INTERNATIONAL CIVIL AVIATION ORGANIZATION

ICAO document

CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels

June 2022

CORSIA

Carbon Offsetting and Reduction Scheme for International Aviation

This ICAO document is referenced in Annex 16 — *Environmental Protection*, Volume IV — *Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)*. This ICAO document is material approved by the ICAO Council for publication by ICAO to support Annex 16, Volume IV and is essential for the implementation of the CORSIA. This ICAO document is available on the ICAO CORSIA website and may only be amended by the Council.

Table A shows the origin of amendments to this ICAO document over time, together with a list of the principal subjects involved and the dates on which the amendments were approved by the Council.

Table A. Amendments to the ICAO document "CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels"

Amendment	*Source(s)*	*Subject(s)*	*Approved*
1st Edition	Eleventh meeting of the Committee on Aviation Environmental Protection	First edition of the document.	25 Nov 2019
2nd Edition	2020 Steering Group meeting of the Committee on Aviation Environmental Protection	a) new default LCA values for CORSIA Sustainable Aviation Fuels (SAFs) produced with new pathways (HEFA Brassica Carinata, and ETJ agricultural residues, forestry residues, Miscanthus, and Switchgrass); and b) editorial amendments that clarify the purpose of the ICAO document.	12 March 2021
3rd Edition	2021 Steering Group meeting of the Committee on Aviation Environmental Protection	a) new default emission values for SAF produced from waste gases (ETJ conversion process) b) new default emission values for SAF from tallow, soybean oil, and used cooking oil co-processed at petroleum refineries; c) specifications for various pathways (agricultural residues-FT and ATJ; corn oil HEFA; palm oil HEFA; corn grain / sugarcane ATJ and ETJ; forestry residues / miscanthus / switchgrass ETJ); d) editorial amendments to improve readability of the document	10 November 2021
4tj Edition	Twelfth meeting of the Committee on Aviation Environmental Protection	a) inclusion of global ILUC values for various pathways b) new default emission values for SAF produced from molasses (ATJ conversion process) c) new default values for SAF produced from jatropha (HEFA conversion process) d) inclusion of guidance for the calculation of life cycle emissions of co-processed fuels	3 June 2022

CORSIA DEFAULT LIFE CYCLE EMISSIONS VALUES FOR CORSIA ELIGIBLE FUELS

1. ACRONYMS

ATJ	Alcohol-to-jet
CO_2e	Carbon dioxide equivalent
ETJ	Ethanol-to-jet
FT	Fischer-Tropsch
HEFA	Hydroprocessed esters and fatty acids
ILUC	Induced land use change
LCA	Life cycle assessment
LS_f	Life cycle emissions factor for a CORSIA Eligible fuel in gCO_2e/MJ
MSW	Municipal Solid Waste
NBC	Non-biogenic carbon
POME	Palm Oil Mill Effluent
SIP	Synthetic iso-paraffin

2. DEFINITIONS

Standalone conversion design – pathway utilizes a facility to produce fuel from an intermediate product (e.g., ethanol/isobuthanol) that is not co-located with the facility that produces the intermediate product from the fuel feedstock.

Integrated conversion design - pathway utilizes a co-located facility where heat is integrated between the systems to produce the fuel and intermediate products (e.g., ethanol/isobuthanol) from the fuel feedstock to minimize energy requirements.

3. CORSIA DEFAULT LIFE CYCLE EMISSIONS VALUES FOR CORSIA ELIGIBLE FUELS

Tables 1 to 6 provide the list of CORSIA Default Life Cycle Emissions Values that may be used by an aeroplane operator to claim emissions reductions from the use of CORSIA eligible fuels in a given year.

Note: The CORSIA Supporting Document "CORSIA Eligible Fuels - Life Cycle Assessment Methodology" describes the methodologies used by ICAO to calculate these Default Life Cycle Emissions Values, as well as the process for requesting the inclusion of a new conversion process, feedstock, and/or region on this table.

During the CORSIA pilot phase, negative ILUC values, as shown in Tables 1 to 6, will be provisionally allowed to obtain a negative LS_f. A decision on whether to continue allowing negative LS_f values, due to reductions from negative ILUC, will be made by the end of the CORSIA pilot phase.

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

USA	Switchgrass (herbaceous energy crops)		10.4	-3.8	6.6
Global	Switchgrass (herbaceous energy crops)		10.4	5.3	15.7

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	0.0	22.5
Global	Used cooking oil		13.9		13.9
Global	Palm fatty acid distillate		20.7		20.7
Global	Corn oil	Oil from dry mill ethanol plant	17.2		17.2
USA	Soybean oil		40.4	24.5	64.9
Brazil	Soybean oil		40.4	27.0	67.4
Global	Soybean oil		40.4	25.8	66.2
EU	Rapeseed oil		47.4	24.1	71.5
Global	Rapeseed oil		47.4	26.0	73.4
Malaysia & Indonesia	Palm oil	At the oil extraction step, at least 85% of the biogas released from the Palm Oil Mill Effluent (POME) treated in anaerobic ponds is captured and oxidized.	37.4	39.1	76.5
Malaysia & Indonesia	Palm oil	At the oil extraction step, less than 85% of the biogas released from the Palm Oil Mill Effluent (POME) treated in anaerobic ponds is captured and oxidized.	60.0	39.1	99.1
Brazil	Brassica carinata oil	Feedstock is grown as a secondary crop that avoids other crops displacement	34.4	-20.4	14.0
USA	Brassica carinata oil	Feedstock is grown as a secondary crop that avoids other crops displacement	34.4	-21.4	13.0
Global	Brassica carinata oil	Feedstock is grown as a secondary crop that avoids other crops displacement	34.4	-12.7	21.7
Global	Camelina oil	Feedstock is grown as a secondary crop that avoids other crops displacement	42.0	-13.4	28.6
India	Jatropha oil	Meal used as fertilizer or electricity input	46.9	-24.8	22.1
India	Jatropha oil	Meal used as animal feed after detoxification	46.8	-48.1	-1.3

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

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

Table 4. CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels produced with the Alcohol (ethanol) to jet (ETJ) Fuel Conversion Process

Region	Fuel Feedstock	Pathway Specifications	Core LCA Value	ILUC LCA Value	LS_f (gCO_2e/MJ)
Brazil	Sugarcane	Integrated conversion design	24.1	8.7	32.8
Global	Sugarcane	Integrated conversion design	24.1	8.5	32.6
USA	Corn grain	Standalone or integrated conversion design	65.7	25.1	90.8
Global	Corn grain	Standalone or integrated conversion design	65.7	34.9	100.6
Global	Agricultural residues	Standalone conversion design Residue removal does not necessitate additional nutrient replacement on the primary crop.	39.7	0	39.7
Global	Agricultural residues	Integrated conversion design Residue removal does not necessitate additional nutrient replacement on the primary crop.	24.6	0	24.6
Global	Forestry residues	Standalone conversion design	40.0	0	40.0
Global	Forestry residues	Integrated conversion design	24.9	0	24.9
USA	Miscanthus (herbaceous energy crops)	Standalone conversion design	43.3	-42.6	0.7
EU	Miscanthus (herbaceous energy crops)	Standalone conversion design	43.3	-23.3	20.0
Global	Miscanthus (herbaceous energy crops)	Standalone conversion design	43.3	-19.0	24.3
USA	Miscanthus (herbaceous energy crops)	Integrated conversion design	28.3	-42.6	-14.3
EU	Miscanthus (herbaceous energy crops)	Integrated conversion design	28.3	-23.3	5.0
Global	Miscanthus (herbaceous energy crops)	Integrated conversion design	28.3	-19.0	9.3
USA	Switchgrass (herbaceous energy crops)	Standalone conversion design	43.9	-10.7	33.2
Global	Switchgrass (herbaceous energy crops)	Standalone conversion design	43.9	4.8	48.7
USA	Switchgrass (herbaceous energy crops)	Integrated conversion design	28.9	-10.7	18.2
Global	Switchgrass (herbaceous energy crops)	Integrated conversion design	28.9	4.8	33.7
Global	Waste gases	Ethanol produced via microbiologic conversion route Standalone conversion design	42.4	0	42.4
Global	Waste gases	Ethanol produced via microbiologic conversion route Integrated conversion design	29.4	0	29.4

Table 5. CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels produced with the Synthesized iso-paraffins (SIP) Fuel Conversion Process

Region	Fuel Feedstock	Pathway Specifications	Core LCA Value	ILUC LCA Value	LS_f (gCO_2e/MJ)
Brazil	Sugarcane		32.8	11.3	44.1
Global	Sugarcane		32.8	11.1	43.9
EU	Sugar beet		32.4	20.2	52.6
Global	Sugar beet		32.4	11.2	43.6

Table 6. CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels produced with the Hydroprocessed Esters and Fatty Acids (HEFA) Fuel Conversion Process co-processed at petroleum refineries*

Region	Fuel Feedstock	Pathway Specifications	Core LCA Value	ILUC LCA Value	LSf_{bio} (gCO_2e/MJ)
Global	Tallow	Maximum of 5% of tallow in volume Feedstock inserted at either the hydrotreater (HDT) or hydrocracker (HYK) points	27.2	0	27.2
Global	Used cooking oil	Maximum of 5% of used cooking oil in volume Feedstock inserted at either the hydrotreater (HDT) or hydrocracker (HYK) points	16.7	0	16.7
USA	Soybean oil	Maximum of 5% of soybean oil in volume Feedstock inserted at either the hydrotreater (HDT) or hydrocracker (HYK) points	40.7	24.5	65.2
Brazil	Soybean oil	Maximum of 5% of soybean oil in volume Feedstock inserted at either the hydrotreater (HDT) or hydrocracker (HYK) points	40.7	27.0	67.7
Global	Soybean oil	Maximum of 5% of soybean oil in volume Feedstock inserted at either the hydrotreater (HDT) or hydrocracker (HYK) points	40.7	25.8	66.5

*The $LS_{f\,bio}$ values in Table 6 refer only to the biogenic fraction of the fuel. The LSf of a finished co-processed fuel needs to be calculated as the sum of the LSf of the two components, weighted by their energy contributions, as provided in Equation 1 below:

$$LSf_{CoPro} = \frac{89 * \%Mass_{fossil} * LHV_{fossil} + LSfbio * \%Mass_{bio} * LHV_{bio}}{\%Mass_{fossil} * LHV_{fossil} + \%Mass_{bio} * LHV_{bio}} \text{ (eq.1)}$$

Where:

$\%Mass_{fossil}$ *percentage of the final co-processed fuel derived from petroleum, in mass*

$\%Mass_{bio}$ *percentage of the final co-processed fuel derived from SAF feedstocks, in mass*

LHV_{fossil} *lower heating value of the fossil* fraction of the fuel.

LHV_{fossil} *lower heating value of the biogenic* fraction of the fuel.

LSf_{bio} *lifecycle emission value of the* biogenic fraction of the fuel

Due to the difficulties and the approximations related to the definition of the LHV and %mass for each group of molecules constituting the fuel components, Equation 2 below can be used as a practical solution for operators and the SCS for calculating LSf of the finished jet fuel from co-processing facilities. This equation allows the calculation of LSf with the information coming from the process simulation (%vol.) and/or from measurements (for instance with 14C techniques).

$$LSf_{CoPro} = 89 * \%vol_{fossil} + LSf_{o} * \%vol_{bio} \text{(eq.2)}$$

Where:

$\%vol_{fossil}$ *percentage of the final co-processed fuel derived from petroleum, in volume*

$\%vol_{bio}$ *percentage of the final co-processed fuel derived from SAF feedstocks, in volume*

LSf_{bio} *lifecycle emission value of the* biogenic fraction of the fuel.

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