February 24, 2025

Introducing Sustainable Aviation Fuels in R&D GREET®

2:00-3:00 p.m. CT

Instructors

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What Does R&D GREET Encompass?

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R&D GREET covers many groups of energy systems

Petroleum

Electric Systems

Natural Gas

Renewable Energy/Fuels

Hydrogen

Electro-fuels

And More

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R&D GREET in the petroleum sector

Conventional Oil
Shale Oil
Oil Sands

Gasoline
Diesel
Jet fuel
Liquified petroleum gas (LPG)
Naphtha
Residual oil
and more

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R&D GREET and renewable energy/fuels

Corn
Soybean
Sorghum
Rapeseeds
Sugarcane
Dedicated Energy Crops
Crop Residues
Forest Residues
Municipal Solid Waste (MSW)
Animal Wastes
Algae
and More

Ethanol
Biodiesel
Renewable diesel
Renewable gasoline
Sustainable aviation fuel
Renewable natural gas
and more

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Sustainable Aviation Fuels

"SAF is a biofuel used to power aircraft that has similar properties to conventional jet fuel but with a smaller carbon footprint"

- Sustainable Aviation Fuels | Department of Energy

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Aviation fuels

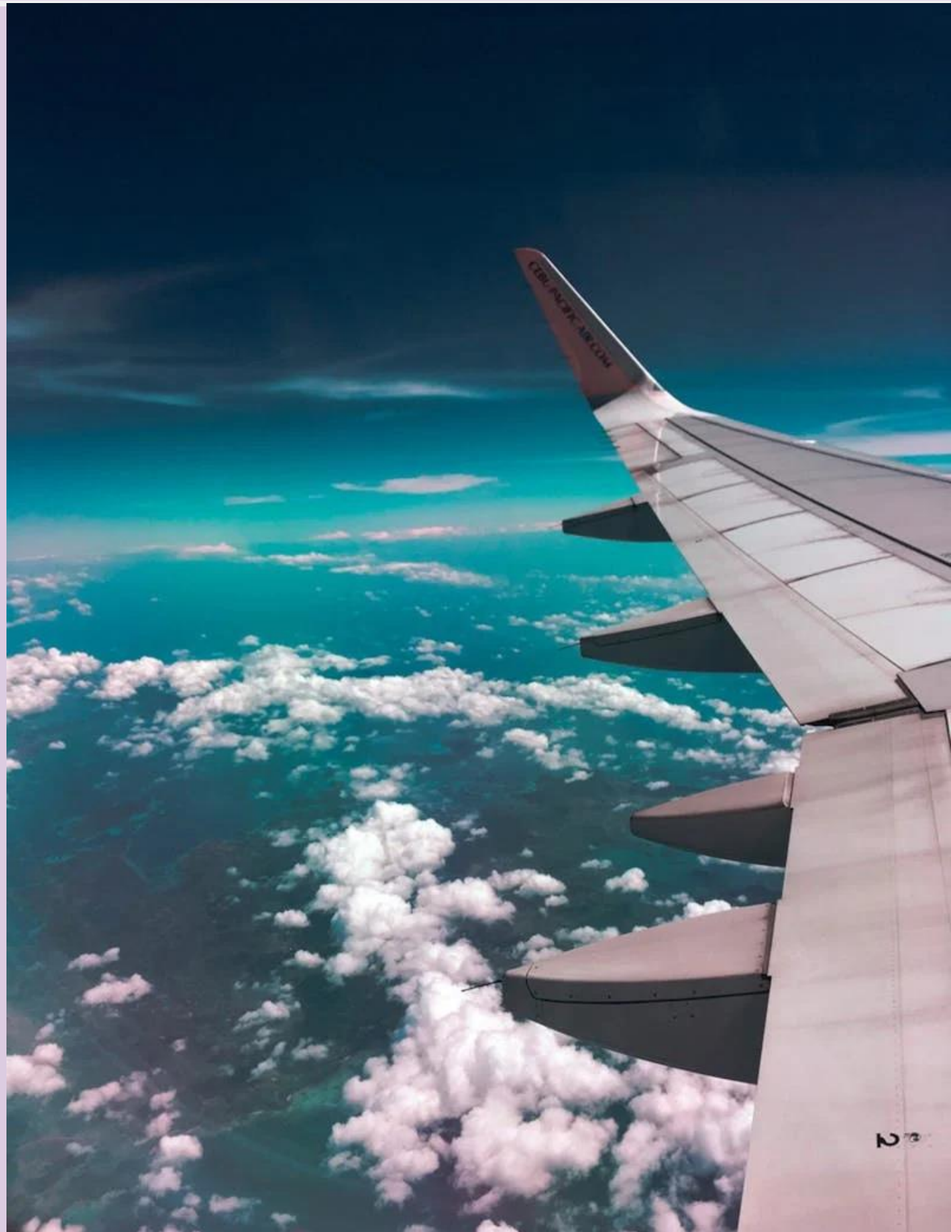
Sustainable aviation fuels (SAFs) can play an important role in reducing GHG emissions from the aviation sector

Emission reductions through SAFs can be quantified through life cycle assessments (LCAs)

LCA has been the basis for international, federal, and state-level SAF programs to boost GHG emission reductions

LCA can be used to identify emission hotspots and to further decarbonize the SAF production pathways

R&D GREET offers a standardized and publicly available data source to aid this decarbonization



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LCA of Aviation Fuel in R&D GREET

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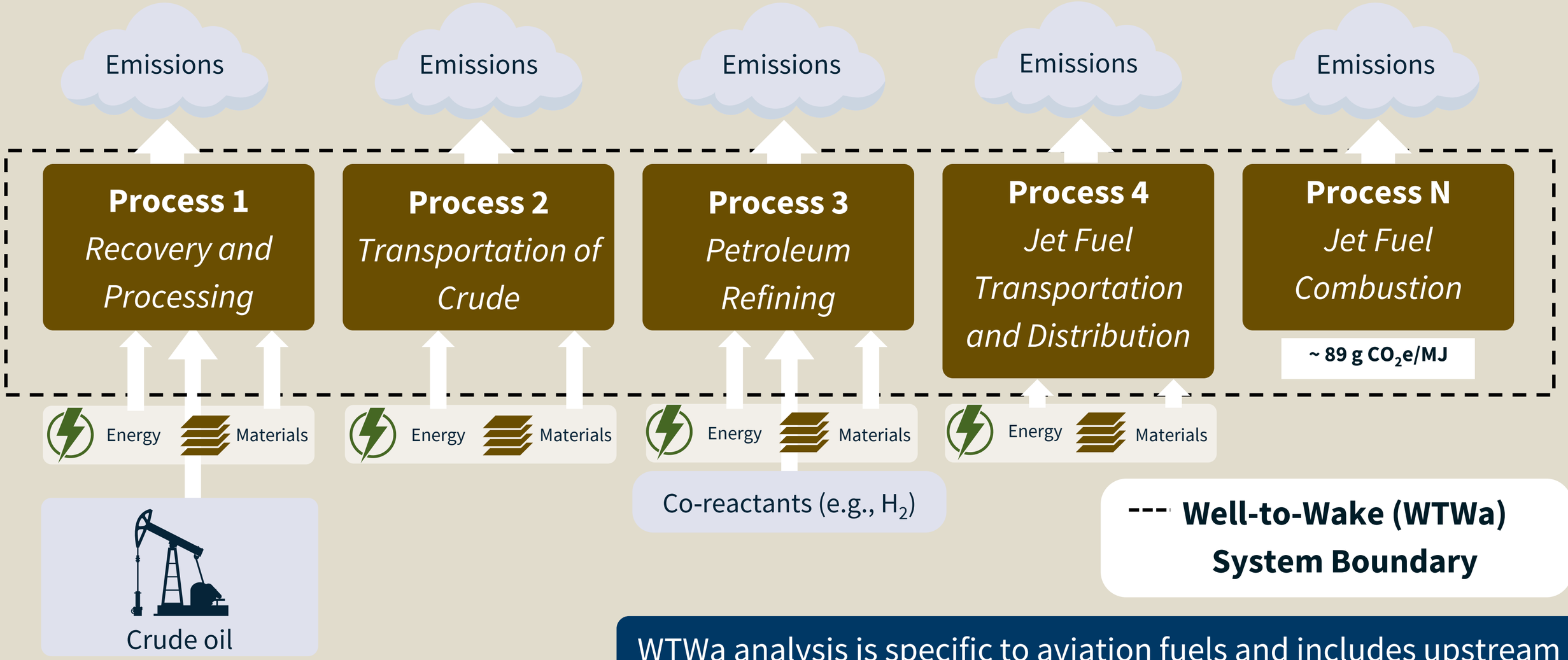
Life cycle of petroleum jet fuels in R&D GREET



WTWa analysis is specific to aviation fuels and includes upstream energy use and associated emissions

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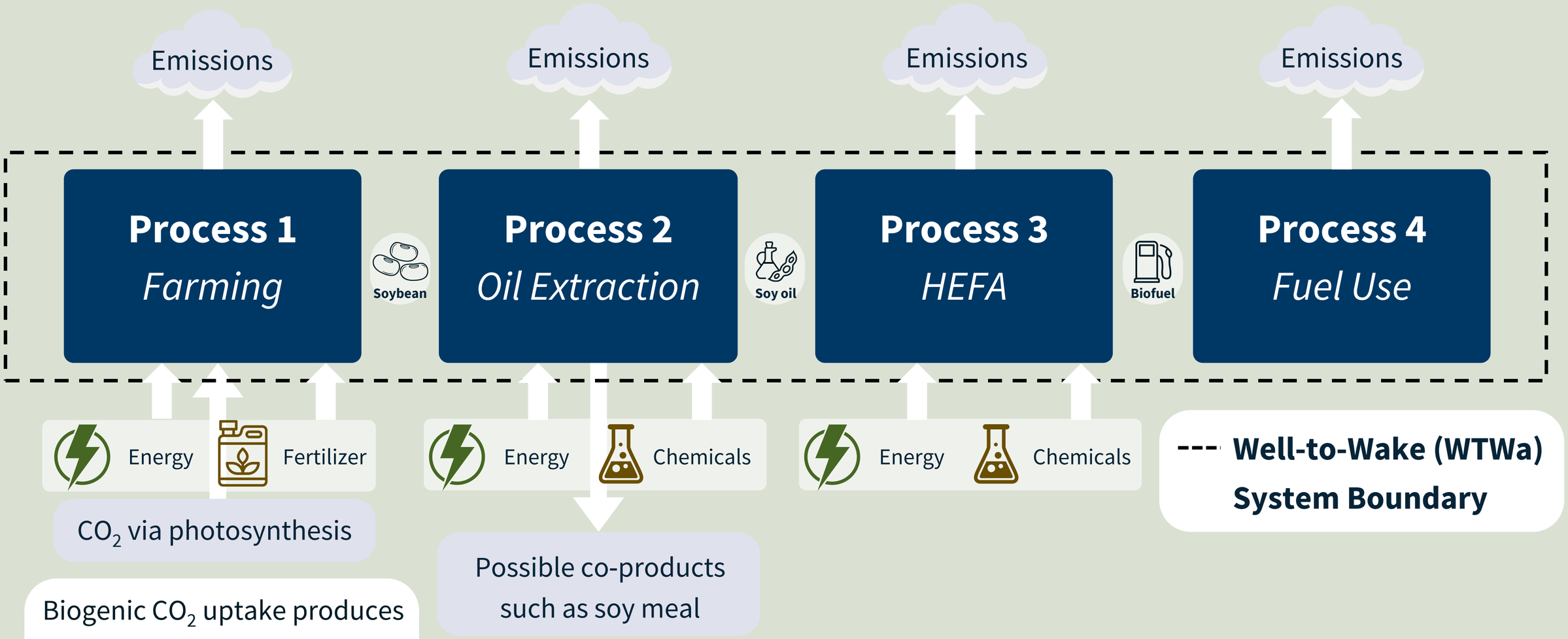
Blend requirements for petroleum jet fuels

In GREET, you can change the blend you model on **cell A39** in the JetFuel_PTWa tab

- Alternative Fuels Data Center: Sustainable Aviation Fuel | Department of Energy

Pathways	Blend Limitations
Fischer-Tropsch (FT) Synthetic Paraffinic Kerosene (SPK)	50%
Hydroprocessed Esters and Fatty Acids	50%
Hydroprocessed Fermented Sugars to Synthetic Isoparaffins	10%
FT-SPK with Aromatics	50%
Alohol-to-Jet Synthetic Paraffinic Kerosene	50%
Catalytic Hydrothermolysis Synthesized Kerosene	50%
Hydrocarbon-Hydroprocessed Esters and Fatty Acids	10%
Fats, Oils, and Greases (FOG) Co-Processing	10%
FT Co-Processing	5%

Life cycle of sustainable aviation fuels: *soybean HEFA*



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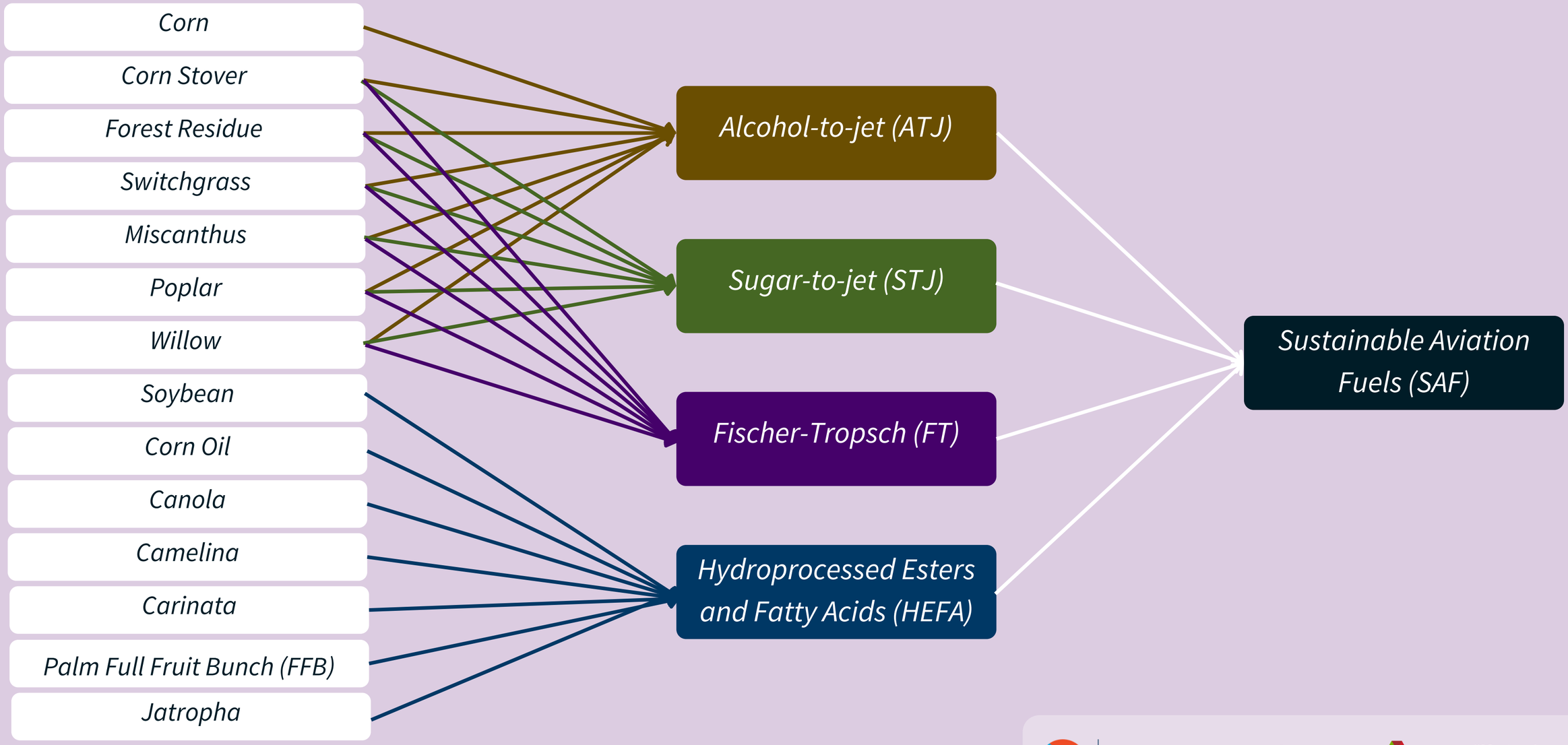
Life cycle of sustainable aviation fuels: *agricultural feedstocks*

Major parameters in each process for agricultural feedstocks

Feedstock Production	Conversion	Feedstock and Fuel Transportation
• Farming inputs: **fertilizer and energy** • Farming emissions: **e.g., N_2O** • Feedstock collection and extraction: **energy inputs**	• Energy use: **heat and electricity** • Hydrogen • Fuel conversion yield • Heat integration	• Transport mode and share • Distance • Urban share emissions

Some available sustainable aviation fuel pathways in R&D GREET



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Sustainable Aviation Fuel Processes

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Alcohol-to-jet via ethanol (ATJ-ethanol) process

ATJ-ethanol fuels can be synthesized through two major steps

1. Biomass Fermentation

2. Ethanol Upgrading to SAF

Dehydration
Hydrogenation
Oligomerization
Hydrotreatment

- Alternative Fuels Data Center: Sustainable Aviation Fuel | Department of Energy

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Sugar-to-jet (STJ) process in R&D GREET

STJ fuels can be synthesized through two major steps

1. Biomass is Converted to Sugar

2. Sugar Upgrading to SAF

Microbial conversion of sugar to SAF

Examples: *biological and catalytic*

- Alternative Fuels Data Center: Sustainable Aviation Fuel | Department of Energy

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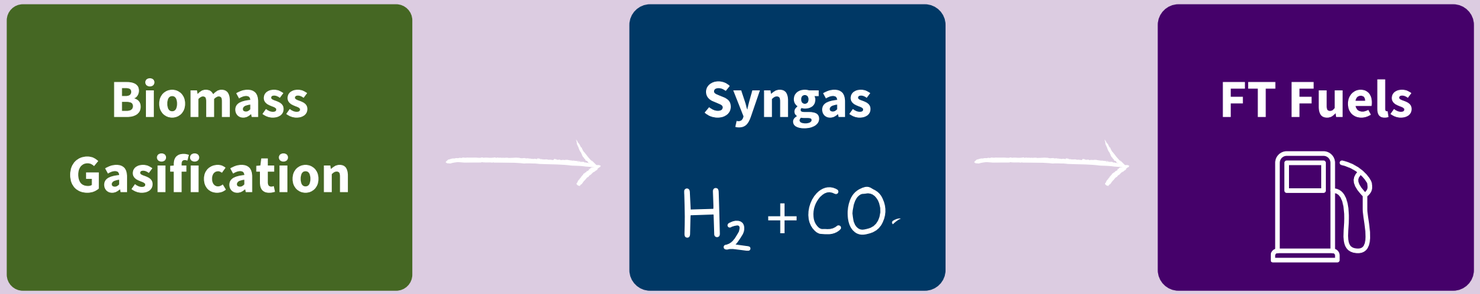
Fischer-tropsch process in R&D GREET

FT fuels can be synthesized by using **carbon monoxide** and **hydrogen** via FT reaction



- Alternative Fuels Data Center: Sustainable Aviation Fuel | Department of Energy

HEFA/Hydroprocessed process in R&D GREET

HEFA fuels are modeled through two steps in R&D GREET

1. Oil Extraction

2. HEFA Synthesis

Hydroprocessing

Hydrogen reacts with long fatty acid chains, breaking them apart

Hydrocracking

Hydrogen reacts with heavy oils under high temperature and pressure, converting them into lighter products

Lipids
(vegetable oil, used cooking oil, tallow, and more)

→

Sustainable Aviation Fuel

Co-products
(e.g., RD and propane)

- Alternative Fuels Data Center: Sustainable Aviation Fuel | Department of Energy

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Pump-to-Wake (PTWa) GHG Emissions

Pump-to-wake (PTWa) GHG emissions in R&D GREET

Air pollutant emissions from the fuel combustion stage may pose significant environmental and health issues

Fuel energy intensity values vary by the type of aircraft and trips

Fuel consumption data uses the latest U.S. transportation statistics conducted by BlueSky

Raw Data Source

2019 Bureau of Transportation Statistics (BTS)

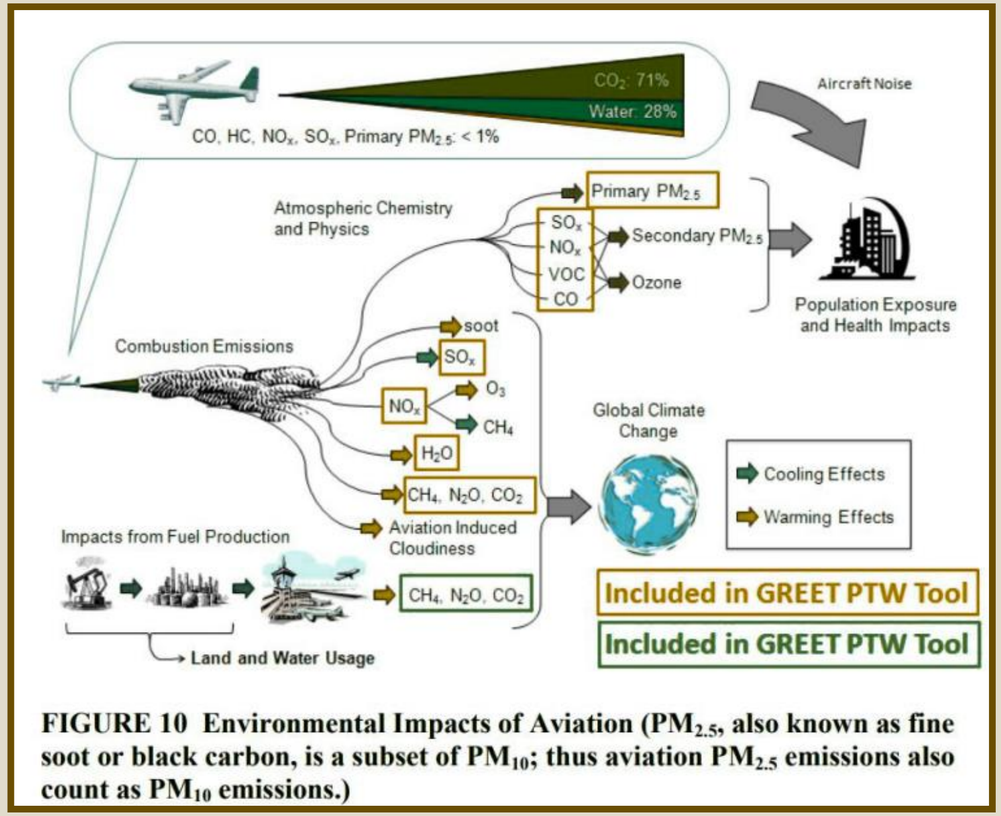

FIGURE 10 Environmental Impacts of Aviation ($PM_{2.5}$, also known as fine soot or black carbon, is a subset of PM_{10}; thus aviation $PM_{2.5}$ emissions also count as PM_{10} emissions.)

- Elgowainy et al., 2012, Bioresource Technologies

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Aircraft types covered in R&D GREET

Units for Aviation in R&D GREET

Per passenger-km or per kg-km

Freight Aircraft
Single Aisle (SA-F)

Freight Aircraft
Small Twin Aisle (STA-F)

Freight Aircraft
Large Twin Aisle (LTA-F)

Freight Aircraft
Large Quad (LQ)

Passenger Aircraft
Single Aisle (SA)

Passenger Aircraft
Small Twin Aisle (STA)

Passenger Aircraft
Large Twin Aisle (LTA)

Passenger Aircraft
Large Quad (LQ)

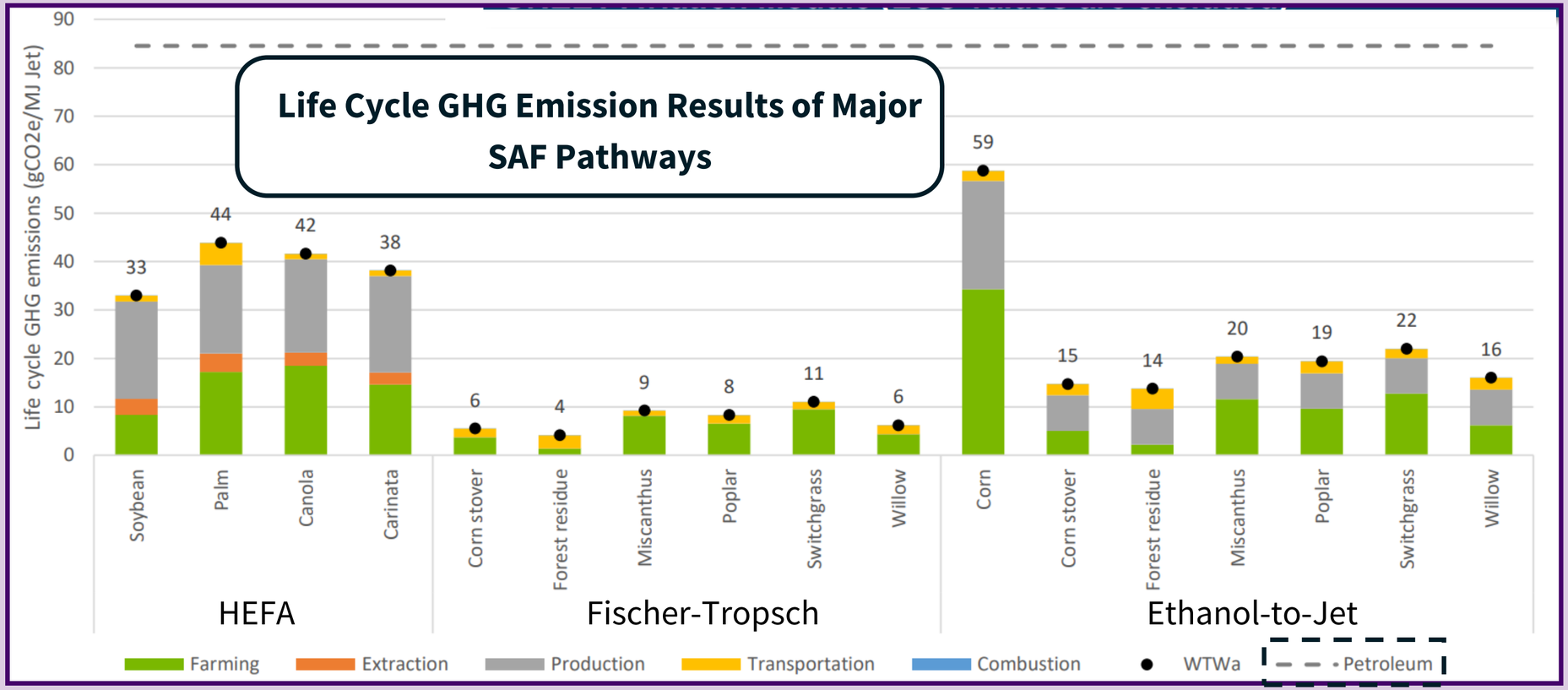
Passenger Aircraft
Regional Jet (RJ)

Passenger Aircraft
Business Jet (BJ)

Well-to-Wake (WTWa) GHG Emissions

Well-to-wake (WTWa) GHG emissions in R&D GREET

SAF LCA results present significant emission reduction potential compared to the petroleum jet baseline



- R&D GREET 2022

Note: this figure was generated for illustrative purposes. As R&D GREET is updated, the values could change

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R&D GREET capabilities for LCA of sustainable aviation fuel

Feedstock Types

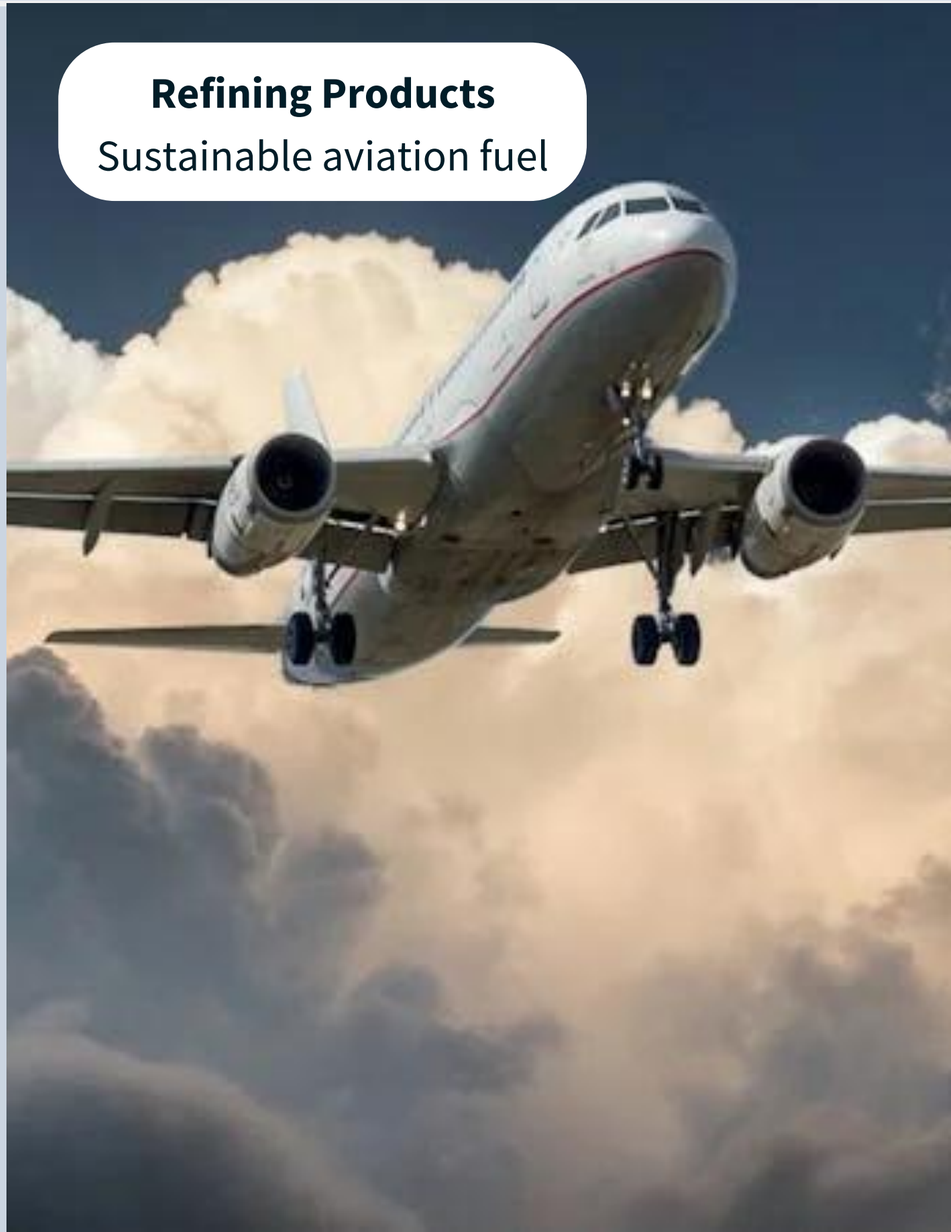
Ethanol (e.g., from corn or sugarcane), isobutanol, natural gas (NA, non-NA, flared gas, and RNG), coal, biomass (e.g., corn stover, forest residue, and switchgrass) vegetable oil (e.g., from soybean or canola), waste oils and fats (e.g., used cooking oil and tallow)

Co-products from a SAF Production Facility

Renewable diesel, propane, steam, electricity, naphtha, and carbon dioxide (if employing CCS)

Energy and Environmental Metrics

Energy intensities of total, fossil (petroleum, gas, and coal), water use intensities, GHG emission intensities (total and CO_2, CH_4, and N_2O separately), air pollutants' emissions intensities of VOC, CO, NO_x, $PM_{2.5}$, PM_{10}, SO_x, BC, and OC



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Sustainable aviation fuel tabs in R&D GREET 1

Primary

JetFuel_WTP

JetFuel_PTWa

JetFuel_WTWa

SAF_Interface

Some Secondary

Fuel_Prod_TS

Fuel_Specs

Car_TS

Vehicles

EF

OilCoalGasInfra

EtOH

BioOil

Petroleum

NG

RNG

Hydrogen

Algae

Macroalgae

Waste

Pyrolysis_IDL

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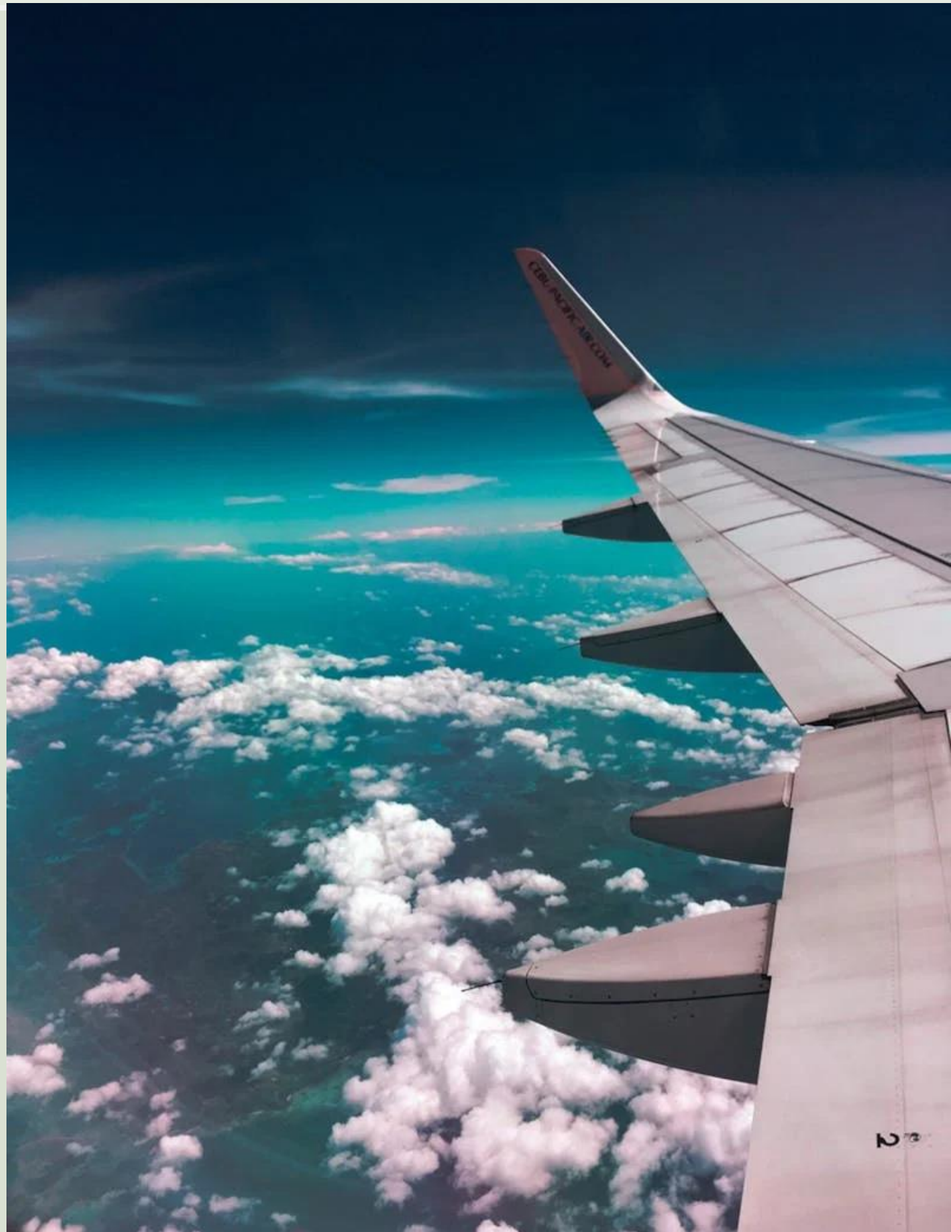
R&D GREET results for SAF

Weighted-average Results

Located on the JetFuel_WTP tab

Aircraft-specific Results

Located in the JetFuel_WTWa tab



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