

MEO & University of Illinois Chicago partnership study, US-Japan-ISCC Platform, and iLUC Updates

**Presented at: ISCC PLUS & SAF Conference
– Sustainability Certification in Japan**

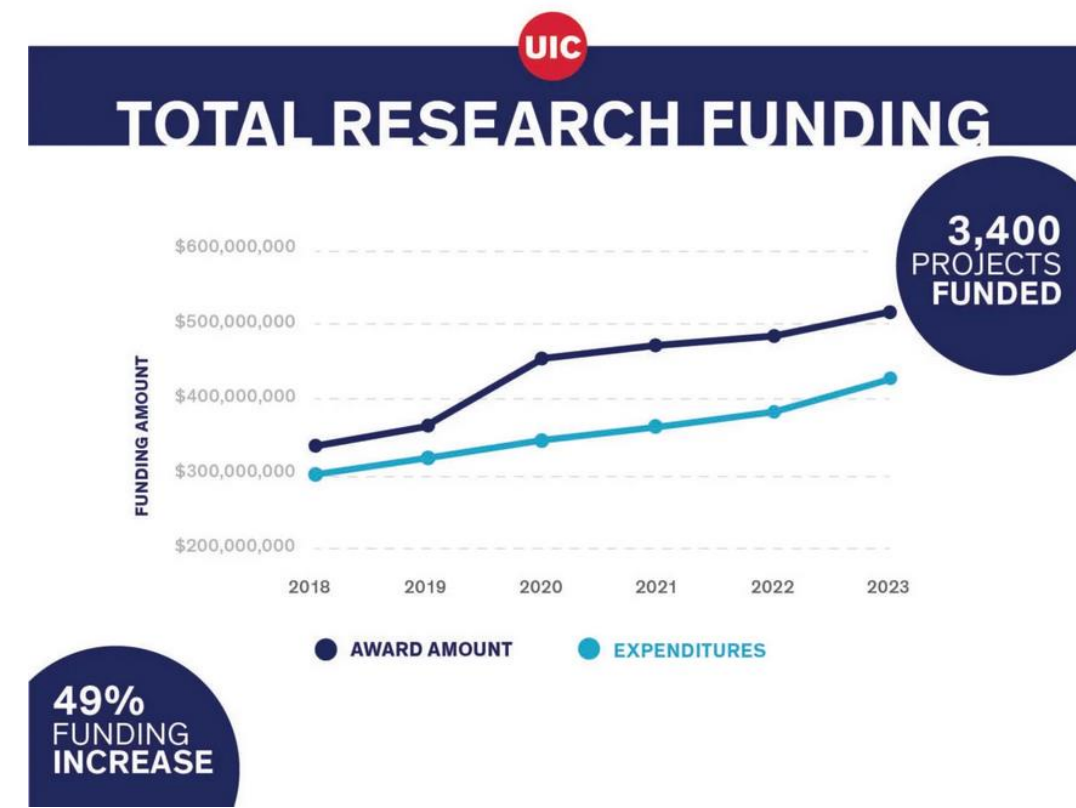
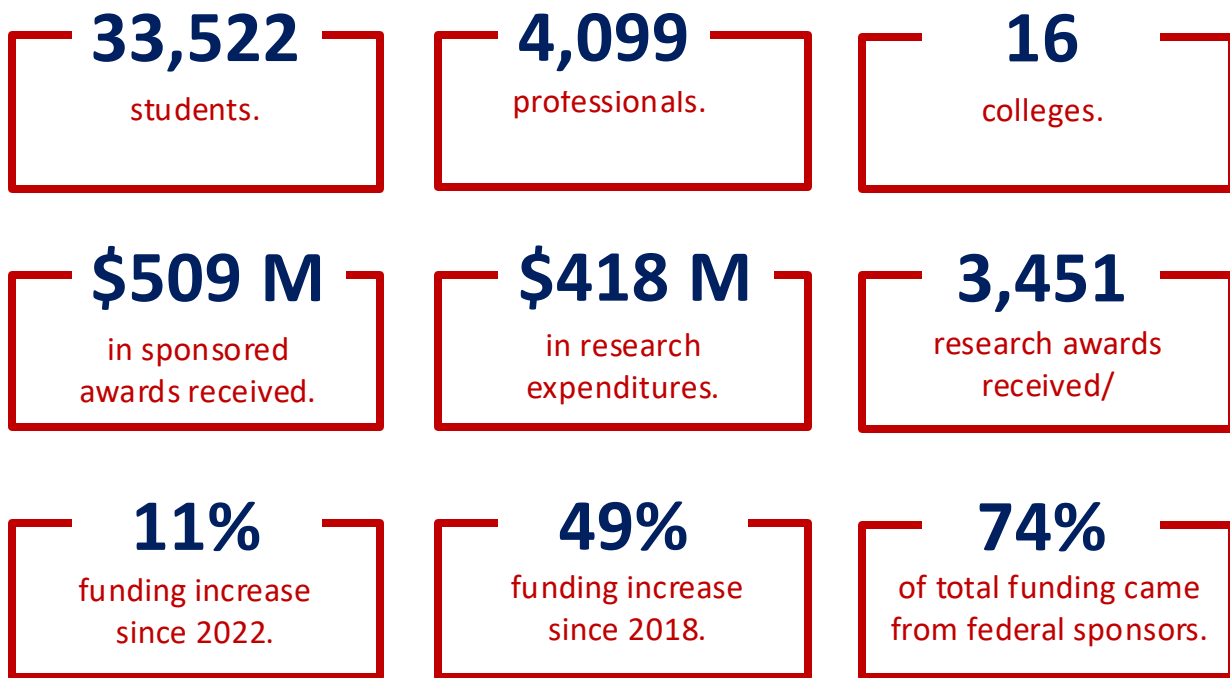
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Tokyo, Japan**



**ENERGY RESOURCES
CENTER**

About the University of Illinois Chicago (UIC)



Note: From fiscal year 2023.

“Surpassing the half-billion-dollar milestone in research funding is a clear marker of the exceptional research program at the University of Illinois Chicago and the vitality of our mission to create knowledge that transforms the world. The funding also reflects our commitment to creating positive and enduring impact in science and society.”

Marie Lynn Miranda | Chancellor, University of Illinois Chicago

UIC's Energy Resources Center (ERC) at the College of Engineering

Established in 1973 as an energy advisor to the State of Illinois and City of Chicago

Today, the ERC is an applied research center, based out of the UIC College of Engineering, with a focus on **clean energy and environmental sustainability solutions** providing education and technical assistance services

40 team member staff (50:50 staff-to-student ratio) with advanced degrees in engineering, business, and policy and various professional certifications, including Professional Engineer, CEM, LEED, etc. ERC **regularly utilizes 10+ consultants & contractors** per year.

ERC's **annual operating budget averaged \$4.5M** over past 10 years, **~97% soft funded**.

ERC's Core Areas of Research

Bioenergy



Distributed Energy & Renewables



Energy Efficiency



Sustainable Landscapes



Policy & Utility Data Analytics



Clean Transportation



Presentation Overview

- Quick Review: Life Cycle Greenhouse Gas Modeling of Biofuels Pathways
- Corn Ethanol to Jet Opportunities under CORSIA
 - New Study on US Corn Ethanol Carbon Intensities under CORSIA
 - New Publications on Induced Land Use Change
 - SAF from US Corn Ethanol Adds to the ISCC Certified Product Platform

Quick Review: LCA of Biofuels Pathways

Greenhouse gases, Regulated Emissions, and Energy use in Technologies

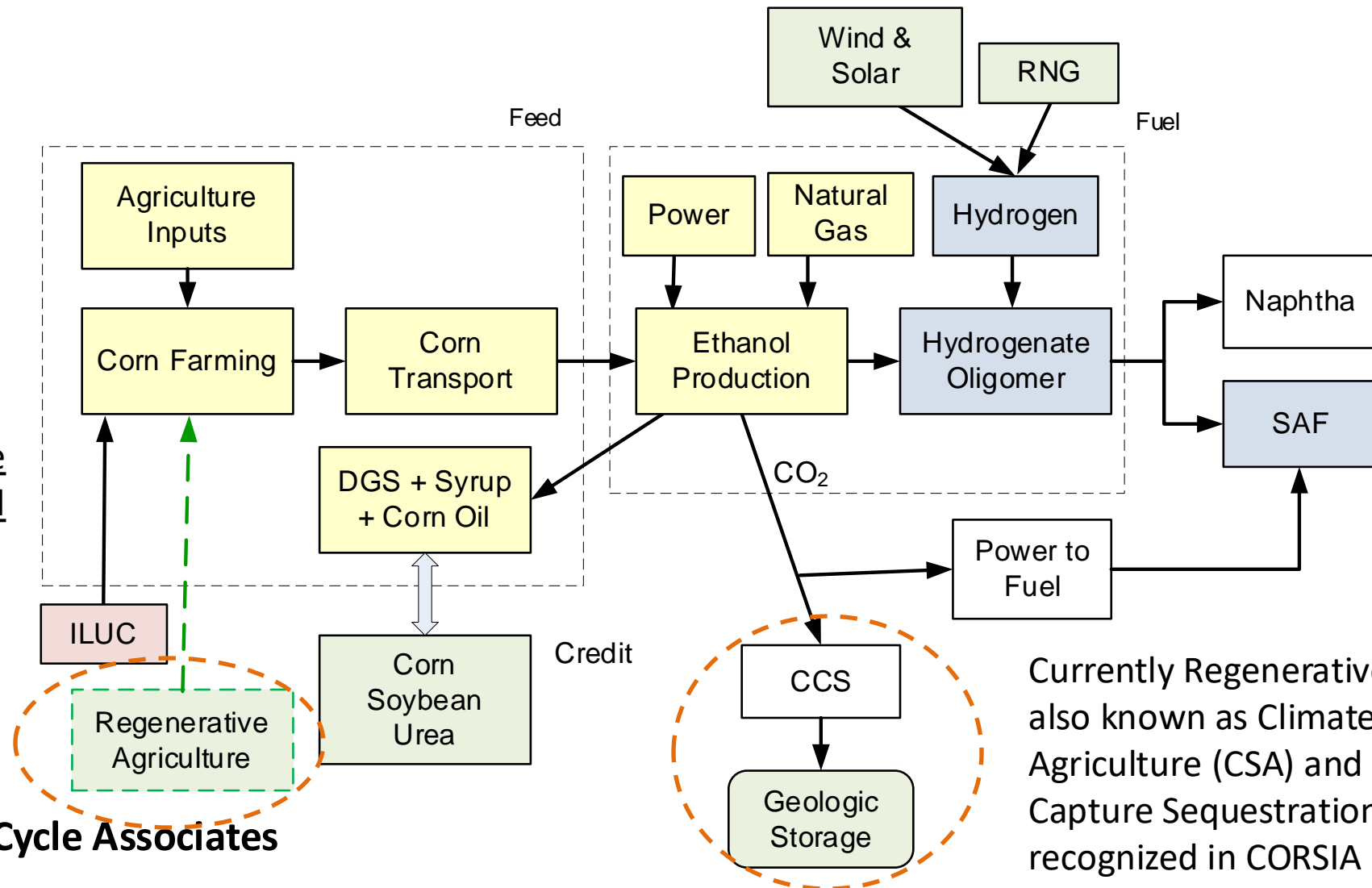
- Life cycle analysis (LCA) is a framework for assessing the environmental impacts associated with all stages of the supply chain of a technology or product
- For transportation, a main LCA metric is the Carbon Intensity (CI) or “gCO₂e emitted per megajoule” of the produced fuel (e.g. ethanol, ETBE, blended fuels such as E10, E15, SAF)
- Important LCA model in the United States and increasingly globally: The U.S. Department of Energy’s Argonne National Laboratory GREET® (Greenhouse gases, Regulated Emissions, and Energy use in Technologies) life cycle analysis (LCA) model
- Emissions along the fuel’s production pathway are added up including:
 - Main product emissions with credits for co-products
 - Emissions from direct and indirect effects
- Ethanol to jet pathway = emissions from ethanol production + emissions from conversion of ethanol into jet fuel + emissions from induced land use change (iLUC)

LCA Modeling: Corn to Ethanol and Ethanol to SAF

Emissions along the fuel's production pathway are added up including:

- Main product and co-product
- Direct and indirect effects

iLUC or induced land use change is highly debated indirect effect. Accounts for emissions associated with land use responses from a biofuels policy



Currently Regenerative Agriculture also known as Climate Smart Agriculture (CSA) and Carbon Capture Sequestration (CCS) are not recognized in CORSIA

Main Drivers of Differences in Biofuel Carbon Score

- Carbon score unit is grams CO₂ emitted per megajoule of fuel (gCO₂/MJ)
 - Petroleum based aviation fuels have carbon score between 84-89 gCO₂/MJ
 - Ethanol-to-Jet or Soy-to-Jet can be much lower depending on production method
- Key Drivers of Carbon Score for Biofuels/SAF
 - How the crop feedstock is grown. Opportunities to reduce carbon score via Climate Smart Agriculture (CSA)
 - E.g. Cover crops, optimized nitrogen use, conservation tillage, N-inhibitors
 - How Corn is Converted into Ethanol:
 - Carbon Capture Sequestration & Utilization (CCSU) of fermentation CO₂ at the ethanol plant
 - Drying of animal feed co-product (dried distillers grains - DDG) or not drying (wet distiller grains – WDG)
 - Updates to induced land use change (iLUC) modeling
 - Updated GTAP/Purdue University iLUC model

Example CI Values

Note: For Illustration Only; Do not Cite or Reference

Pathway	gCO2e/MJ	Notes
Petroleum Based Gasoline and Jet Fuel	88-110	Depending on Crude Oil Source & Refinery Type
US Produced Corn Ethanol Feedstock	~ 15-65	Depending on Ethanol Plant, CCSU, Corn Agriculture etc.
Upgrade of Ethanol into Jet	add ~ 10-30	Depending on Technology
Induced Land Use Change for ETJ	11-25	Depending on Model and Amortization Period

Corn Ethanol to Jet Opportunities under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

Current US Corn Ethanol to Jet under CORSIA

Core LCA (ethanol + Upgrade to SAF)	+	Induced Land Use Change	=	Life Cycle Emissions Factor LSF
65.7 gCO ₂ e/MJ	+	25.1 gCO ₂ e/MJ	=	90.8 gCO ₂ e/MJ

For US Corn Ethanol to Jet Pathway:

- Conversion Efficiencies (Core LCA) are Dramatically Improving
- Updates to high iLUC value are in progress

ICAO document

**CORSIA Default Life Cycle Emissions Values for
CORSIA Eligible Fuels**

Joint Study: MEO Carbon/UIC funded by US Grains Council

Summary of U.S. Corn Ethanol Carbon Intensity Assessment for CARB and CORSIA Compliance

THE FOLLOWING SUMMARY OF MEO CARBON SOLUTIONS' "ASSESSMENT OF WEIGHTED CARBON INTENSITY (CI) FOR CALIFORNIA AIR RESOURCES BOARD (CARB) – CERTIFIED U.S. CORN ETHANOL PRODUCERS" HAS BEEN PREPARED BY THE U.S. GRAINS COUNCIL.



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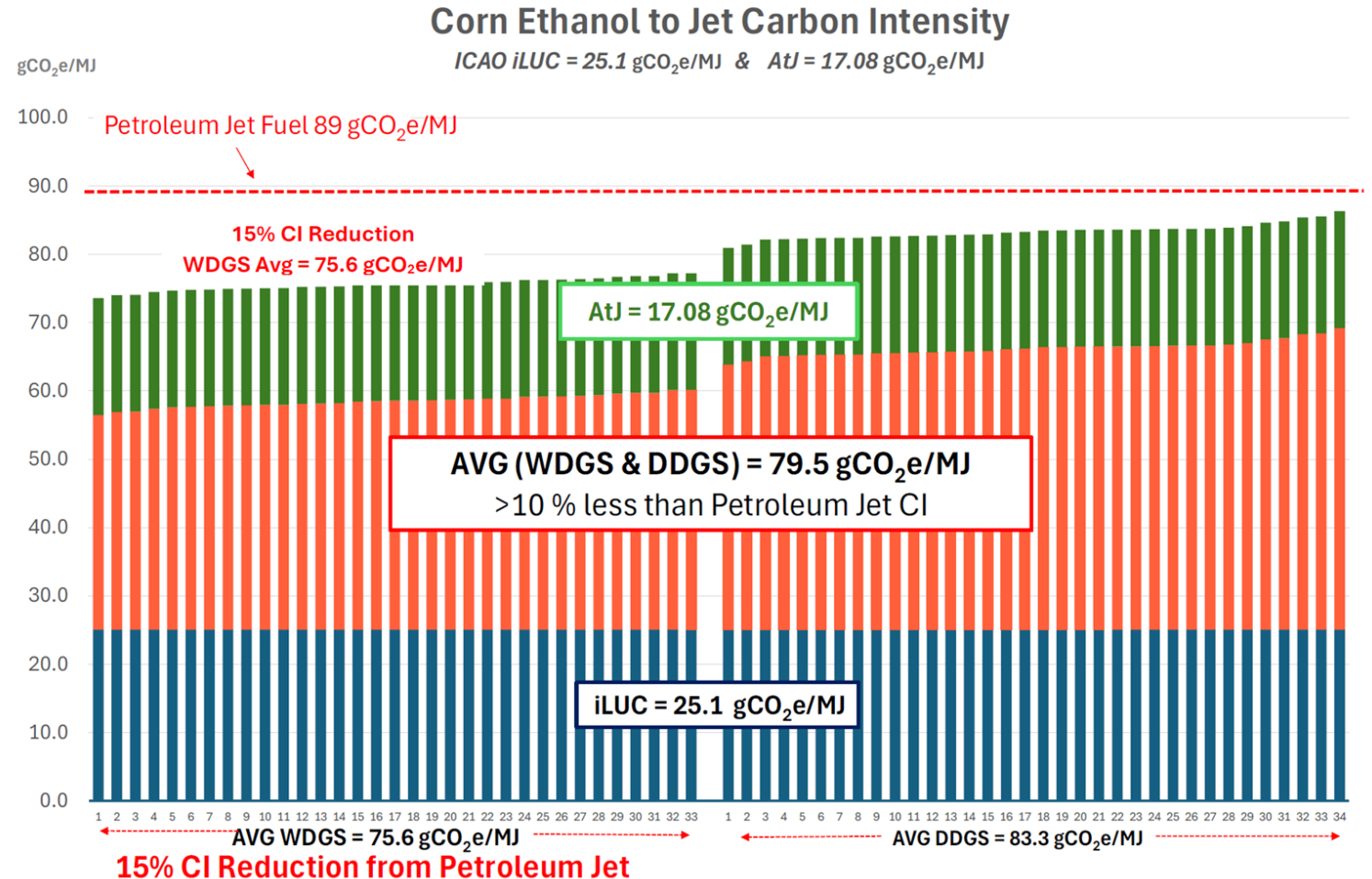
Recent US Corn Ethanol CI Study

- An independent study conducted by MEO Carbon Solutions (affiliated with ISCC) and the University of Illinois at Chicago
- Study Question: Can corn ethanol provide High Volumes of SAF that the World Aviation Sector needs.
- **Study Objective:** Using certified volumes of US ethanol shipments as feedstock, determine if SAF produced by the Alcohol to Jet pathway would achieve a sufficient CI reduction, as compared to petroleum Jet Fuel, to qualify for CORSIA offsets
 - Study utilizes public CI data from plants with existing ethanol shipments into the California Low Carbon Fuels Standard market
 - New Study uses up-to-date data on US Ethanol CI and up to date data on conversion technologies for ethanol to jet production
- Study represents up to 4 billion gallons of US ethanol capacity

Key Results

- The analyzed ethanol biorefinery plants will on average meet the 10% CORSIA GHG reduction requirement.
- Note: this includes CORSIA iLUC of 25.1 gCO₂/MJ and US default corn agriculture contributions.
- Individual pathway certification will likely also show reduced agricultural feedstock CI relative to assumed US average.

Attachment C2a



Study Implications

- U.S. corn ethanol is increasingly well-positioned to meet the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) standards for Sustainable Aviation Fuel (SAF).
- Establishing certified CI values for both ethanol production and Ethanol-to-Jet (EtJ) conversion pathways is critical in achieving compliance and opening global SAF market access.
- With ongoing CI improvements and alignment to certified pathways, U.S. ethanol producers are well-positioned to play a substantial role in reducing aviation emissions and achieving long-term CORSIA compliance.

New Publications on Induced Land Use Change

iLUC Science is Evolving



Article

Biofuels Induced Land Use Change Emissions: The Role of Implemented Land Use Emission Factors

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Table 3. Estimated ILUC emissions values for various SAF pathways using different emissions accounting models for 25- and 30-year amortization time periods (gCO₂e/MJ).

Pathways	Amortization Time Horizon			
	25 Years		30 Years	
	AEZ-EF	CCLUB	AEZ-EF	CCLUB
Soy oil HEFA	20.0	15.0	16.6	12.5
Corn ATJ	22.5	14.4	18.7	12.0
Corn ETJ	24.9	15.6	20.8	13.0
Miscanthus FTJ	-37.3	-12.8	-31.1	-10.7
Switchgrass FTJ	-8.2	1.0	-6.8	0.9
Poplar FTJ	-9.6	7.0	-8.0	5.9
Miscanthus ATJ iBuOH	-58.5	-26.1	-48.7	-21.8
Switchgrass ATJ iBuOH	-18.9	-14.1	-15.7	-11.8
Grain ATJ	22.5	14.4	18.7	12.0
Grain ETJ	24.9	15.6	20.8	13.0

Corn Ethanol to Jet iLUC under US Inflation Reduction Act



Development of R&D GREET 2023 Rev1 to Estimate
Greenhouse Gas Emissions of Sustainable Aviation
Fuels for 40B Provision of the Inflation Reduction Act

Table 6. Adjusted indirect effects of the four SAF pathways (in g CO₂e/MJ of liquid fuels)

	Pathway			
	Corn ATJ-E	Soy HEFA	Canola HEFA	Sugarcane ATJ-E
ILUC	9.0	12.2	18.1	10.6
Non-Feedstock Crops	3.8	3.5	5.9	-3.0
Livestock	-1.4	1.4	0.1	-1.6
Rice Methane	-0.3	-0.8	-0.3	-0.1
Total	11.1	16.2	23.7	5.9

Note: 11.1 gCO₂/MJ adjusted to the CORSIA Amortization Period would return 13.3 gCO₂/MJ

Latest US Corn Ethanol to Jet iLUC publications show Reduction of
~10gCO₂e/MJ in iLUC over CORSIA iLLUC Value

Note: Same amortization period



SAF from US Corn Ethanol Adds to the ISCC Certified Product Platform

SAF from US Corn Ethanol Adds to the ISCC Certified Product Platform

In flexible, certified platform corn-based ETBE, Ethanol, SAF, Chemicals can be important or produced in Japan

Direct Blending, not practiced but should be considered

Road Transportation under Japan Biofuels Policy



ISCC Plus for Japan

ISCC PLUS 201-1
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Corn

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Chemicals

Feed

ISCC CORSIA
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ISCC PLUS for Circular
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Chemicals

ISCC PLUS



ISCC Japan FIT

If In country processing:
via SCC Japan FIT (Feed-
in Tarif)



Summary

- Carbon Intensity of US produced corn ethanol feedstock is continuously decreasing
- Carbon Intensity of technologies that convert ethanol feedstock into SAF is continuously decreasing (e.g. since original CORSIA calculations)
- Study shows that with updated technologies many ethanol plants will meet CORSIA GHG reduction requirements
- The Science of Induced land use change (iLUC) is evolving and now shows a trend towards much lower iLUC values for SAF
- With these trends US Ethanol to Jet can be easily integrated into the ISCC certified sustainable fuels & products platform

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