuel production facilities	**1.6**
5 - Feedstock to fuel conversion	**5.2**
6 and 7 - Fuel transportation and distribution	**0.4**
8 - fuel combustion on aircraft engine	**0 (biogenic feedstock)**
total (core LCA value)	**24.1**
Induced Land use Change (ILUC value)	**8.7**
SAF Life cycle emission value (L_{CEF}) = core LCA + ILUC	**32.8**

63% emission reduction on a life cycle basis
(Compared with Baseline emission value of 89 gCO2e/MJ)

***Assumptions are published on the** CORSIA supporting document "CORSIA eligible fuels – LCA Methodology"*



CORSIA SUPPORTING DOCUMENT

CORSIA Eligible Fuels – Life Cycle Assessment Methodology

CORSIA

Version 5 – June 2022

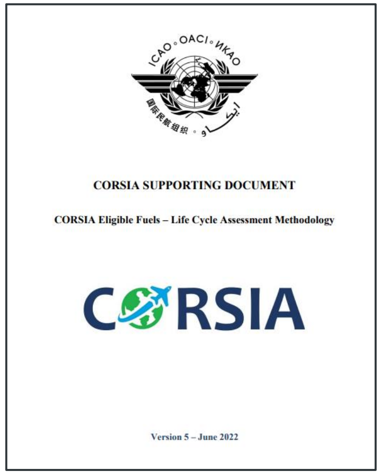
ICAO ENVIRONMENT

Life cycle assessment

Example: Jatropha-based SAF in India

Production step	Associated emissions (gCO2e/MJ)
1, 2, and 3 - Feedstock cultivation Feedstock processing, collection and recovery Feedstock processing and extraction	**32.7**
4 - Feedstock transportation to processing and fuel production facilities	**0.8**
5 - Feedstock to fuel conversion	**12.5**
6 and 7 - Fuel transportation and distribution	**0.4**
8 - Fuel combustion on aircraft engine	**0 (biogenic feedstock)**
total (core LCA value)	46.8

Assumptions are published on the CORSIA supporting document "CORSIA eligible fuels – LCA Methodology"



CORSIA SUPPORTING DOCUMENT

CORSIA Eligible Fuels – Life Cycle Assessment Methodology

CORSIA

Version 5 – June 2022

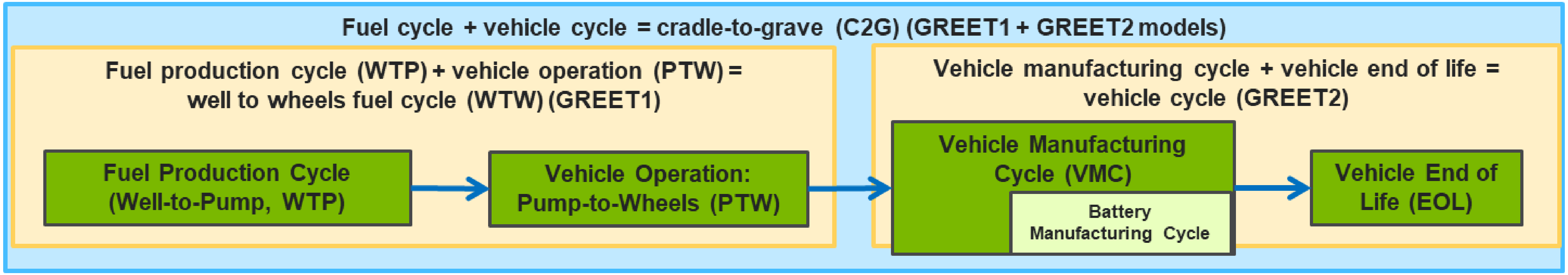
Induced Land use Change (ILUC value) *(Meal used as animal feed after detoxification)*	**-48.1**
SAF Life cycle emission value (L_{CEF}) = core LCA + ILUC	**-1.3**

101% emission reduction on a life cycle basis
(Compared with Baseline emission value of 89 gCO2e/MJ)

Presentation of the GREET model and its use under CORSIA

Presented by Argonne National Laboratory

Argonne's GREET model supported by U.S. Department of Energy



Fuel cycle + vehicle cycle = cradle-to-grave (C2G) (GREET1 + GREET2 models)

Fuel production cycle (WTP) + vehicle operation (PTW) = well to wheels fuel cycle (WTW) (GREET1)

Fuel Production Cycle (Well-to-Pump, WTP)

Vehicle Operation: Pump-to-Wheels (PTW)

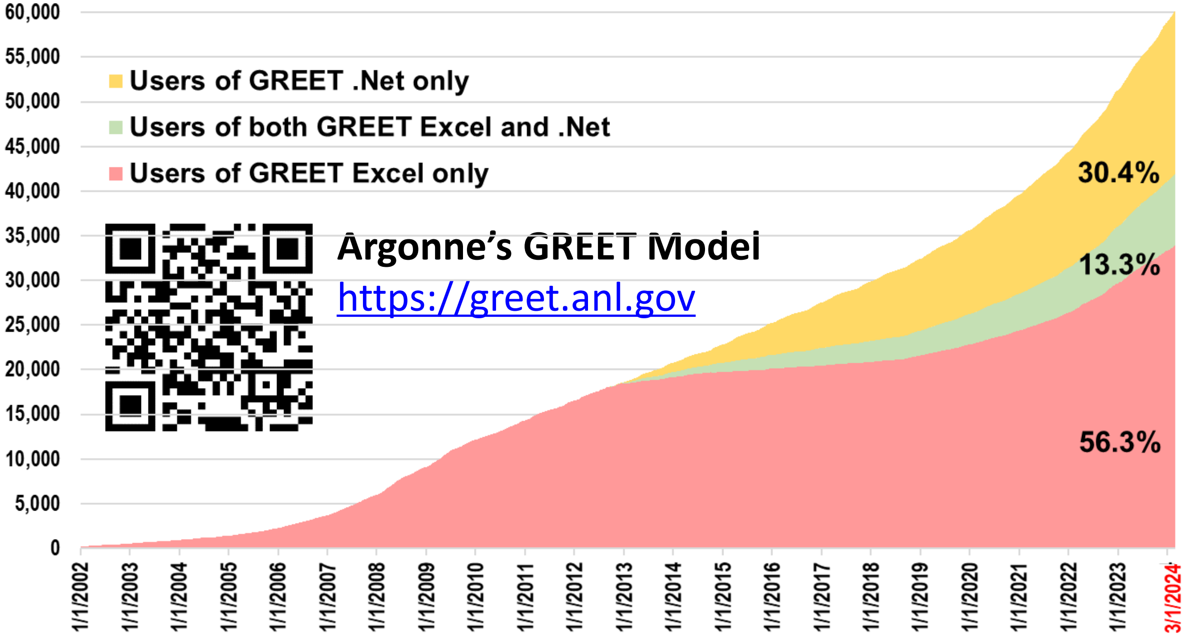
Vehicle manufacturing cycle + vehicle end of life = vehicle cycle (GREET2)

Vehicle Manufacturing Cycle (VMC)

Battery Manufacturing Cycle

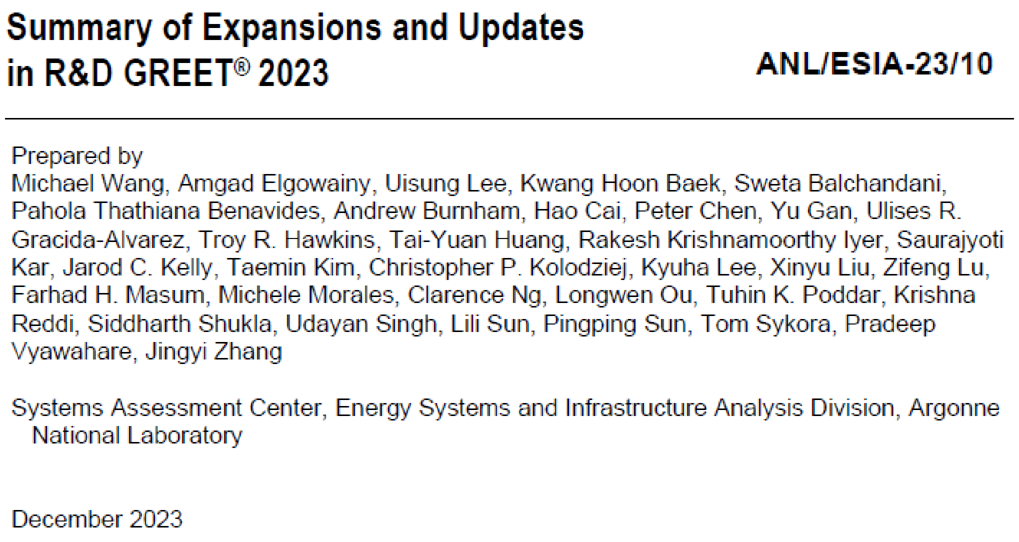
Vehicle End of Life (EOL)

- **GREET (Greenhouse gases, Regulated Emissions, and Energy use in Technologies)** examines life-cycle impacts, simulating the energy use and emissions output for vehicle and fuel combinations, covering road, air, rail and maritime transportation
- GREET development has been supported mainly by DOE since 1994; It is available at greet.anl.gov



Argonne's GREET Model

https://greet.anl.gov



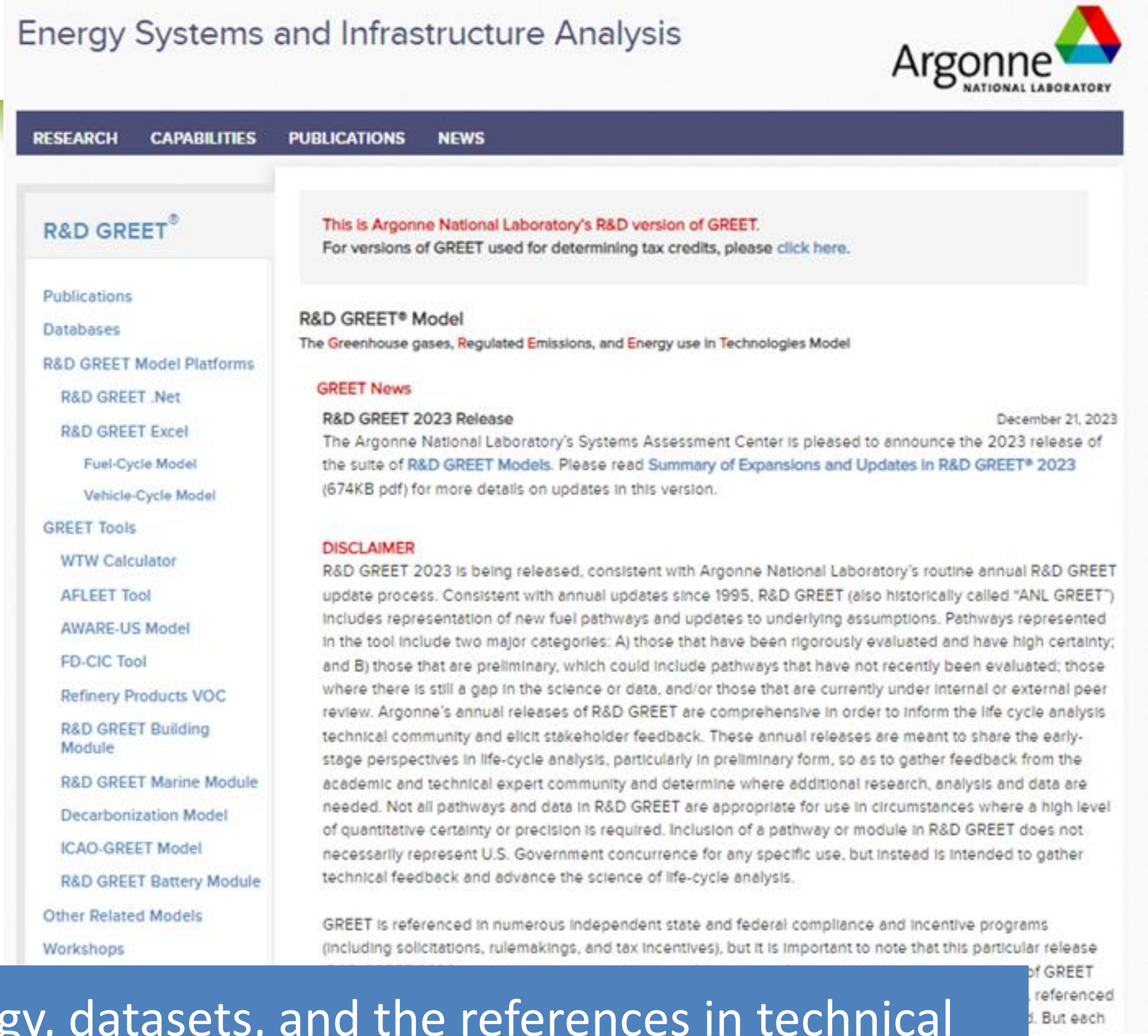
Summary of Expansions and Updates in R&D GREET® 2023

ANL/ESIA-23/10

Prepared by
Michael Wang, Amgad Elgowainy, Uisung Lee, Kwang Hoon Baek, Sweta Balchandani, Pahola Thathiana Benavides, Andrew Burnham, Hao Cai, Peter Chen, Yu Gan, Ulises R. Gracida-Alvarez, Troy R. Hawkins, Tai-Yuan Huang, Rakesh Krishnamoorthy Iyer, Saurajyoti Kar, Jarod C. Kelly, Taemin Kim, Christopher P. Kolodziej, Kyuha Lee, Xinyu Liu, Zifeng Lu, Farhad H. Masum, Michele Morales, Clarence Ng, Longwen Ou, Tuhin K. Poddar, Krishna Reddi, Siddharth Shukla, Udayan Singh, Lili Sun, Pingping Sun, Tom Sykora, Pradeep Vyawahare, Jingyi Zhang

Systems Assessment Center, Energy Systems and Infrastructure Analysis Division, Argonne National Laboratory

December 2023



This is Argonne National Laboratory's R&D version of GREET.
For versions of GREET used for determining tax credits, please click here.

R&D GREET® Model
The Greenhouse gases, Regulated Emissions, and Energy use in Technologies Model

GREET News

R&D GREET 2023 Release December 21, 2023

The Argonne National Laboratory's Systems Assessment Center is pleased to announce the 2023 release of the suite of R&D GREET Models. Please read Summary of Expansions and Updates in R&D GREET® 2023 (674KB pdf) for more details on updates in this version.

DISCLAIMER

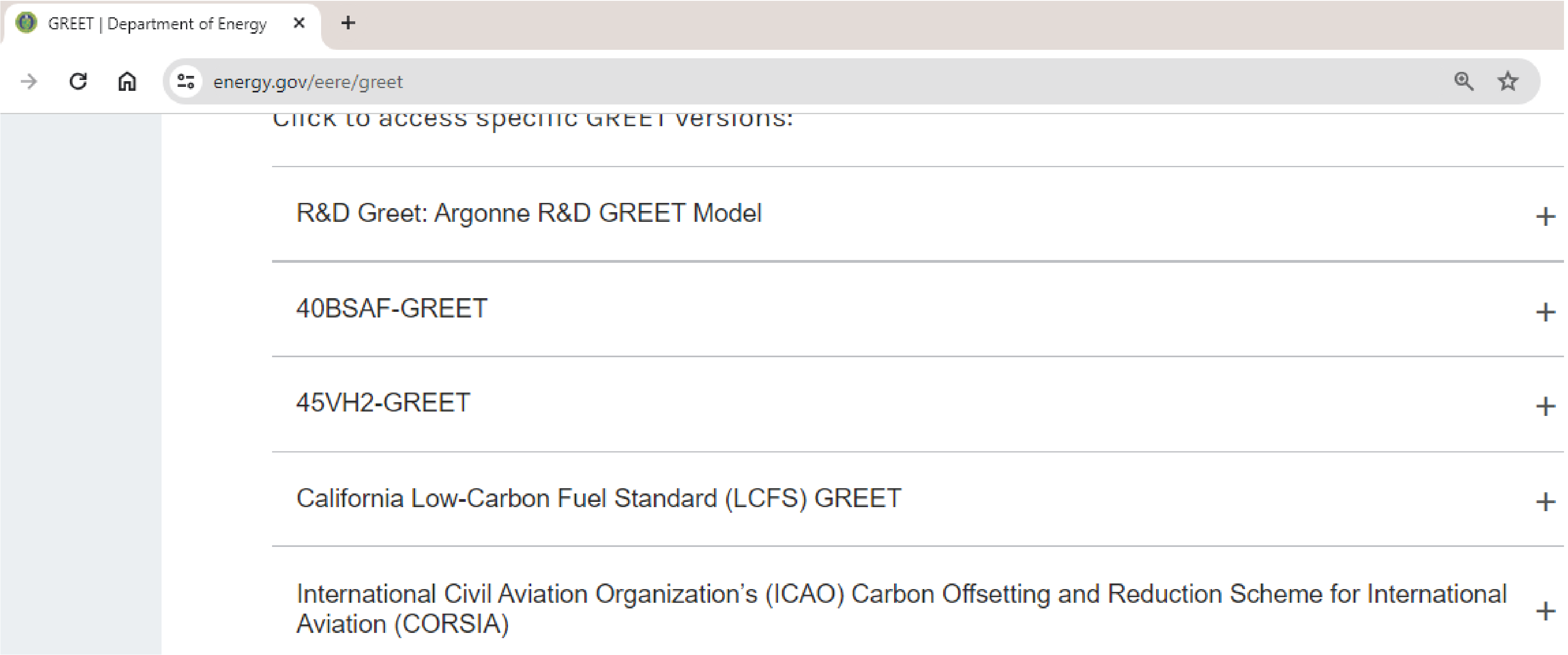
R&D GREET 2023 is being released, consistent with Argonne National Laboratory's routine annual R&D GREET update process. Consistent with annual updates since 1995, R&D GREET (also historically called "ANL GREET") includes representation of new fuel pathways and updates to underlying assumptions. Pathways represented in the tool include two major categories: A) those that have been rigorously evaluated and have high certainty; and B) those that are preliminary, which could include pathways that have not recently been evaluated; those where there is still a gap in the science or data, and/or those that are currently under internal or external peer review. Argonne's annual releases of R&D GREET are comprehensive in order to inform the life cycle analysis technical community and elicit stakeholder feedback. These annual releases are meant to share the early-stage perspectives in life-cycle analysis, particularly in preliminary form, so as to gather feedback from the academic and technical expert community and determine where additional research, analysis and data are needed. Not all pathways and data in R&D GREET are appropriate for use in circumstances where a high level of quantitative certainty or precision is required. Inclusion of a pathway or module in R&D GREET does not necessarily represent U.S. Government concurrence for any specific use, but instead is intended to gather technical feedback and advance the science of life-cycle analysis.

GREET is referenced in numerous independent state and federal compliance and incentive programs (including solicitations, rulemakings, and tax incentives), but it is important to note that this particular release

f GREET
referenced
. But each

Argonne documents the methodology, datasets, and the references in technical reports, journal articles, and technical memos.

Different GREET versions are for different applications



Click to access specific GREET versions:

- R&D Greet: Argonne R&D GREET Model
- 40BSAF-GREET
- 45VH2-GREET
- California Low-Carbon Fuel Standard (LCFS) GREET
- International Civil Aviation Organization's (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

Argonne annually releases Argonne R&D GREET.
There are several versions of GREET used for other purposes.

GREET informs policies and regulations

- CA-GREET is an adaptation of Argonne’s GREET model
- Oregon Clean Fuels Program also uses an adaptation of Argonne’s GREET model
- State of Washington Clean Fuel Regulation relies on CA-GREET
- U.S. EPA uses GREET with other sources for Renewable Fuels Standard pathway evaluations
- National Highway Traffic Safety Administration for fuel economy regulation
- Federal Aviation Administration and International Civil Aviation Organization using GREET to evaluate aviation fuel pathways
- Canadian Clean Fuel Standard for Environment and Climate Change Canada fuel pathways
- LCA results for use in different provisions of the 2021 Bipartisan Infrastructure Law and the 2022 Inflation Reduction Act

LCA objectives of GREET

- Track life cycle performance of technologies to examine their sustainability performance and to inform R&D and business decisions
- Build LCA modeling capacity for DOE, other agencies, and R&D community
- Develop a consistent LCA platform with reliable, widely accepted methods/protocols
- Curate data for technologies, processes, and materials to LCA community
- Address emerging LCA issues
- Conduct detailed LCA and to document data sources, modeling and analysis approaches, and results/conclusions
- Maintain openness and transparency of LCA by making GREET, its data, and publications publicly available

GREET covers many energy systems

Petroleum Sector:
- Conventional oil
- Shale oil
- Oil Sands

- Gasoline
- Diesel
- **Jet fuel**
- Liquefied petroleum gas
- Naphtha
- Residual oil

Natural Gas Sector:
- Conventional NG
- Shale gas

- NG end use in electric, industrial, and residential sectors
- Transportation sector: CNG, LNG
- Alternative fuels: LPG, methanol, DME, FT diesel, FT jet

- Natural gas
- Biomass
- Coal
- Petroleum coke
- Coke oven gas
- Electrolysis
- Nuclear energy

Hydrogen Economy:
- Gaseous hydrogen
- Liquid hydrogen
- With CCS, if applicable

- Natural gas
- Coal
- Residual oil
- Biomass
- Nuclear
- Hydro
- Wind
- Solar

Electric Systems:
- Electricity generation at US plant level
- Aggregate to national, NERC, and state level
- With CCS, if applicable

1st Gen Feedstocks:
- Corn
- Sorghum
- Soybeans
- Rapeseeds
- Sugarcane
- Palm

2nd Gen Feedstocks:
- Dedicated energy crops
- Crop residues
- Forest residues
- MSW
- Animal wastes

Algae

Renewable Energy/Fuels:
- Ethanol
- Biodiesel
- Renewable diesel
- Renewable gasoline
- Renewable natural gas
- **Sustainable aviation fuel**

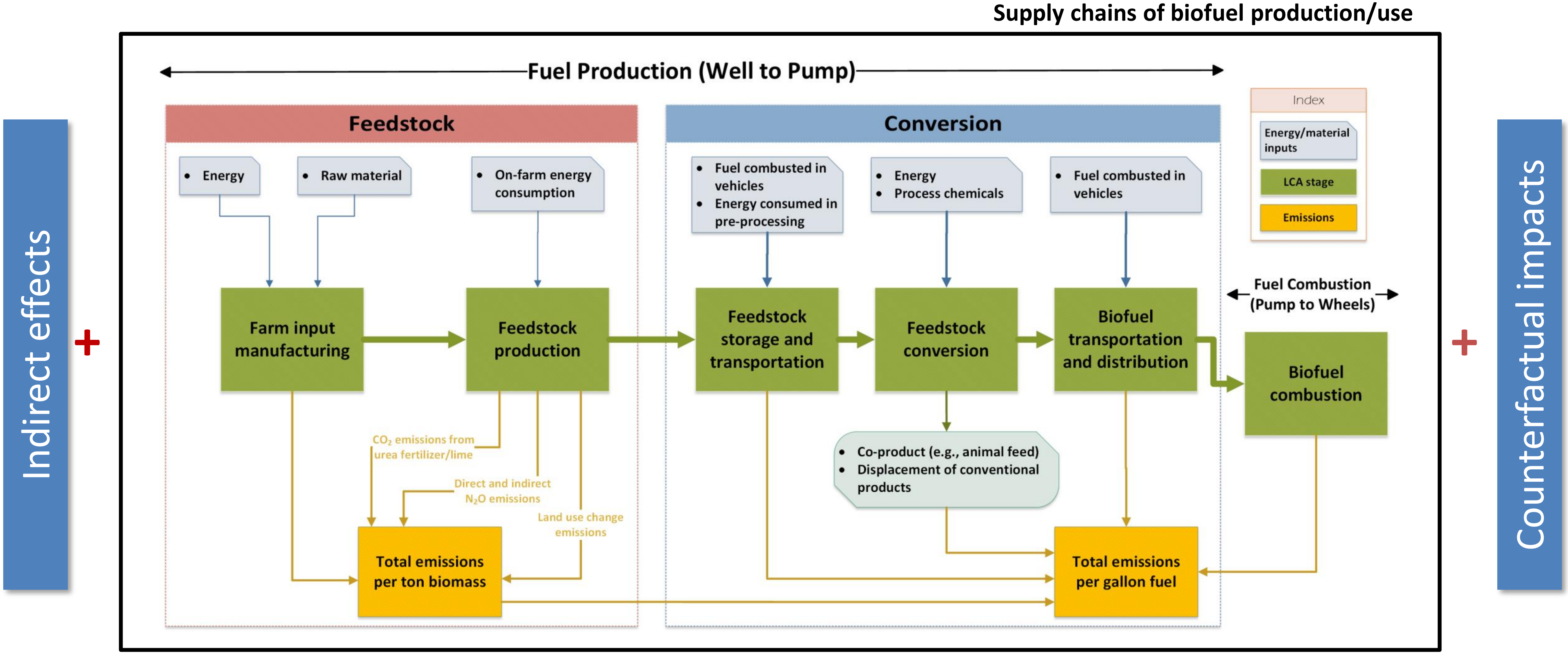
Renewable Hydrogen via electrolysis:
- Wind
- Solar
- Nuclear

E-fuels:
- Gasoline
- Diesel
- Methanol
- **Jet fuel**

CO_2 Sources
- Ethanol plants
- NG SMR plants
- Cement plants
- Etc.

Photo credit: Shutterstock.com

Biofuel LCA system boundary covers all stages along the supply chain



Supply chains of biofuel production/use

Fuel Production (Well to Pump)

Feedstock

- Energy
- Raw material
- On-farm energy consumption

Farm input manufacturing

Feedstock production

CO₂ emissions from urea fertilizer/lime

Direct and indirect N_2O emissions

Land use change emissions

Total emissions per ton biomass

Conversion

- Fuel combusted in vehicles
- Energy consumed in pre-processing

- Energy
- Process chemicals

- Fuel combusted in vehicles

Feedstock storage and transportation

Feedstock conversion

Biofuel transportation and distribution

- Co-product (e.g., animal feed)
- Displacement of conventional products

Total emissions per gallon fuel

Index

Energy/material inputs

LCA stage

Emissions

Fuel Combustion (Pump to Wheels)

Biofuel combustion

Indirect effects +

+ Counterfactual impacts

EU REDII, Canadian Clean Fuel Standard, Brazilian RenovaBio, and ICAO CORSIA allow feedstock certification to some degree

All biofuel regulations in place or under development allow biofuel facility certification

R&D GREET vs. CORSIA

- R&D GREET has been used for CORSIA core LCA value development
  - Argonne developed ICAO-GREET that is based on R&D GREET to calculate the core LCA values of SAFs for CORSIA
- Major differences between R&D GREET and ICAO-GREET leading to different LCA results
  - **Co-product handling**: CORSIA uses the energy allocation for all; GREET includes all available co-product handling methods and uses a given allocation method for each process/pathway as appropriate.
  - **Data**: Argonne annually updates the R&D GREET model with the latest datasets; the data used for CORSIA development vary by the time of evaluation.
  - GREET is not the only model/tool used for CORSIA default value calculation, which leads to having variations by regional impacts and the datasets.

Summary

- Argonne’s R&D GREET model development has been benefited from
  - LCA methodology advancement over the past 30 years,
  - increasingly available data,
  - comprehensive research activities by Argonne and others
- GREET can be used to quantify life-cycle emissions, identify emission hotspots, and to further decarbonize various biofuel production pathways.
- GREET has been used for international, federal, and state-level biofuel programs to achieve GHG emission reductions
- Consistent LCA methodologies and representative datasets are key to reliable LCA.

ACT SAF

Assistance, Capacity-building and Training for SAF

Presentation of the LCA models used for CORSIA default LCA values

Presented by the Brazilian Center for Research in Energy and Materials (CNPEM)

CNPEM

LNLS sirius

LNBio

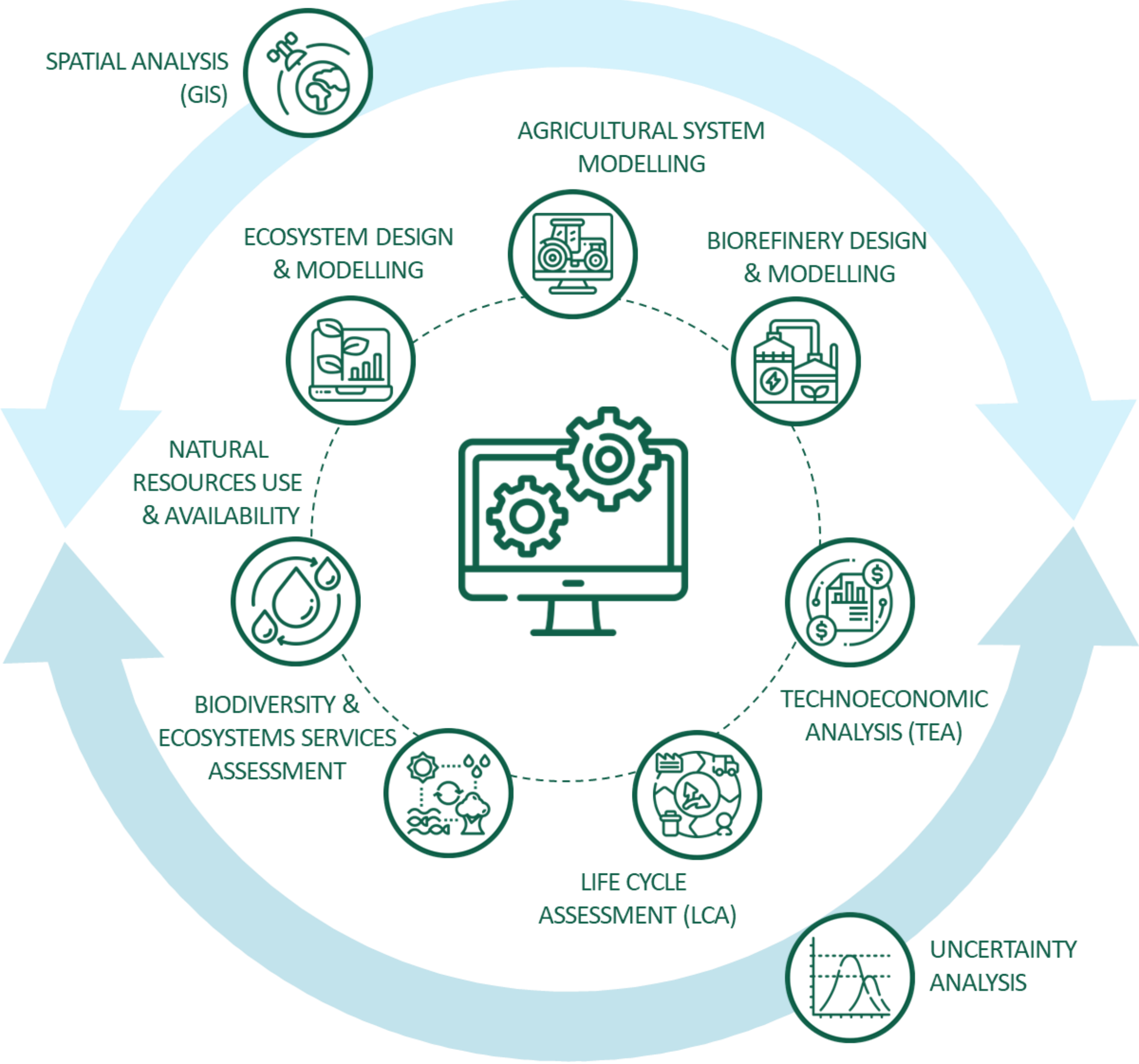
LNNano
Brazilian Nanotechnology
National Laboratory

lnbr
Brazilian Biorenewables
National Laboratory

ilum

The Brazilian Center for Research in Energy and Materials (CNPEM)

Integrated Framework for Sustainability Assessment



VIRTUAL BIOREFINERY:

Assessing Current Technologies & Anticipating Impacts of Future Innovations

Agricultural System Modeling

- Biomass production costs
- Inventories for LCA

Process Design

- Flowsheeting
- Mass and energy balances
- Inventories for TEA and LCA

Techno-Economic Assessment (TEA)

- Capital cost estimation
- Cash flow analysis
- Costs breakdown

Life Cycle Assessment (LCA)

- GHG emissions
- Energy use
- Other impacts

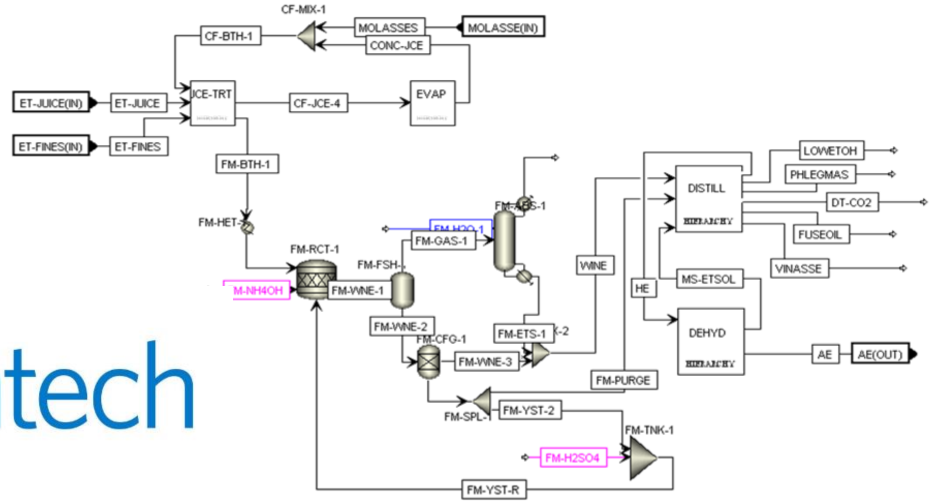
Modeling the Agricultural Systems

CanaSoft
Biorrefinaria Virtual de Cana-de-Açúcar

- ✓ Proprietary model, **integrated with other simulation and evaluation tools**
- ✓ **Extensive databases** for biomass production systems in the **Brazilian context**
- ✓ Tailored biomass production costs and life cycle inventories **for each specific biorefinery configuration**

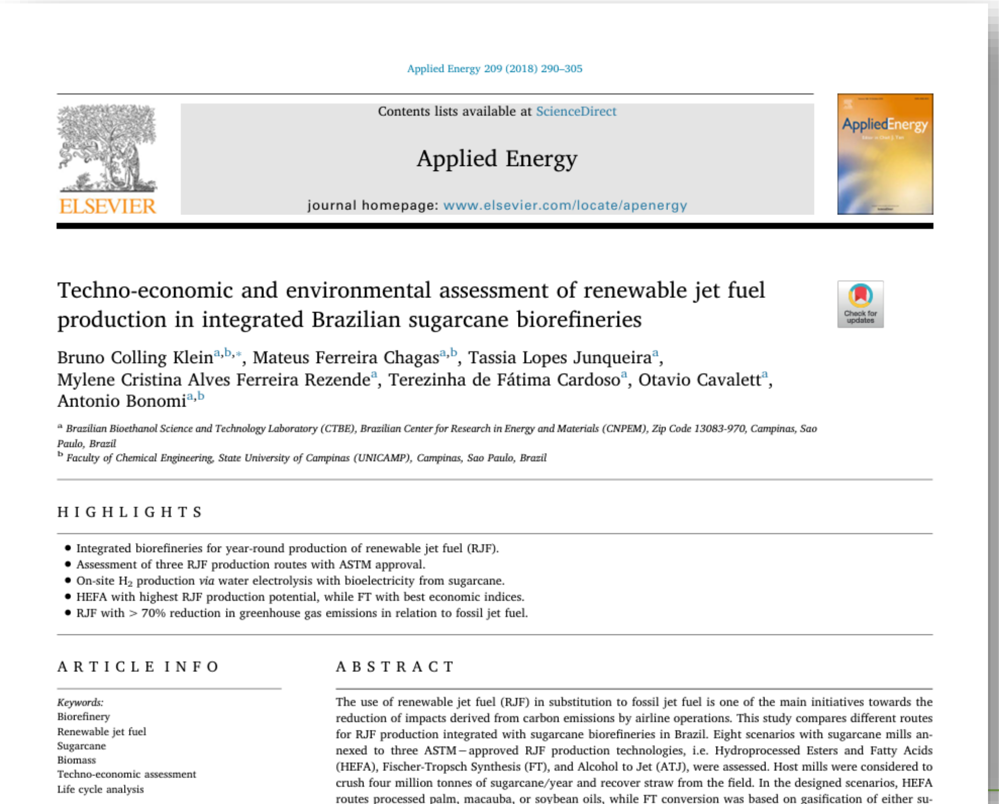
Modeling the Industrial Systems

aspentech



- ✓ Accurate biorefinery assessments: **employing Aspen Plus®** process simulator for comprehensive mass and energy balances
- ✓ **Validation** of sugarcane biorefinery simulations with real data from diverse technological levels in Brazilian mills

Techno-economic and environmental assessment of renewable jet fuel production in integrated Brazilian sugarcane biorefineries



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Techno-economic and environmental assessment of renewable jet fuel production in integrated Brazilian sugarcane biorefineries

Bruno Colling Klein[a,b,*], Mateus Ferreira Chagas[a,b], Tassia Lopes Junqueira[a], Mylene Cristina Alves Ferreira Rezende[a], Terezinha de Fátima Cardoso[a], Otavio Cavalett[a], Antonio Bonomi[a,b]

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HIGHLIGHTS

- Integrated biorefineries for year-round production of renewable jet fuel (RJF).
- Assessment of three RJF production routes with ASTM approval.
- On-site H_2 production *via* water electrolysis with bioelectricity from sugarcane.
- HEFA with highest RJF production potential, while FT with best economic indices.
- RJF with > 70% reduction in greenhouse gas emissions in relation to fossil jet fuel.

ARTICLE INFO

Keywords:
Biorefinery
Renewable jet fuel
Sugarcane
Biomass
Techno-economic assessment
Life cycle analysis

ABSTRACT

The use of renewable jet fuel (RJF) in substitution to fossil jet fuel is one of the main initiatives towards the reduction of impacts derived from carbon emissions by airline operations. This study compares different routes for RJF production integrated with sugarcane biorefineries in Brazil. Eight scenarios with sugarcane mills annexed to three ASTM – approved RJF production technologies, i.e. Hydroprocessed Esters and Fatty Acids (HEFA), Fischer-Tropsch Synthesis (FT), and Alcohol to Jet (ATJ), were assessed. Host mills were considered to crush four million tonnes of sugarcane/year and recover straw from the field. In the designed scenarios, HEFA routes processed palm, macauba, or soybean oils, while FT conversion was based on gasification of either su-

HEFA

- Soybean oil
- Palm oil
- Macauba oil

FT

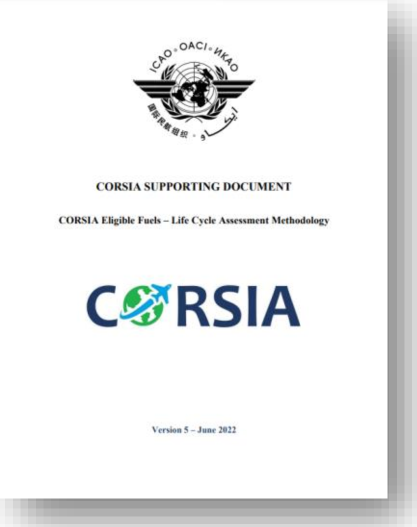
- Sugarcane bagasse
- Sugarcane straw
- Eucalyptus

ATJ

- **Sugarcane ethanol**
- Cellulosic ethanol (sugarcane residues)
- **Sugarcane iso-butanol**

CNPEM data adapted to CORSIA

- Premises from Klein et al (2018) were adjusted:
  - green diesel is not used to substitute fossil diesel at sugarcane production
  - straw is not recovered from the field
- CNPEM generated new life cycle inventories for sugarcane ATJ
- Results were regenerated in **GREET 2016**
- Impacts were allocated accordingly to CAEP Core-LCA methodology



CORSIA SUPPORTING DOCUMENT

CORSIA Eligible Fuels – Life Cycle Assessment Methodology

CORSIA

Version 5 – June 2022

- Difference between the analyses is lower than 8.9 gCO_2e/MJ_{SAF}
- The mid-point between the results is taken as the default value

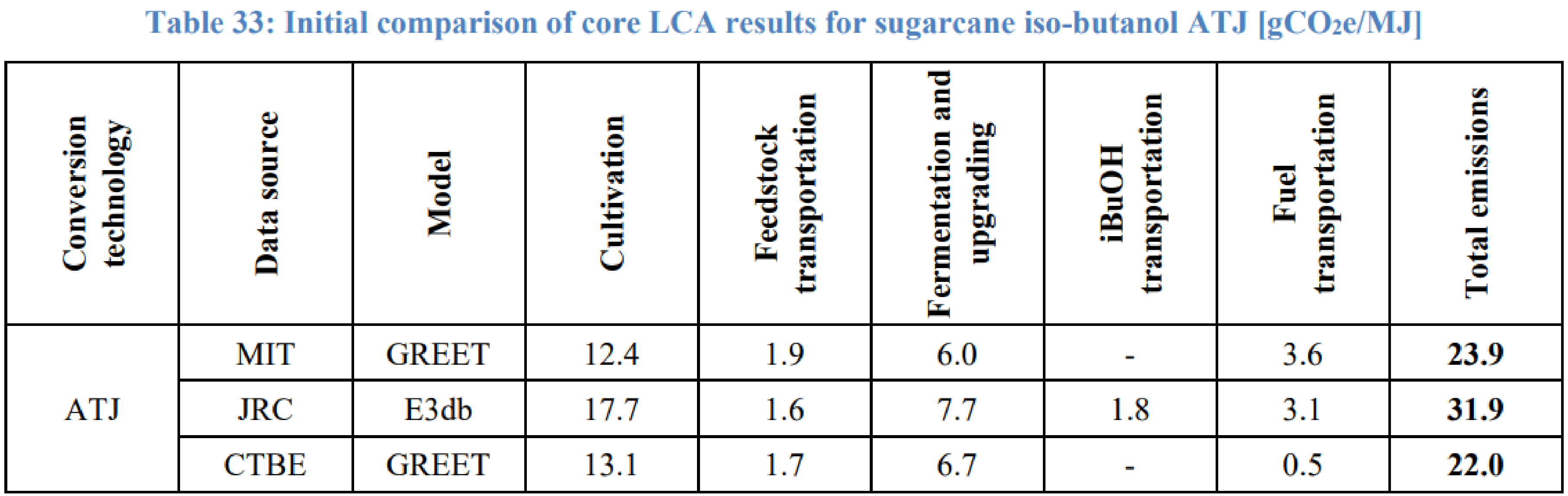


Table 33: Initial comparison of core LCA results for sugarcane iso-butanol ATJ [gCO_2e/MJ]

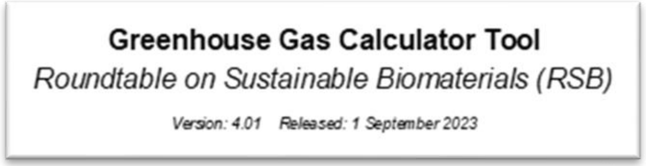
Conversion technology	Data source	Model	Cultivation	Feedstock transportation	Fermentation and upgrading	iBuOH transportation	Fuel transportation	Total emissions
ATJ	MIT	GREET	12.4	1.9	6.0	-	3.6	**23.9**
	JRC	E3db	17.7	1.6	7.7	1.8	3.1	**31.9**
	CTBE	GREET	13.1	1.7	6.7	-	0.5	**22.0**

Application of LCA models for certification processes

Presented by The Roundtable on the Sustainability of Biomaterials (RSB)

RSB-CORSIA methodology

- Tools approved by RSB:



Greenhouse Gas Calculator Tool
Roundtable on Sustainable Biomaterials (RSB)
Version: 4.01 Released: 1 September 2023

RSB
www.rsb.org

- Other tools accepted?

  - As long as they comply with RSB-CORSIA methodology
  - The auditors will check the use of correct methodology as well as input values, emission factors, etc.

GREET
LIFE-CYCLE MODEL

BIOGRACE
Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe

GHGenius

RSB-CORSIA methodology

- Difference between CORSIA and RSB CORSIA GHG reductions

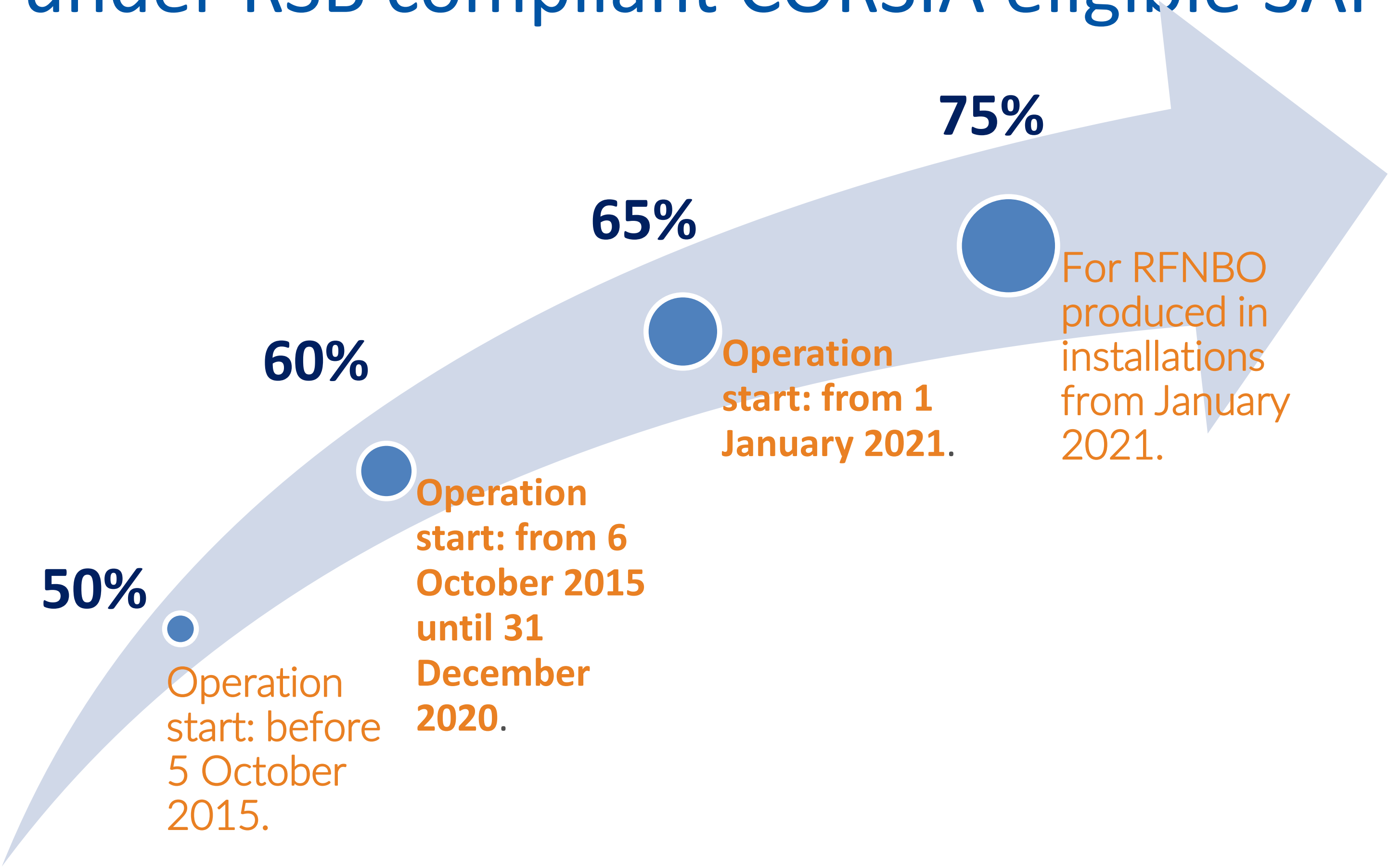
CORSIA requirement	**RSB** CORSIA requirement *(optional - not required for CORSIA compliance)*	
GHG LCA + ILUC	**GHG LCA + ILUC**	**GHG LCA**
>10%	>10%	>50% (according to next slide)

CORSIA baseline = 89 g CO_2e/MJ for jet fuel and 95 g CO_2e/MJ for AvGas

ILUC = *Induced* Land Use Change, includes both Direct & Indirect Land Use Change

RSB-CORSIA methodology

- GHG emission reduction: additional and optional requirement to certify under RSB compliant CORSIA eligible SAF



50%

Operation start: before 5 October 2015.

60%

Operation start: from 6 October 2015 until 31 December 2020.

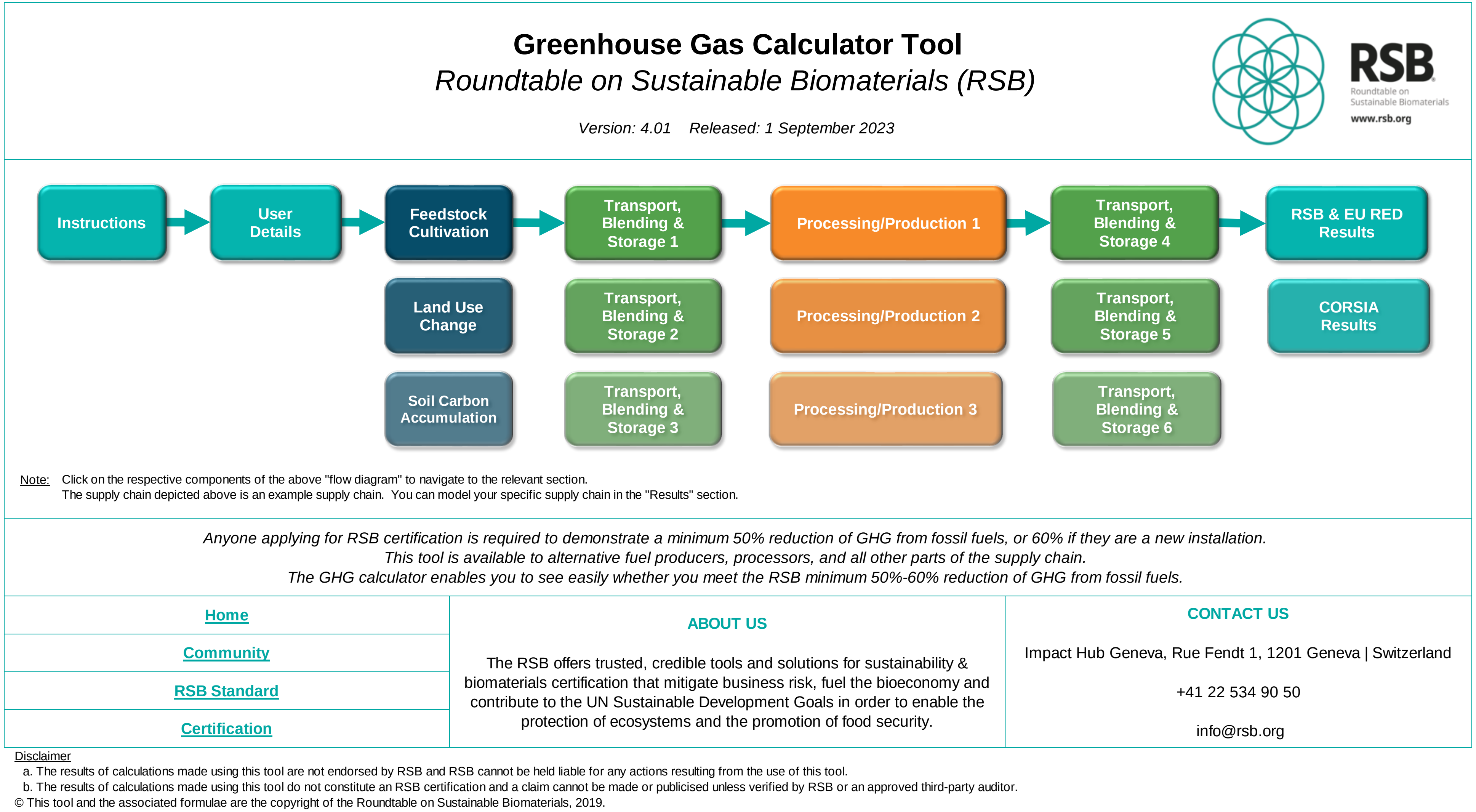
65%

Operation start: from 1 January 2021.

75%

For RFNBO produced in installations from January 2021.

RSB GHG Calculator Tool



Greenhouse Gas Calculator Tool

Roundtable on Sustainable Biomaterials (RSB)

Version: 4.01 Released: 1 September 2023

Note: Click on the respective components of the above "flow diagram" to navigate to the relevant section.
The supply chain depicted above is an example supply chain. You can model your specific supply chain in the "Results" section.

Anyone applying for RSB certification is required to demonstrate a minimum 50% reduction of GHG from fossil fuels, or 60% if they are a new installation.
This tool is available to alternative fuel producers, processors, and all other parts of the supply chain.
The GHG calculator enables you to see easily whether you meet the RSB minimum 50%-60% reduction of GHG from fossil fuels.

Home
Community
RSB Standard
Certification

ABOUT US

The RSB offers trusted, credible tools and solutions for sustainability & biomaterials certification that mitigate business risk, fuel the bioeconomy and contribute to the UN Sustainable Development Goals in order to enable the protection of ecosystems and the promotion of food security.

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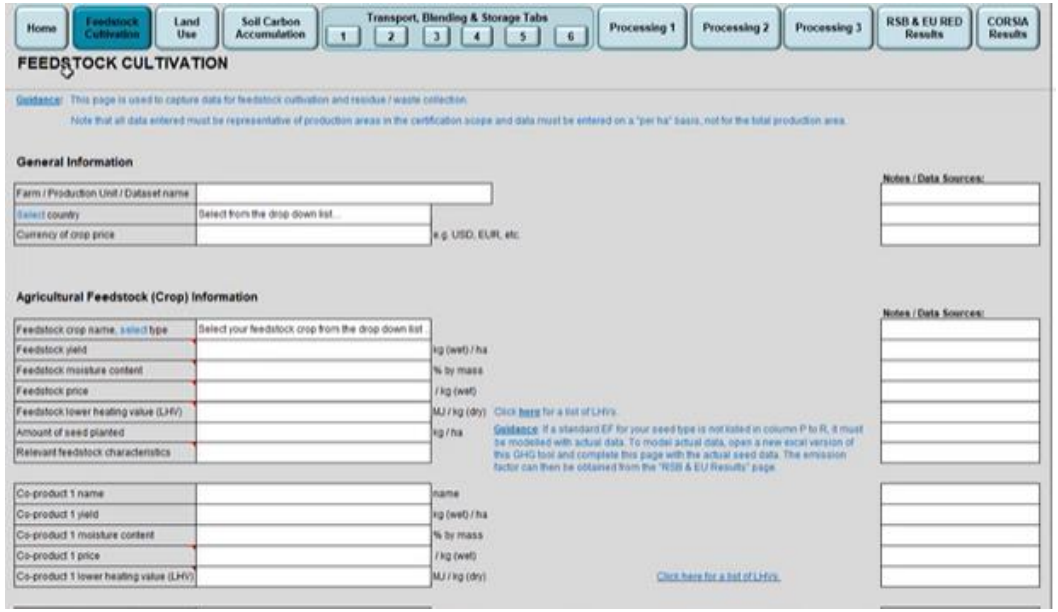
Disclaimer
a. The results of calculations made using this tool are not endorsed by RSB and RSB cannot be held liable for any actions resulting from the use of this tool.
b. The results of calculations made using this tool do not constitute an RSB certification and a claim cannot be made or publicised unless verified by RSB or an approved third-party auditor.

RSB GHG Calculator Tool

- **RSB GHG Calculator Tool**

ONE tool for THREE methodologies:

1. RSB Global (also applicable to RSB Japan FIT)
2. RSB EU RED
3. RSB CORSIA



FEEDSTOCK CULTIVATION

Guidance: This page is used to capture data for feedstock cultivation and residue / waste collection.

Note that all data entered must be representative of production areas in the certification scope and data must be entered on a "per ha" basis, not for the total production area.

General Information

Notes / Data Sources:

Farm / Production Unit / Dataset name		
Select country	Select from the drop down list...	
Currency of crop price		e.g. USD, EUR, etc

Agricultural Feedstock (Crop) Information

Notes / Data Sources:

Feedstock crop name, select type	Select your feedstock crop from the drop down list...	
Feedstock yield		kg (wet) / ha
Feedstock moisture content		% by mass
Feedstock price		/ kg (wet)
Feedstock lower heating value (LHV)		MJ / kg (dry)
Amount of seed planted		kg / ha
Relevant feedstock characteristics		

Click here for a list of LHVs.

Guidance: If a standard EF for your seed type is not listed in column P to R, it must be modelled with actual data. To model actual data, open a new excel version of this GHG tool and complete this page with the actual seed data. The emission factor can then be obtained from the "RSB & EU Results" page.

Co-product 1 name		name
Co-product 1 yield		kg (wet) / ha
Co-product 1 moisture content		% by mass
Co-product 1 price		/ kg (wet)
Co-product 1 lower heating value (LHV)		MJ / kg (dry)

Click here for a list of LHVs.

- **WHAT MAKES IT UNIQUE?**
  - Life cycle approach, helps identifying hotspots
  - Simple navigation to move between supply chain steps.
  - Data-driven modelling that evolves with methodologies
  - User flexibility
  - Instruction notes built into the tool – no user manual needed.
  - Calculates the results for three methodologies simultaneously.
  - Emissions factors from Ecoinvent and Biograce included, but can be overwritten with actual values (to be verified by auditors).

RSB GHG Calculator Tool

DATA ENTRY TABS

- Cultivation
    - Type and region
    - LUC: baseline January 2008 and current management practices
    - Use of fertilisers (N, P, K & CaO) and organic fertilisers
    - Use of pesticides
    - Mechanical operations (use of diesel)
    - Irrigation
- Processing and biofuel production
    - Energy consumption
    - Inputs
    - Water
    - Conversion rates
    - Air emissions
- Distribution, transport, final user
    - Type of transport
    - Type of fuel, km, consumption
    - Energy consumption (storage, distribution)
    - Losses

RSB GHG Calculator Tool

CORSIA COMPLIANCE

Current version (v4.03)

- Considers full supply chain of CORSIA eligible fuels
- Emission Credits methodology
- Non-biogenic CO2
- Waste/residues have zero emissions
- Construction/manufacturing emissions not included
- Total LC emissions cannot be smaller than 0
- CO_2 calculated on a basis of a 100-year GWP
- Low LUC risk considered
- Only includes biofuels, not fossil fuels
- Default CORSIA values from June 2022

New tool release (v5.0) April 2024

- Land Use Change (LUC) update:
  - IPCC 2006 GHG guidelines, data, and methodology updated to 2019 refinement.
  - CORSIA now fully based on IPCC LUC methodology.
- Emissions breakdown tab specifically for CORSIA.
- Updated default core LCA and ILUC values.

Application of LCA models for certification processes

Presented by International Sustainability and Carbon Certification (ISCC)

Verification of GHG emissions reductions

Verification of a correct and consistent application of the CORSIA life cycle emissions methodology is one of the cornerstones of certification under sustainability certification schemes (SCS)

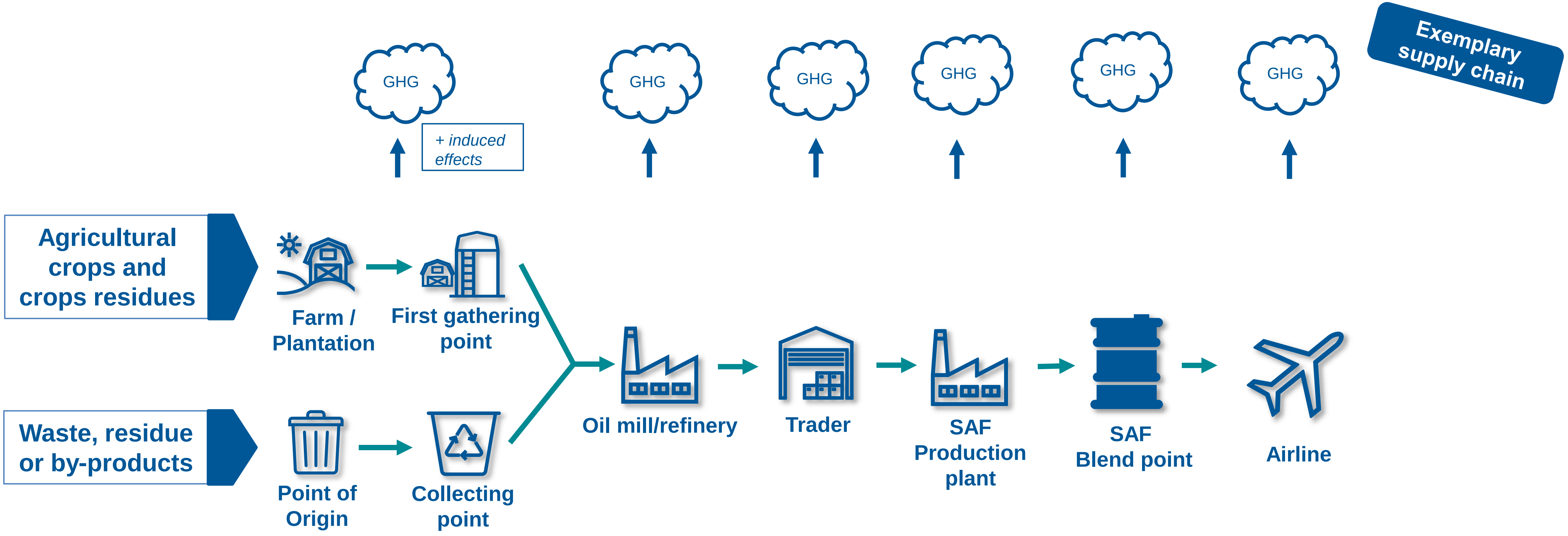
Sustainability in feedstock production

Traceability of sustainable materials through the supply chain

Verified reduction in life cycle emissions

Accounting of full life cycle emissions

GHG emissions are emitted along all life cycle steps of CORSIA eligible SAF production

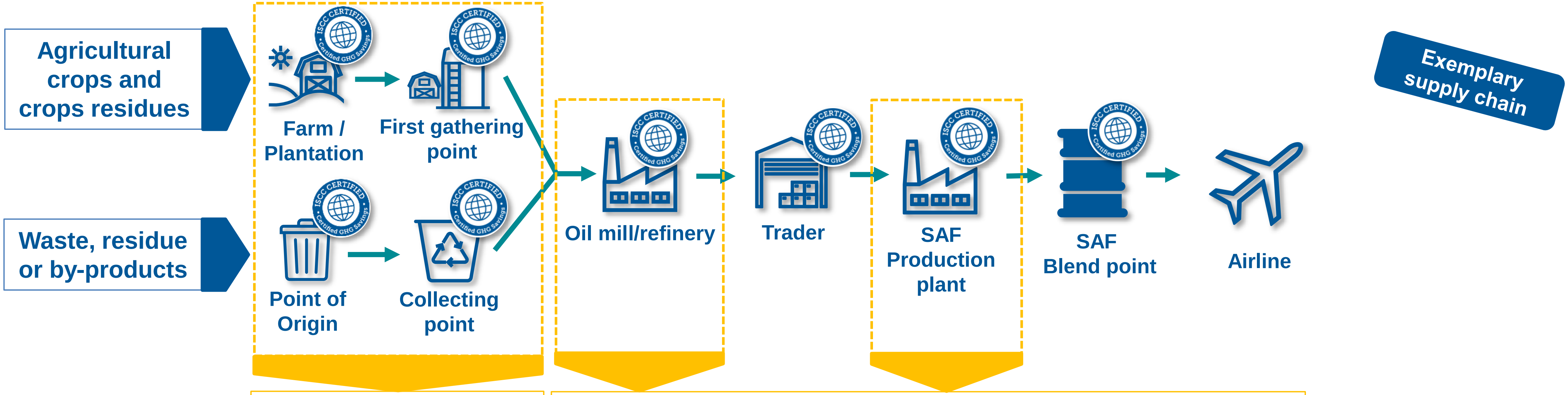


ICAO ENVIRONMENT

Verification of GHG emissions reductions

ACT SAF

GHG emissions from each life cycle step are calculated and added up along the supply chain to determine the SAF's carbon intensity



Agricultural crops and crops residues

Waste, residue or by-products

Farm / Plantation

First gathering point

Point of Origin

Collecting point

Oil mill/refinery

Trader

SAF Production plant

SAF Blend point

Airline

Exemplary supply chain

Feedstock production and collection

- Emissions from **feedstock cultivation and collection**
- Emissions from **direct land use change (DLUC)**
- Emissions from **upstream transport**

Processing; upstream and downstream transport and distribution

- Emissions from **processing**
- Emissions from **transport and distribution** (upstream and downstream)
- Emissions from **combustion**

+
induced land use change (ILUC) value if relevant

The GHG emissions value calculated at each step must be audited and verified by a certification body before it can be forwarded in the supply chain.

Certification process for actual life cycle emission values

1

Company

(or external expert) conducts GHG emissions calculation for its operation (e.g., in Excel)

Calculating actual values – data collection

Feedstock production and conditioning

- Data includes input of e.g. fertilizer, pesticides, seeds
- Yields of main product (dry or wet + moisture content)
- Emission factors and sources

Transport and distribution

- Number of transports and transport distance
- Fuel consumption
- Emission factor of fuel
- Amount of total transported material

Feedstock-to-fuel conversion

- Consumption of electricity, process-specific inputs and heat; fuel used for heat production
- Wastewater
- Yields of main product and co-products
- Emission factors and sources

Emission factors

- Reliable sources of emission factors
  - Databases (e.g. GREET, Ecoinvent)
  - Scientific literature sources (peer-reviewed)

Feedstock factors

- Used to convert GHG emissions from incoming feedstocks to outgoing products in production processes

Emissions allocation

- Correct allocations of emission among co-products of production processes

- No emissions allocated to wastes, residues and by-products generated in production processes

Data documentation in Technical Report

Content includes

- **GHG emissions by life cycle step** (100 years GWP)
- **LCA inventory data** by life cycle step, including all energy and material inputs
- **Emission factors** used, including source
- All relevant **feedstock characteristics** (e.g. agricultural yield, LHV, moisture content, content of sugar, starch, lignin)
- **Quantities for all final and intermediate products**
- Relevant data required for the calculation **emissions credits**, if Municipal Solid Waste is being used as a feedstock

Technical Report audited by SCS-approved certification bodies

Verification by Auditor

- Availability completeness and correctness of Technical Report

Certification process for actual life cycle emission values

1. **Company** (or external expert) conducts GHG emissions calculation for its operation (e.g., in Excel)

2. **CB/ GHG expert** checks information (e.g. methodology, emission factors, lower heating values, etc.) in a desk audit

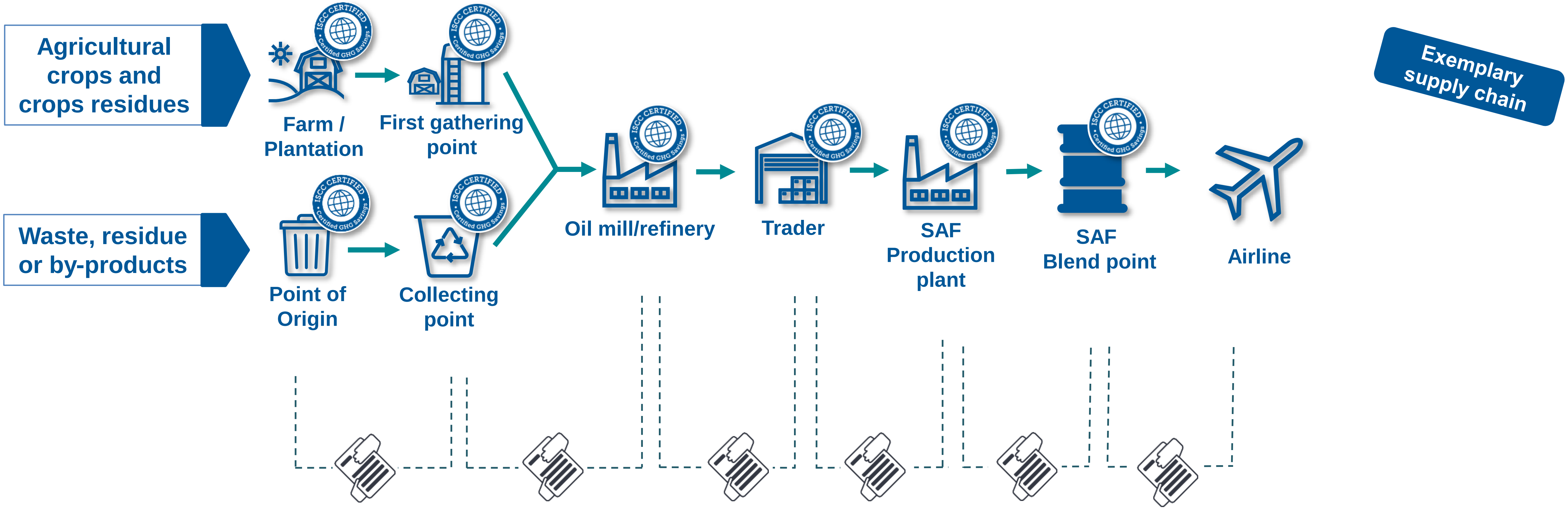
3. **Auditor** verifies all relevant information concerning the calculation of actual GHG values during on-site certification audit

4. If deviations are found the company must provide corrections and an updated calculator to the **CB for final confirmation**

5. **Company** is allowed to use **certified actual GHG value** for the upcoming year of operation

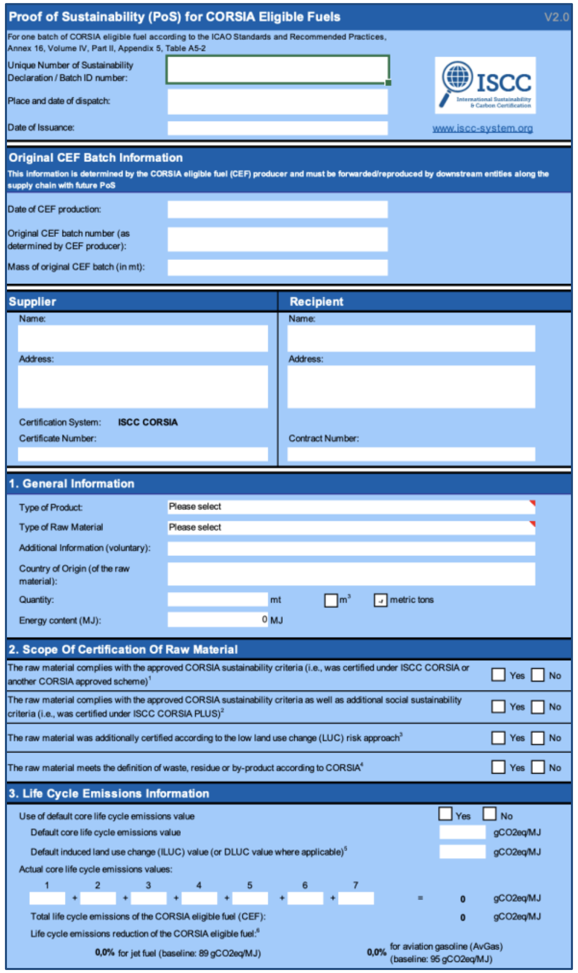
Forwarding of emissions information

Every supply chain element is certified to ensure full traceability. Emissions information is forwarded through the chain via sustainability declarations



Forwarding of emissions information

Information on life cycle emissions is forwarded between supply chain operators via sustainability documentation, so-called proof of sustainability (PoS) documents



Proof of Sustainability (PoS) for CORSIA Eligible Fuels V2.0

For one batch of CORSIA eligible fuel according to the ICAO Standards and Recommended Practices, Annex 16, Volume IV, Part II, Appendix 5, Table A5-2

Unique Number of Sustainability Declaration / Batch ID number:

Place and date of dispatch:

Date of Issuance:

ISCC International Sustainability & Carbon Certification

www.iscc-system.org

Original CEF Batch Information

This information is determined by the CORSIA eligible fuel (CEF) producer and must be forwarded/reproduced by downstream entities along the supply chain with future PoS

Date of CEF production:

Original CEF batch number (as determined by CEF producer):

Mass of original CEF batch (in mt):

Supplier	**Recipient**
Name:	Name:
Address:	Address:
Certification System: **ISCC CORSIA**	
Certificate Number:	Contract Number:

1. General Information

Type of Product: Please select

Type of Raw Material Please select

Additional Information (voluntary):

Country of Origin (of the raw material):

Quantity: mt ☐ m³ ☑ metric tons

Energy content (MJ): 0 MJ

2. Scope Of Certification Of Raw Material

The raw material complies with the approved CORSIA sustainability criteria (i.e., was certified under ISCC CORSIA or another CORSIA approved scheme)[1] ☐ Yes ☐ No

The raw material complies with the approved CORSIA sustainability criteria as well as additional social sustainability criteria (i.e., was certified under ISCC CORSIA PLUS)[2] ☐ Yes ☐ No

The raw material was additionally certified according to the low land use change (LUC) risk approach[3] ☐ Yes ☐ No

The raw material meets the definition of waste, residue or by-product according to CORSIA[4] ☐ Yes ☐ No

3. Life Cycle Emissions Information

Use of default core life cycle emissions value ☐ Yes ☐ No

Default core life cycle emissions value gCO2eq/MJ

Default induced land use change (ILUC) value (or DLUC value where applicable)[5] gCO2eq/MJ

Actual core life cycle emissions values:

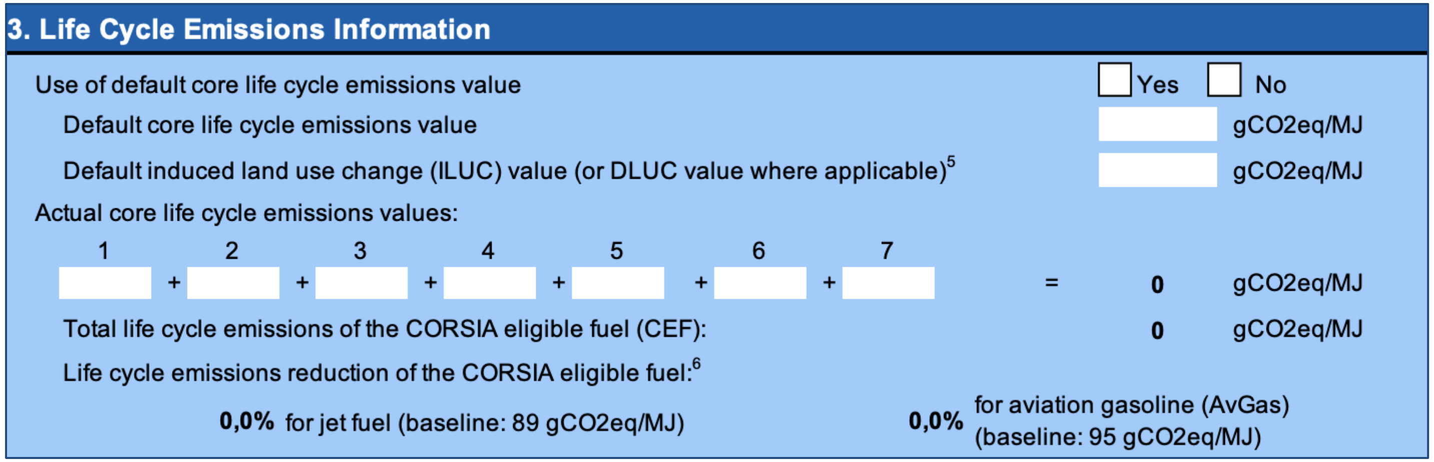
1 + 2 + 3 + 4 + 5 + 6 + 7 = 0 gCO2eq/MJ

Total life cycle emissions of the CORSIA eligible fuel (CEF): 0 gCO2eq/MJ

Life cycle emissions reduction of the CORSIA eligible fuel:[6]

0,0% for jet fuel (baseline: 89 gCO2eq/MJ) **0,0%** for aviation gasoline (AvGas) (baseline: 95 gCO2eq/MJ)

- **Relevant life cycle emissions information on the PoS** includes
  - Life cycle emissions option (Default or actual values?)
  - If actual values: Separate indication of actual values for individual life cycle steps
  - Indication of total life cycle emissions and emissions savings of CORSIA eligible SAF compared to the CORSIA baseline of fossil jet fuel



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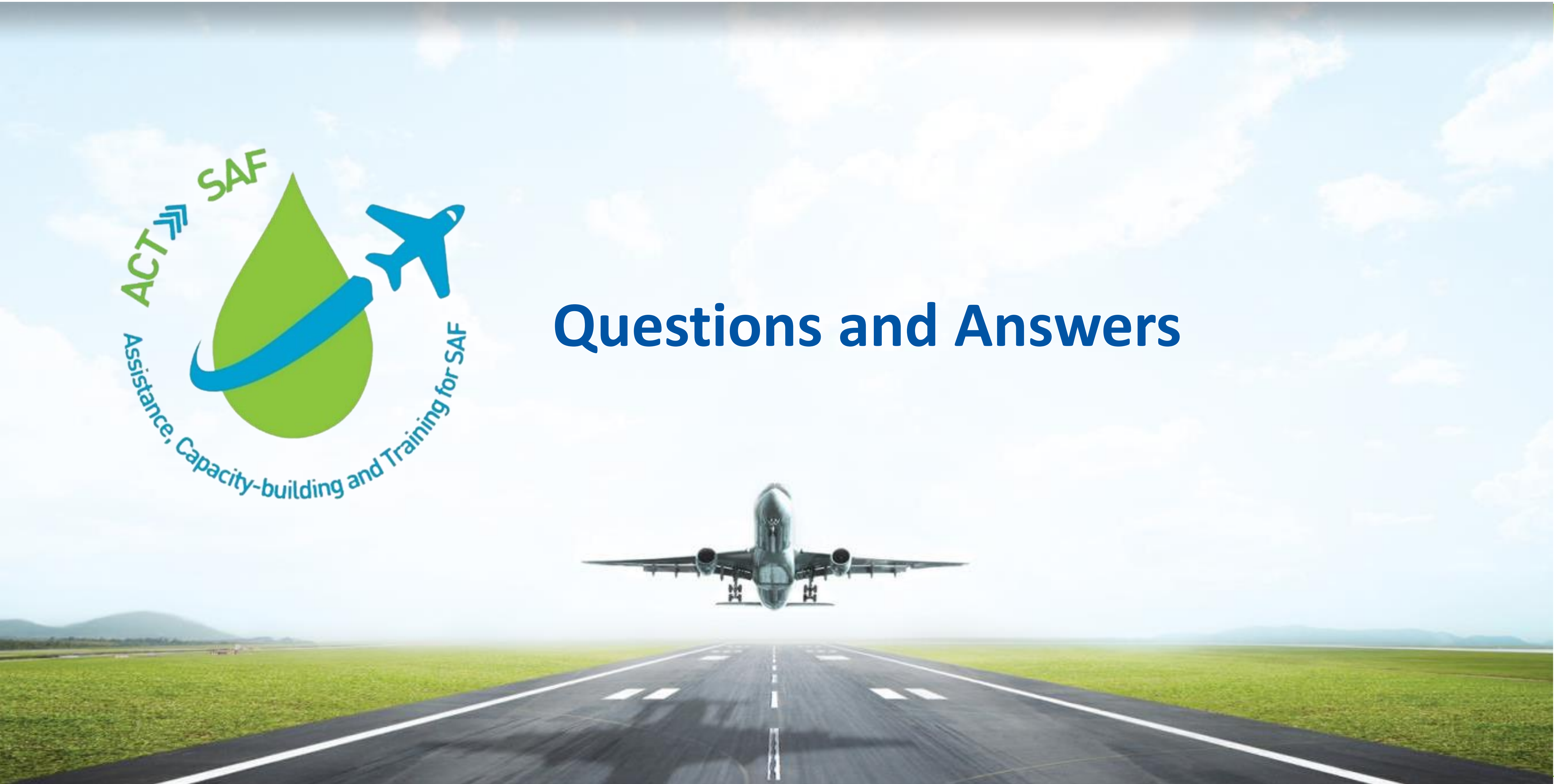
ACT SAF
Assistance, Capacity-building and Training for SAF

Questions and Answers



ACT SAF

Assistance, Capacity-building and Training for SAF

Closing Remarks

ACT-SAF updates

ACT-SAF Series - SEASON 2
#9 Green Hydrogen for aviation
#10 ICAO methodologies and tools for life cycle assessment
#11 CAAF/3 Global Framework
#12 SAF in State Action Plans
#13 Multi-stakeholder SAF Alliances
#14 Feasibility assessments
#15 Economics and Financing (SAF projects)
#16 Updates on recent developments (policies)

Next Session

- Future sessions on specific aspects
- Subject to review – **feedback welcome**

https://www.icao.int/environmental-protection/Pages/ACT-SAF-Series.aspx

Upcoming ICAO Events

ICAO Seminar on Green Airports
18-19 April 2024, Athens, Greece
https://www.icao.int/Meetings/greenairports2024/

ICAO Symposium on Non-CO2 Aviation Emissions
16-18 September 2024, ICAO HQ, Montreal, Canada
https://www.icao.int/Meetings/SymposiumNonCO2AviationEmissions2024/

ICAO LTAG Stocktaking event
7-10 October 2024, ICAO HQ, Montreal, Canada
https://www.icao.int/Meetings/LTAGStocktaking2024/

Follow up actions

We need your assistance on the following actions:

- Support the development of the SAF business implementation template
  - ACT-SAF Partners with competencies in economics, financing, or experience with similar studies
  - Draft template will be circulated for further discussion
- Suggest “latest news” for inclusion in next ACT-SAF series
- Suggest possible consultants with suitable expertise for the upcoming ACT-SAF Projects.
- Contact ICAO if your State is looking for any specific support (e.g. local training)

Responses to officeenv@icao.int are most welcome

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THANK YOU