



# Sustainable Aviation Fuel Grand Challenge Roadmap

*To enable the production of 3 billion gallons of SAF  
per year by 2030 and 35 billion gallons by 2050*



# The SAF Grand Challenge

## MEMORANDUM OF UNDERSTANDING SUSTAINABLE AVIATION FUEL GRAND CHALLENGE

Among the  
THE U.S. DEPARTMENT OF ENERGY,  
THE U.S. DEPARTMENT OF TRANSPORTATION and the  
THE U.S. DEPARTMENT OF AGRICULTURE

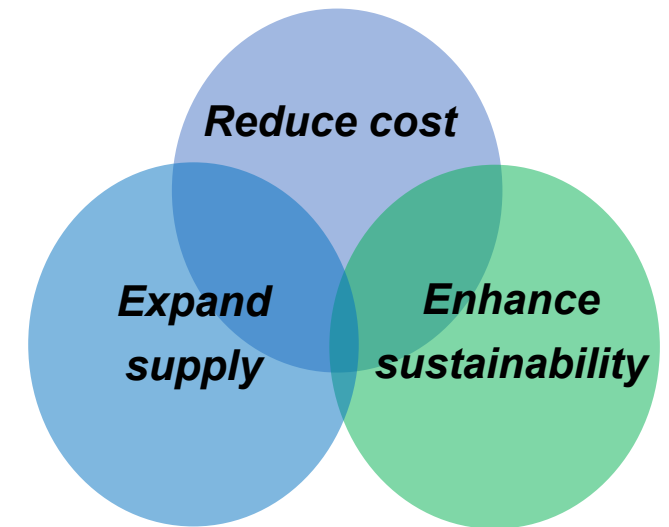
September 9, 2021



[https://www.energy.gov/sites/default/files/2021-09/S1-Signed-SAF-MOU-9-08-21\\_0.pdf](https://www.energy.gov/sites/default/files/2021-09/S1-Signed-SAF-MOU-9-08-21_0.pdf)

# SAF Grand Challenge

- Agreement by the Departments of Transportation, Energy and Agriculture coordinated with EPA
- Achieve 3 billion gallons of domestic SAF production in 2030 and put U.S. on trajectory to 35 billion gallons per year by 2050
- At least a 50% reduction in life cycle greenhouse gas emissions, as compared to conventional jet fuel
- Multi-agency roadmap to focus federal actions to support industry scale-up





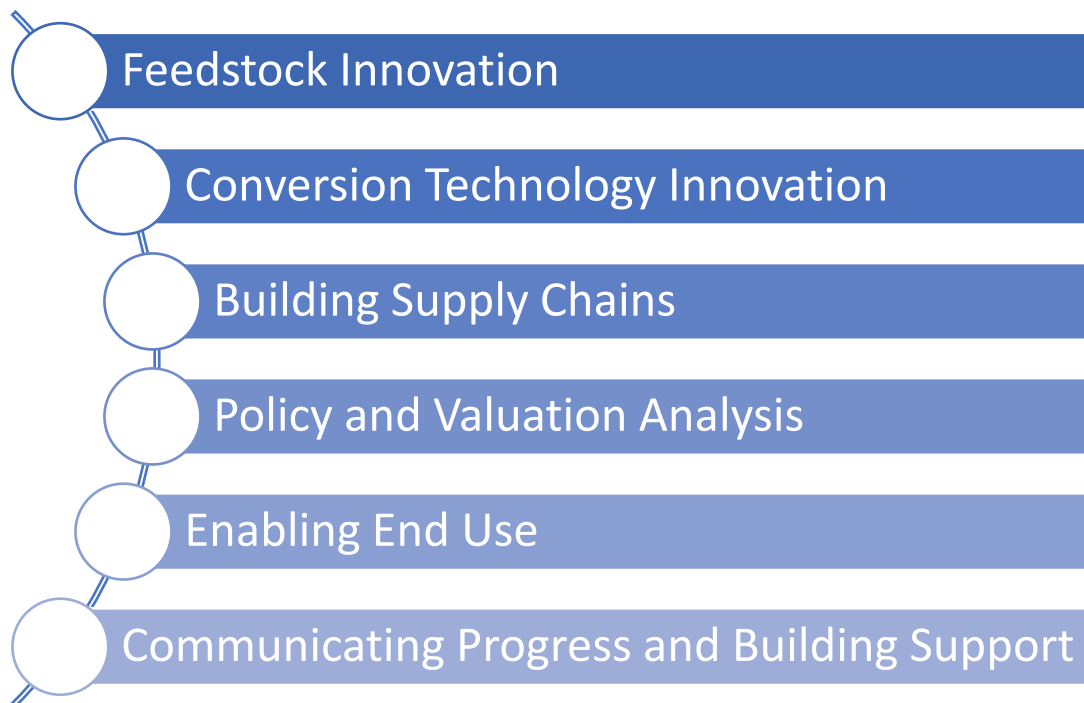
# SAF Grand Challenge Roadmap

- A coordinated approach to federal agency actions that derisks technology, supply chains, and markets, and reduces barriers
  - Actions that support near-term production
  - Ongoing innovation to support future production
  - Data collection and analysis to support markets for SAF through strong policies and focus on sustainability



<https://www.energy.gov/sites/default/files/2022-09/beto-saf-gc-roadmap-report-sept-2022.pdf>

# Roadmap Structure



- **26 Workstreams**
- **140 Activities**
- **2030 & 2030-2050 impact timeframes**



# Roadmap Implementation – Activities to date

- Federal agencies
  - Inventory and map existing and planned activities aligned with roadmap
  - Identify RDD&D gaps and funding needs
  - Creation of working groups
- Communications
  - Develop and launch a SAF Grand Challenge Website
  - Planning for an FY23 Roadmap Annual Progress Report



# Implementation Activities

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*To enable the production of 3 billion gallons of SAF  
per year by 2030 and 35 billion gallons by 2050*



# SAF GC Roadmap - Summary

## Six Action Areas:

- 1. Feedstock Innovation (FI)**
- 2. Conversion Technology Innovation (CT)**
- 3. Building Supply Chains (SC)**
- 4. Policy and Valuation Analysis (PA)**
- 5. Enabling End Use (EU)**
- 6. Communicating Progress and Building Support (CP)**



# Deploying Purpose-Grown Energy Crops for SAF Workshop



## Workshop Summary

- June 6-7, in Kansas City, MO
- 109 Attendees
  - Federal Agencies (23)
  - Industry (36)
  - National Labs (23)
  - Universities (27)
- Promise of Purpose-Grown Energy Crops moderated panel
- Resource Considerations presentations
- 20, 3x5 Lightning Talks
- Expanding the Network for Energy Crop Deployment

## Feedstock Specific Breakout Sessions

- Identifying Knowledge Gaps
- Ideas and Strategies for Addressing Knowledge Gaps
- Innovative Solutions for Successful Deployment



# Top 5 Knowledge Gaps Identified by Feedstock Breakouts

<u>Herbaceous</u>	<u>Woody</u>	<u>Algae</u>	<u>Secondary</u>
1. Long term risk for farmers	1. Large scale studies	1. Large scale demos	1. <b>Market requirements</b>
2. <b>Market requirements</b>	2. <b>Preprocessing and logistics</b>	2. <b>Long term data</b>	2. Regulatory barriers
3. How to measure success	3. <b>Updated yield and quality data</b>	3. <b>Fractionation and downstream processing</b>	3. What should be grown where
4. <b>Consistent carbon accounting</b>	4. Soil characteristics	4. Engineering models with process control	4. <b>Consistent carbon accounting</b>
5. <b>Understanding value chains</b>	5. Social and stakeholder engagement	5. <b>Consistent carbon accounting</b>	5. Information sharing

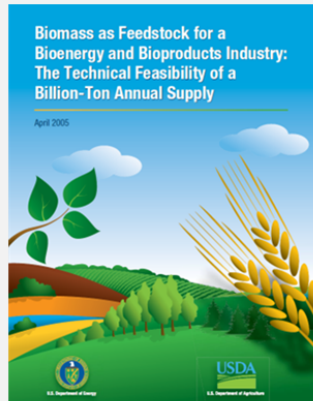
# 2023 Billion-ton Report, in Preparation

(FI.1 Understand resource markets and availability; PA.2 Conduct techno-economic and production potential analysis)

**To inform research, development, and deployment strategies.**

- Policy agnostic
- End-use agnostic
- Not predictions
- Not targets

2005



Supply...

Can we displace 30% of the country's petroleum consumption?

2011



...Cost...

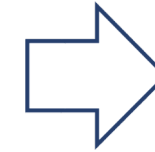
- County-level supplies by cost.
- Economic model of ag+energy crops.

2016 (BT16)



...Sustainability.

- 44 feedstocks w/ modeled crop yields
- Forest model
- Delivered costs
- 2 Volumes + visualization tools



**2023 (BT23)**

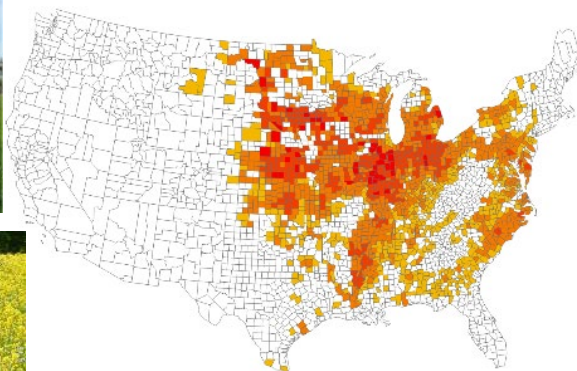


Add new feedstocks  
Update waste and algae Refine forest resources



# New Feedstocks in BT23

## Oilseed crops for SAFs



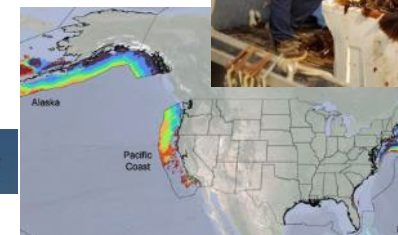
## Macro- (“seaweed” algae)

- Collaboration with ARPA-E



OceanReports  
A BOEM/NOAA PARTNERSHIP

MarineCadastre.gov



## Western Forest Fuels for biomass with USFS

- Biomass from 2022 USFS Wildfire Crisis Strategy



## CO<sub>2</sub> to e-fuels

- Proximity to renewable electricity
- High concentration (e.g. fermentation)





# Feedstock Innovation/Supply Chain Action Areas Webinar - March 28, 2023

- **Feedstock Producers/Seed Companies\***

- Algae Biomass Organization
- Bayer
- Beck's Hybrids
- Illinois Corn Growers
- Illinois Farm Bureau
- Minnesota Soybean Association
- Minnesota Soybean Association Ag Utilization Research Institute
- National Association of Wheat Growers
- National Corn Growers Association
- Nebraska Corn Growers Association
- Syngenta
- United Sorghum Checkoff Program
- US Grains Council

- **Feedstock Processors/Fuel Producers/End Users**

- Archer Daniels Midland
- Gevo
- Magellan Pipeline
- National Association of State Departments of Agriculture
- National Corn to Ethanol Research Center
- Performance for Production Ag (Pork)
- Renewable Fuel Association
- Southwest Airlines

\* Represent 240 Million Acres of US Crop Production

# DOE FY23 Scale-up Funding Opportunity Announcement –

## Topic Area 1 – Pre-Pilot Scale-Up of Integrated Biorefineries

Selectee	Location	Project Title
Algenesis Corporation	Cardiff, CA	<a href="#"><u>Pre-Pilot Scale Production of Algae-based Jet Fuel and Polyurethane Monomers</u></a>
Captis Aire LLC	East Point, GA	<a href="#"><u>Renewable Blending Components to Enable 100% Sustainable Aviation Fuel (SAF)</u></a>
Comstock Inc.	Virginia City, NV	<a href="#"><u>Production of Renewable Diesel, Sustainable Aviation Fuel, Gasoline, and Marine Fuel from Lignocellulosic Biomass at Dramatically Improved Yield, Efficiency, and Cost.</u></a>
Global Algae Innovations	San Diego, CA	<a href="#"><u>Algae Direct Air Capture Scale-up to Multi-Acre Raceways</u></a>
MicroBio Engineering Inc.	San Luis Obispo, CA	<a href="#"><u>Attached Algae Flow Ways for Biofuels Production Utilizing Air-CO2</u></a>
Research Triangle Institute	Research Triangle Park, NC	<a href="#"><u>A Corn Stover Pyrolysis Pathway for Sustainable Aviation Fuel</u></a>
University of California: Riverside	Riverside, CA	<a href="#"><u>Scale-up Demonstration of Hybrid Catalytic Biorefining of Biomass to Sustainable Aviation and Marine Fuels</u></a>
University of Utah	Salt Lake City, UT	<a href="#"><u>Entrained-Flow Biomass Gasification with Syngas Fermentation for Production of Sustainable Aviation Fuels</u></a>
Viridos, Inc.	La Jolla, CA	<a href="#"><u>Pre-pilot Integrated Sustainable Aviation Fuels Algae Biorefinery</u></a>

# DOE FY23 Scale-up FOA – Topic Area 2 and 3 – Pilot Scale-Up and Demonstration Scale-Up of Integrated Biorefineries

Pilot_Scale Selectee	Location	Project Title
LanzaTech, Inc.	Skokie, IL	<a href="#"><u>RESTORE: Replenishing EcoSystems by Transforming Residues to Energy</u></a>
MicroBio Engineering Inc.	San Luis Obispo, CA	<a href="#"><u>Scale-up of Hydrothermal Liquefaction with Supercritical Water Oxidation in an Integrated Biorefinery</u></a>

Demo Selectee	Location	Project Title
Alder Fuels, LLC	Washington DC	<a href="#"><u>Decarbonizing the Skies – Sustainable Aviation Fuel from Alder Biocrude Oil</u></a>
AVAPCO LLC	Thomaston, GA	<a href="#"><u>AVAP Biorefinery: Enabling Net Zero™</u></a>



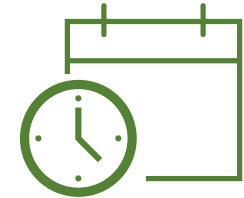
## Clean Fuels & Products Shot

### Alternative Sources for Carbon-based Products

Develop **cost-effective fuels and products** from sustainable carbon sources to achieve **>85% lower net GHG emissions** by 2035



>85% net  
reduction vs. fossil-  
based sources



2035

Timed with 2035 Clean Grid and Industrial Heat Goals.



# Liquid Fuels and Hydrocarbon Chemicals for Hard to Abate Sectors

## Liquid transportation fuels

- Aviation, maritime, rail, and off-road fuels have:
  - Significant GHG emissions impacts
  - Limited potential for electrification and hydrogen due to energy density requirements for long haul
  - Projected growth



Shot Focus: Clean sources for 100% of aviation, 50% of maritime, rail and off-road fuels

## Hydrocarbon chemicals

- **Chemicals** sector is the largest contributor to U.S. industrial GHG emissions and expected to grow

Shot Focus: Clean sources for chemical feedstocks and polymer resins



# SAF Grand Challenge emissions working group

(PA.1 Improved environmental models and data for SAF)



- From the MOU – “The parties and EPA, along with other relevant agencies, will define and agree on the appropriate science-based methodology for establishing life cycle emissions reductions.”
- “ACTIVITY PA.1.1: Convene life cycle GHG modeling working group to support needs of the SAF Grand Challenge, in line with the SAF Grand Challenge memorandum of understanding.”
- federal agency working group made up of agency and national labs technical experts (DOT, DOE, USDA, EPA, Treasury, ANL)
- IRA SAF Tax Credit – section 40B – collaborative discussions across agency technical experts
  - working group shared deliberative and non-binding technical findings on options implementable in the near term with Treasury/IRS
  - Intended to support their efforts in developing final guidance to be released this year
- Next step – scope ongoing development of methods and tools to estimate life cycle GHG emissions for use in SAF Grand Challenge activities that require GHG evaluation.

# FAST-SAF Grant Program

(EU.4 Integrate SAF into fuel distribution infrastructure)

- Fueling Aviation's Sustainable Transition (FAST) SAF & Technology competitive grant program
- Section 4007 of Inflation Reduction Act of 2022
- for U.S. projects that “produce, transport, blend, or store sustainable aviation fuel”
  - \$244.5 million for projects relating to SAF production, transportation, blending, or storage
  - \$46.5 million for projects relating to low-emission aviation technologies
  - \$5.9 million to fund grant award program administration
- Grant program office being organized
- NOFO in advanced state of development

<https://www.transportation.gov/mission/office-secretary/office-policy/aviation-policy/fueling-aviations-sustainable-transition>



# SAF Grand Challenge Website

(CP.4 Communicate public benefits of the SAF Grand Challenge)

## Sustainable Aviation Fuel Grand Challenge



Inaugurated on Sept. 9, 2021, the Sustainable Aviation Fuel Grand Challenge is the result of the U.S. Department of Energy (DOE), the U.S. Department of Transportation (DOT), the U.S. Department of Agriculture (USDA), and other federal government agencies working together to develop a comprehensive strategy for scaling up new technologies to produce sustainable aviation fuels (SAF) on a commercial scale.

The SAF Grand Challenge will guide federal actions to support industry to reduce the cost, enhance the sustainability, and expand the production and use of SAF to:

- Produce 3 billion gallons per year of domestic SAF production that achieve a minimum of a 50% reduction in life cycle greenhouse gas emissions compared to conventional fuel by 2030.
- Meet a goal of supplying 100% of projected domestic aviation jet fuel use, or 35 billion gallons of annual production, by 2050.

### SAF Grand Challenge Roadmap

To achieve the SAF Grand Challenge 2030 and 2050 goals, the interagency team worked with other government agencies; stakeholders from national labs, universities, non-governmental organizations; and the aviation, agricultural, and energy industries to develop the [SAF Grand Challenge Roadmap: Flight Plan for Sustainable Aviation Fuel](#).

### SAF Grand Challenge Partners


Successful implementation of the SAF Grand Challenge will require close collaboration of agencies across the federal government—particularly DOE, USDA, DOT and its



#### SAF Grand Challenge Roadmap

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The SAF Grand Challenge Roadmap overview figure depicts how the six action areas address barriers across the entire supply chain from innovations in feedstock supply through end use. Within each of the six action areas are workstreams that define critical topics to be addressed.



[Feedstock Innovation](#)

[Conversion Technology Innovation](#)

[Building Supply Chains](#)

[Policy and Valuation Analysis](#)

[Enabling End Use](#)

[Communicating Progress and Building Support](#)

<https://biomassboard.gov/sustainable-aviation-fuel-grand-challenge>



# Roadmap Implementation – Next Steps

- Stakeholder engagement
  - Obtain external stakeholder input on federal activity plans
  - Provide recommendation on research focus areas
  - Identify/map industry supported/funded efforts aligned with roadmap
  - Identify opportunities for public-private partnerships to implement roadmap actions (e.g. working groups/technical teams)



# Thank You!

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# The Path to Success on SAF

- Create an environment where producers choose to produce and sell SAF
  - Legislative action to reduce cost and risk
- A coordinated approach to federal agency actions that derisks technology, supply chains, and markets, and reduces barriers
  - Actions that support near-term production
  - Ongoing innovation to support future production
  - Data collection and analysis to support markets for SAF through strong policies and focus on sustainability
- Industry action to build and purchase SAF supply



**Inflation  
Reduction  
Act**



**SAF Grand  
Challenge  
Roadmap**



**Industry  
commitments**

# Action Area: Feedstock Innovation (FI)

*Support and conduct R&D on sustainable feedstock supply system innovations across the range of SAF-relevant feedstocks and identify optimization to reduce cost, reduce technology uncertainty and risk, increase yield and sustainability, and optimize SAF precursors.*

## **Feedstock Innovation Workstreams**

- FI.1** Understand resource markets and availability across all SAF feedstocks
- FI.2** Maximize sustainable lipid supply for 2030
- FI.3** Increase production of biomass resources and collection of wastes and residues
- FI.4** Improve feedstock supply logistics (harvest/collection, transport, storage, preprocessing)
- FI.5** Increase reliability of feedstock handling systems
- FI.6** Improve sustainability of biomass and waste supply systems





# Action Area: Conversion Technologies and Processes (CT)

*Support and conduct R&D, through pilot scale, on unit operations (and integration thereof) from the receipt of biomass at the refinery gate through to finished fuel for technology improvements/carbon intensity reductions. The effort includes processes that are already commercial, such as HEFA or nearing commercialization (alcohol to jet), and considers work on processes that will be ready for commercialization beyond 2030, but need to be developed now.*

## **Conversion Workstreams**

**CT.1** Decarbonize, diversify, and scale current fermentation-based fuel industry

**CT.2** Develop options to increase production and reduce carbon intensity of ASTM-approved pathways

**CT.3** Develop bio-intermediates and pathways for compatibility with existing capital assets

**CT.4** Reduce risk during scale-up and operations

**CT.5** Develop innovative unit operations and pathways



# Action Area: Building Regional Fuel Supply Chains (SC)

*Support SAF production expansion through regional supply chains ensuring R&D transitions from pilot to large scale, field validation and demonstration projects, validating supply chain logistics, enabling public-private partnerships, developing bankable business models, and collaboration with regional, state, and local stakeholders.*

## **Supply Chains Workstreams**

**SC.1** Build and support regional stakeholder coalitions through outreach, extension, and education

**SC.2** Model SAF supply chains

**SC.3** Support demonstration of regional SAF supply chains

**SC.4** Invest in SAF production infrastructure to support industry deployment



# Action Area: Policy & Valuation Analysis (PA)

*Provide data, tools, and analysis to support policy decisions and maximize social, economic, and environmental value of SAF including evaluation of existing and new policies.*

## **Policy & Valuation Analysis Workstreams**

**PA.1** Improved environmental models and data for SAF

**PA.2** Conduct techno-economic and production potential analysis

**PA.3** Inform SAF policy development



# Action Area: Enabling End Use (EU)

*Facilitate the end use of SAF by civil and military users by addressing critical barriers, including efficient evaluation of fuel engine performance and safety, advancement of certification and qualification processes, expansion of existing blend limits, and integration of SAF into fuel distribution infrastructure.*

## **Enabling End Use Workstreams**

- EU.1** Support SAF evaluation, testing, qualification, and specification
- EU.2** Enable use of drop-in unblended SAF and SAF blends up to 100%
- EU.3** Investigate Jet A fuel derivatives offering performance or producibility advantages
- EU.4** Integrate SAF into fuel distribution infrastructure



# Action Area: Communicating Progress & Building Support (CP)

*Monitor and measure progress against SAF GC goals, provide public information resources, and communicate the public benefits of the SAF GC to critical stakeholders and the public.*

## **Communicating Progress & Building Support Workstreams**

**CP.1** Stakeholder Outreach and Engagement on Feedstock Sustainability

**CP.2** Conduct benefits assessment/impact analysis of the SAF Grand Challenge

**CP.3** Measure progress of the SAF Grand Challenge

**CP.4** Communicate public benefits of the SAF Grand Challenge

