U.S. Aviation Climate Action Plan, Sustainable Aviation Fuels, and CORSIA

EPA Workshop on Biofuel Greenhouse Gas Modeling

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Aviation Climate Action Plan

• International Civil Aviation Organization (ICAO) – “State Action Plans”
  – In 2012, ICAO encouraged all countries to prepare and submit action plans detailing national action to reduce greenhouse gas emissions from aviation.
  – Well over 100 countries have submitted plans.
  – U.S. submitted plan to ICAO in 2012 with a subsequent update in 2015

• Sec of Transportation announced the 2021 Plan at the COP meeting


U.S. Aviation Climate Goal

To be effective, a goal should be clear, achievable, and ambitious with specific actions that can be taken to achieve it. The goal outlined below contributes to the broader objective to achieve net-zero GHG emissions economy-wide by 2050.

U.S. Aviation Climate Goal:
Net-Zero GHG Emissions* from U.S. Aviation Sector** by 2050

* Aviation GHG emissions include life cycle carbon dioxide (CO2), nitrous oxide (N2O), and methane (CH4) emissions. Aircraft engines produce negligible amounts of nitrous oxides and methane, so this plan has a focus on aviation combustion CO2 emissions and well-to-tank life cycle GHG emissions (CO2, N2O, and CH4). The U.S. Aviation 2050 Goal is based on emissions that are measurable and currently monitored. Research is ongoing into the climate impacts of aviation-induced cloudiness and the indirect climate impacts of aviation combustion emissions (see section 7 for details on the climate impacts of aviation non-CO2 combustion emissions).

** This U.S. aviation goal encompasses CO2 emissions from (1) domestic aviation (i.e., flights departing and arriving within the United States and its territories) from U.S. and foreign operators, (2) international aviation (i.e., flights between two different ICAO Member States) from U.S. operators, and (3) airports located in the United States.
Analysis of U.S. Aviation CO₂ Emissions in 2019

U.S. Domestic & International* Aviation CO₂ Emissions

- Airport Scope 1 Emissions (from airport-owned or controlled sources) - 0.6 MT CO₂
- Airport Scope 2 Emissions (due to use of purchased energy) - 3.1 MT CO₂
- Domestic and International Jet Fuel Emissions (commercial flights) - 200 MT CO₂
- Domestic and International Jet Fuel Emissions (GA flights) - 16 MT CO₂
- Domestic and International Aviation Gasoline Emissions - 2 MT CO₂

Total: 222 MT CO₂

Detailed Analysis of Commercial Aviation Jet Fuel CO₂ Emissions

- Domestic Jet Fuel Emissions (flights within U.S.):
  - Taxi: 14
  - Descent and landing (below 10k ft): 9.8
  - Takeoff and climb (below 10k ft): 4.4
  - En-route (above 10k ft): 6

- International Jet Fuel Emissions (flights to / from U.S.):
  - Taxi: 112
  - Descent and landing (below 10k ft): 94%
  - Takeoff and climb (below 10k ft): 143

* CO₂ emissions from (1) domestic aviation (i.e., flights departing and arriving within the United States and its territories) from U.S. and foreign operators and (2) international aviation (i.e., flights between two different ICAO Member States) from U.S. operators (only). Airport scopes 1 and 2 added for this specific analysis (figure).

** International aviation to / from the United States, regardless of the operator of the flights i.e., including both U.S. and foreign operators.
Jet Fuel

• Jet fuel is a critical component of the safe, reliable, and efficient global air transportation system
• Jet fuel provides a unique combination of properties that enable aircraft to safely carry hundreds of passengers and tons of freight for thousands of miles at high speed
  – Remains a liquid at very low temperatures of flight
  – Does not vaporize at low atmospheric pressures experienced in the upper atmosphere during cruise flight
  – Tolerates relatively high engine temperatures without breaking down and clogging fuel lines
  – Provides considerable energy both in terms of energy per unit mass and per unit volume
• While these properties play a key role in enabling today’s aviation system, they also make it a difficult sector to decarbonize because they are hard to replace
Sustainable Aviation Fuels (SAF)

- SAF are “drop-in” liquid aviation fuels – same infrastructure, engines & aircraft, but derived from renewable or waste materials.
- Since they are drop-in compatible with the existing fleet, SAF are hydrocarbon fuels and emit CO₂ when combusted.
- Extent to which any particular SAF provides a climate benefit depends on the life cycle GHG emissions.
- Some types of SAF reduce emissions that impact air quality and contribute to formation of contrails, which impacts climate change.

- Viable technologies exist – seven alternative fuel pathways currently approved for use, and two approved for co-processing with petroleum, more under evaluation for approval
- Considerable industry support
- Critical to international efforts to address aviation emissions
Longer Term Analysis of Aviation CO₂ Emissions

Legend:
- Historical Data (FAA AEDT / Aerospace Forecast)
- Frozen 2019 Technology Trajectory
- Airline Fleet Renewal
- New Aircraft Diffusion Trajectory
- New Aircraft Technologies
- Operations Improvement
- SAF Uptake: 50% Emission Reduction
- SAF Uptake: 100% Emission Reduction

* Note: Domestic aviation from U.S. and Foreign Carriers. International aviation from U.S. Carriers.

NOTE: Analysis conducted by BlueSky leveraging R&D efforts from the FAA Office of Environment & Energy (AEE) regarding CO₂ emissions contributions from aircraft technology, operational improvements, and SAF
Full Report Contents

• Introduction
• Climate Goals and Approach
• Aircraft and Engine Technology Development
• Operational Improvements
• Sustainable Aviation Fuels
• International Leadership and Initiatives
• Airport Initiatives
• FAA Leadership on Climate, Sustainability and Resilience
• Non-CO₂ Impacts of Aviation on Climate
• Policy and Measures to Close the Gap
Sustainable Aviation Fuels and CORSIA

International Civil Aviation Organization (ICAO) established CORSIA to help international aviation meet Carbon Neutral Growth goal (relative to a 2019/2020 baseline)

Two means for an aeroplane operator to comply with CORSIA

1. Offsetting with Emissions Units
2. Emissions Reductions from CORSIA Eligible Fuels

Two means of determining life cycle emissions credit

- Default life cycle values provided by ICAO
- Actual life cycle values, certified by a third party, that are computed using a process provided by ICAO

To be eligible for CORSIA, a fuel needs to meet the CORSIA Sustainability Criteria as certified by ICAO Council Approved Sustainability Certification Scheme (SCS)

For additional information on CORSIA: https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx/
CORSIA Eligible Fuels – Key Documents

There are a number of ICAO documents that contain information related to CORSIA Implementation:

Annex 16 Volume IV
See: https://www.icao.int/environmental-protection/CORSIA/Pages/SARPs-Annex-16-Volume-IV.aspx

CORSIA Implementation Elements
See: https://www.icao.int/environmental-protection/CORSIA/Pages/implementation-elements.aspx

Five ICAO documents relate to CORSIA Eligible Fuels
See: https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-Eligible-Fuels.aspx

For additional information on CORSIA Eligible Fuels:
https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-Eligible-Fuels.aspx
Sustainability Certification Schemes

- CORSIA Eligible Fuel need to come from a fuel producer that is certified by an ICAO Council approved Sustainability Certification Scheme (SCS)
- SCSs need to meet requirements of ICAO document entitled "CORSIA Eligibility Framework and Requirements for Sustainability Certification Schemes”
- Two SCSs approved for CORSIA:
  - International Sustainability and Carbon Certification (ISCC)
  - Roundtable on Sustainable Biomaterials (RSB)
- Applications by SCSs being reviewed on an ongoing basis by the SCS Evaluation Group (SCSEG).
- SCSs interested in being considered should complete an application (link below).

*To download document: https://www.icao.int/environmental-protection/CORSIA/Documents/ICAO%20document%20%20Approved%20SCSs.pdf*
# Sustainability Criteria

Compiled within the ICAO Document “CORSIA Sustainability Criteria for CORSIA Eligible Fuels”

## Chapter 2: CORSIA Sustainability Criteria Applicable for Batches of CORSIA Sustainable Aviation Fuel Produced by a Certified Fuel Producer on or After 1 January 2024

<table>
<thead>
<tr>
<th>Theme</th>
<th>Principle</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Greenhouse Gases (GHG)</td>
<td>Principle: CORSIA SAF should generate lower carbon emissions on a life cycle basis.</td>
<td>Criterion 1.1: CORSIA SAF will achieve net greenhouse gas emissions reductions of at least 10% compared to the baseline life cycle emissions values for aviation fuel on a life cycle basis.</td>
</tr>
<tr>
<td>2. Carbon stock</td>
<td>Principle: CORSIA SAF should not be made from biomass obtained from land with high carbon stock.</td>
<td>Criterion 2.1: CORSIA SAF will not be made from biomass obtained from land converted after 1 January 2008 that was primary forests, wetlands, or peat lands and/or contributes to degradation of the carbon stock in primary forests, wetlands, or peat lands as these lands all have high carbon stocks. Criterion 2.2: In the event of land use conversion biomass obtained from land after 1 January 2008, as defined based on the Intergovernmental Panel on Climate Change (IPCC) land categories, direct land use change (DLUC) emissions will be calculated. If DLUC greenhouse gas emissions exceed the default induced land use change (ILUC) value, the DLUC value will replace the default ILUC value.</td>
</tr>
<tr>
<td>3. Water</td>
<td>Principle: Production of CORSIA SAF should maintain or enhance water quality and availability.</td>
<td>Criterion 3.1: Operational practices will be implemented to maintain or enhance water quality. Criterion 3.2: Operational practices will be implemented to use water efficiently and to avoid the depletion of surface or groundwater resources beyond replenishment capacities.</td>
</tr>
<tr>
<td>4. Soil</td>
<td>Principle: Production of CORSIA SAFs should maintain or enhance soil health.</td>
<td>Criterion 4.1: Agricultural and forestry best management practices for feedstock production or residue collection will be implemented to maintain or enhance soil health, such as physical, chemical and biological conditions.</td>
</tr>
<tr>
<td>5. Air</td>
<td>Principle: Production of CORSIA SAF should minimize negative effects on air quality.</td>
<td>Criterion 5.1: Air pollution emissions will be limited.</td>
</tr>
<tr>
<td>6. Conservation</td>
<td>Principle: CORSIA SAF will strive to improve the socioeconomic conditions of the communities affected by the operation.</td>
<td></td>
</tr>
<tr>
<td>7. Waste and Chemicals</td>
<td>Principle: CORSIA SAF should contribute to social and economic development in regions of poverty.</td>
<td></td>
</tr>
<tr>
<td>8. Human and labour rights</td>
<td>Principle: CORSIA SAF should promote food security in food insecure regions.</td>
<td></td>
</tr>
<tr>
<td>9. Land use rights and land use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Water use rights</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Local and social development</td>
<td>Principle: CORSIA SAF production will strive to, in regions of poverty, improve the socioeconomic conditions of the communities affected by the operation.</td>
<td></td>
</tr>
<tr>
<td>12. Food security</td>
<td>Principle: CORSIA SAF production will strive to, in food insecure regions, strive to enhance the local food security of directly affected stakeholders.</td>
<td></td>
</tr>
</tbody>
</table>
Life Cycle Emissions for CORSIA Eligible Fuels

Induced Land Use Change (ILUC): included for fuels not derived from wastes, residues, or by-products

Core LCA
Stage #1: Production at source (feedstock cultivation)
Stage #2: Conditioning at source (harvest, collection, recovery)
Stage #3: Feedstock processing and extraction
Stage #4: Feedstock transportation to processing and fuel production facilities
Stage #5: Feedstock-to-fuel conversion process
Stage #6: Fuel transportation and distribution to the blend point
Stage #7: Fuel combustion in aircraft engine

Life cycle values calculated by international team of experts:

Default Core LCA Values:
- DOE Argonne National Laboratory
- Massachusetts Institute of Technology
- E.U. Joint Research Centre
- University of Hasselt
- University of Toronto
- Brazilian Bioethanol Science and Technology Laboratory (CTBE)
- Universidade Estadual de Campinas

Default ILUC Values:
- Purdue University (GTAP-Bio)
- International Institute for Applied Systems Analysis (GLOBIOM)

For additional information on CORSIA Eligible Fuels:
https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-Eligible-Fuels.aspx
Two Methods for Determining Life Cycle Emissions for CORSIA Eligible Fuels

Two methods to determine life cycle emissions value for CORSIA Eligible Fuels
1. CORSIA default life cycle emissions values
2. CORSIA methodology for calculating actual life cycle emissions values

Default LCA values
- Values developed by international team, approved by ICAO Council, and provided in ICAO Document, “CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels”

Actual LCA values using CORSIA Methodology
- Details within ICAO Document, “CORSIA Methodology for Calculating Actual Life Cycle Emissions Values”
- Airline operator / fuel producer can work with an eligible Sustainability Certification Scheme (SCS) to seek a core LCA value representative of their specific fuel production pathway
- SCS will need to prepare a technical report justifying actual LCA value
- Methodology uses attributional process with energy allocation of emissions among co-products to determine core LCA value
- Methodology provides a means to get an ILUC value of zero or negative ILUC values
- Methodology provides credits for MSW Landfill and Recycling Emissions
- Have rules wherein additional credits could be considered in the future for waste and residue feedstocks

For additional information on CORSIA Eligible Fuels: https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-Eligible-Fuels.aspx
CORSIA Default Life Cycle Emissions Values

Compiled within the ICAO Document “CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels”


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

<table>
<thead>
<tr>
<th>Region</th>
<th>Fuel Feedstock</th>
<th>Pathway Specifications</th>
<th>Core LCA Value</th>
<th>ILUC LCA Value</th>
<th>LS____(\text{gCO}_2\text{e}/\text{MJ})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>Tallow</td>
<td></td>
<td>22.5</td>
<td>0.0</td>
<td>22.5</td>
</tr>
<tr>
<td>Global</td>
<td>Used cooking oil</td>
<td></td>
<td>13.9</td>
<td>0.0</td>
<td>13.9</td>
</tr>
<tr>
<td>Global</td>
<td>Palm fatty acid distillate</td>
<td></td>
<td>20.7</td>
<td>0.0</td>
<td>20.7</td>
</tr>
<tr>
<td>Global</td>
<td>Corn oil</td>
<td>Oil from dry mill ethanol plant</td>
<td>17.2</td>
<td>17.2</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>Soybean oil</td>
<td></td>
<td>40.4</td>
<td>24.5</td>
<td>64.9</td>
</tr>
<tr>
<td>Brazil</td>
<td>Soybean oil</td>
<td></td>
<td>40.4</td>
<td>27.0</td>
<td>67.4</td>
</tr>
<tr>
<td>EU</td>
<td>Rapeseed oil</td>
<td></td>
<td>47.4</td>
<td>24.1</td>
<td>71.5</td>
</tr>
<tr>
<td>Malaysia &amp; Indonesia</td>
<td>Palm oil</td>
<td>At the oil extraction step, at least 85% of the biogas released from the POME treated in anaerobic ponds is captured and oxidized</td>
<td>37.4</td>
<td>39.1</td>
<td>76.5</td>
</tr>
<tr>
<td>Malaysia &amp; Indonesia</td>
<td>Palm oil</td>
<td>At the oil extraction step, less than 85% of the biogas released from the POME treated in anaerobic ponds is captured and oxidized</td>
<td>60.0</td>
<td>39.1</td>
<td>99.1</td>
</tr>
<tr>
<td>Brazil</td>
<td>Brassica carinata</td>
<td>Feedstock is grown as a secondary crop that avoids other crops displacement</td>
<td>34.4</td>
<td>-20.4</td>
<td>14.0</td>
</tr>
<tr>
<td>USA</td>
<td>Brassica carinata</td>
<td>Feedstock is grown as a secondary crop that avoids other crops displacement</td>
<td>34.4</td>
<td>-21.4</td>
<td>13.0</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Region</th>
<th>Fuel Feedstock</th>
<th>Pathway Specifications</th>
<th>Core LCA Value</th>
<th>ILUC LCA Value</th>
<th>LS___(\text{gCO}_2\text{e}/\text{MJ})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>Agricultural residues</td>
<td>Residue removal does not necessitate additional nutrient replacement on the primary crop</td>
<td>29.3</td>
<td>0.0</td>
<td>29.3</td>
</tr>
<tr>
<td>Global</td>
<td>Forestry residues</td>
<td></td>
<td>23.8</td>
<td>23.8</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>Sugarcane</td>
<td>Standalone or integrated conversion design</td>
<td>24.0</td>
<td>7.3</td>
<td>31.3</td>
</tr>
<tr>
<td>USA</td>
<td>Corn grain</td>
<td>Standalone or integrated conversion design</td>
<td>55.8</td>
<td>22.1</td>
<td>77.9</td>
</tr>
<tr>
<td>USA</td>
<td>Miscanthus (herbaceous energy crops)</td>
<td></td>
<td>43.4</td>
<td>-54.1</td>
<td>-10.7</td>
</tr>
<tr>
<td>EU</td>
<td>Miscanthus (herbaceous energy crops)</td>
<td></td>
<td>43.4</td>
<td>-31.0</td>
<td>12.4</td>
</tr>
<tr>
<td>USA</td>
<td>Switchgrass (herbaceous energy crops)</td>
<td></td>
<td>43.4</td>
<td>-14.5</td>
<td>28.9</td>
</tr>
</tbody>
</table>
CORSIA Supporting Document “CORSIA Eligible Fuels - LCA Methodology”

• Provides technical information and describes ICAO processes to manage and maintain the ICAO document “CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels”

To download the CEF LCA Methodology document, please visit: https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA%20Supporting%20Document_CORSIA%20Eligible%20Fuels_LCA%20Methodology.pdf
Adding New Default Life Cycle Values

*CORSIA SARP Package contains default life cycle emissions values for a number of fuel pathways.*

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**Adding default life cycle values for a new fuel pathway (Part I of CEF LCA Doc)**

- Following criteria need to be met for a pathway to be evaluated as a CORSIA Eligible Fuel:
  - 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.
  - The conversion process has been validated at sufficient scale to establish a basis for facility design and operating parameters at commercial scale.
  - There are sufficient data on the conversion process of interest to perform LCA modelling.
  - There are sufficient data on the feedstock of interest to perform LCA modelling.
  - There are sufficient data on the region of interest to perform ILUC modelling, where applicable to the pathway.

- CAEP designees will determine if criteria have been met for adding a new pathway, carry out the calculation of default LCA values for the pathway, and communicate the results in this document.

- 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.

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To download the CEF LCA Methodology document, please visit: [https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA%20Supporting%20Document_CORSIA%20Eligible%20Fuels_LCA%20Methodology.pdf](https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA%20Supporting%20Document_CORSIA%20Eligible%20Fuels_LCA%20Methodology.pdf)
Closing Observations

• We are taking a holistic approach to address aviation’s impact on climate change

• SAF are central to this approach - critical to reducing CO₂ emissions from aviation in near, mid, and long term

• U.S. Government committed to SAF production through the SAF Grand Challenge and are working with industry to scale up production with a near term goal of 3 billion gallons per year by 2030

• Developed CORSIA as a rigorous means to do life cycle accounting

First flight from continuous commercial production of SAF UAL 0708, 10 March 2016, LAX-SFO

Fuel from World Energy - Paramount (HEFA-SPK 30/70 Blend).
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