

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

Sustainable Aviation Fuel Research and Development at DOE

DOE Bioenergy Technologies Office

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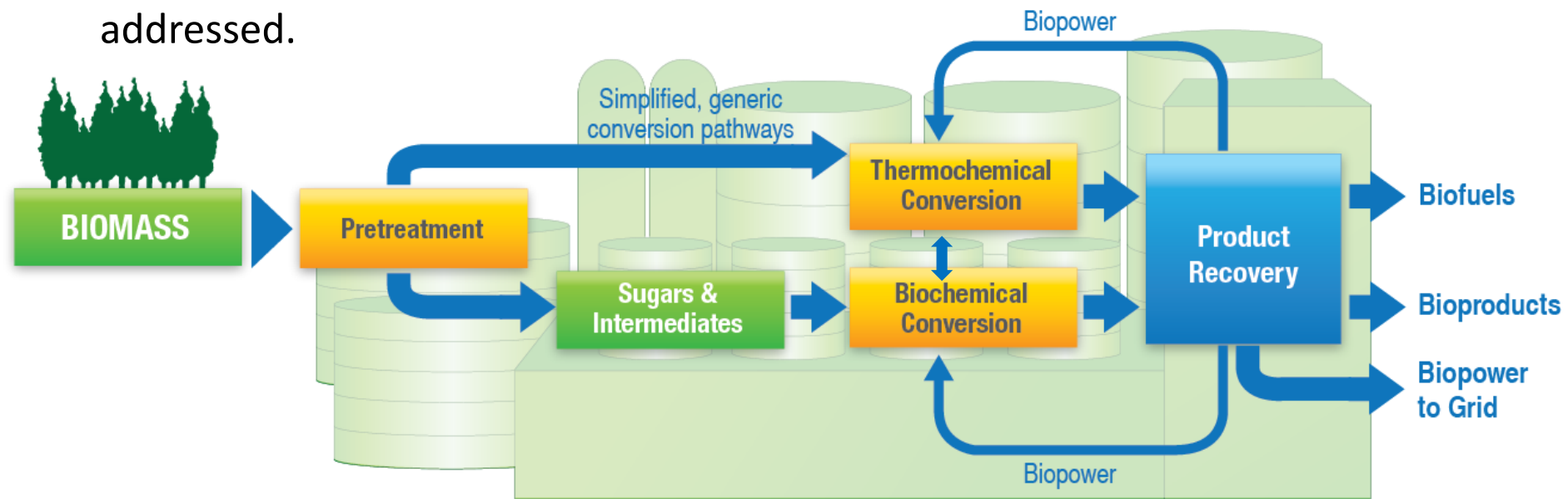
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BETO's Perspective on Renewable Fuels

- Opportunity for **significant new markets for biomass**
- Biomass can fully **supply future aviation/ maritime/rail** (requires 75% of all feedstocks)
- Biggest market pull is **in sustainable aviation fuels** (SAF)
- DOE **has three large-scale SAF demo projects (Fulcrum, Red Rocks, LanzaTech)**
- Provides market for **current ethanol** (~17B gal, ~40% of corn production)
- Supports decarbonization of chemicals via **bioproducts**, and decarbonization of agriculture through healthy forests and sustainable agriculture
- **CO₂-to-fuels** remains to be explored

Biofuels Conversion Technologies

- DOE is focusing on advancing renewable gasoline, diesel, and jet fuels technologies, in addition to bioproducts and biopower.
- Technical, construction, operational and financial/market risks need to be addressed.



Key Challenges

Biomass	Pretreatment	Conversion	Product
<ul style="list-style-type: none">• Reliable supply• Consistent quality• Affordable delivery	<ul style="list-style-type: none">• Biomass feeding, sizing and moisture• Solids handling• Material of construction	<ul style="list-style-type: none">• Products Yields• Material of construction• Catalysts• Fermentation organisms	<ul style="list-style-type: none">• Separations• Catalytic upgrading• Recycle loops

SAF GC Roadmap Outline

- Executive Summary
- Overview
- Action Areas

1. Feedstock Innovation

- a) **Workstream 1**

- b) **Workstream 2**

- c) ...



Current focus is on developing Workstreams under each Action Area

2. Conversion Technology Innovation

3. Building Regional Fuel Supply Chains

4. Fuel Testing, Certification & Qualification

5. Policy & Valuation Analysis

6. Communicating Progress & Building Support

- Appendices

- **A- Detailed activities for 3 Bgy by 2030**

- B – Complete Detailed activity breakdown (to be published later)

SAF GC Roadmap – Workstreams

Action Areas (5-8 pages each)

- 1. Feedstock Innovation
- 2. Conversion Technology Innovation
- 3. Building Regional Fuel Supply Chains
- 4. Fuel Testing, Certification & Qualification
- 5. Policy & Valuation Analysis
- 6. Communicating Progress & Building Support



Workstreams

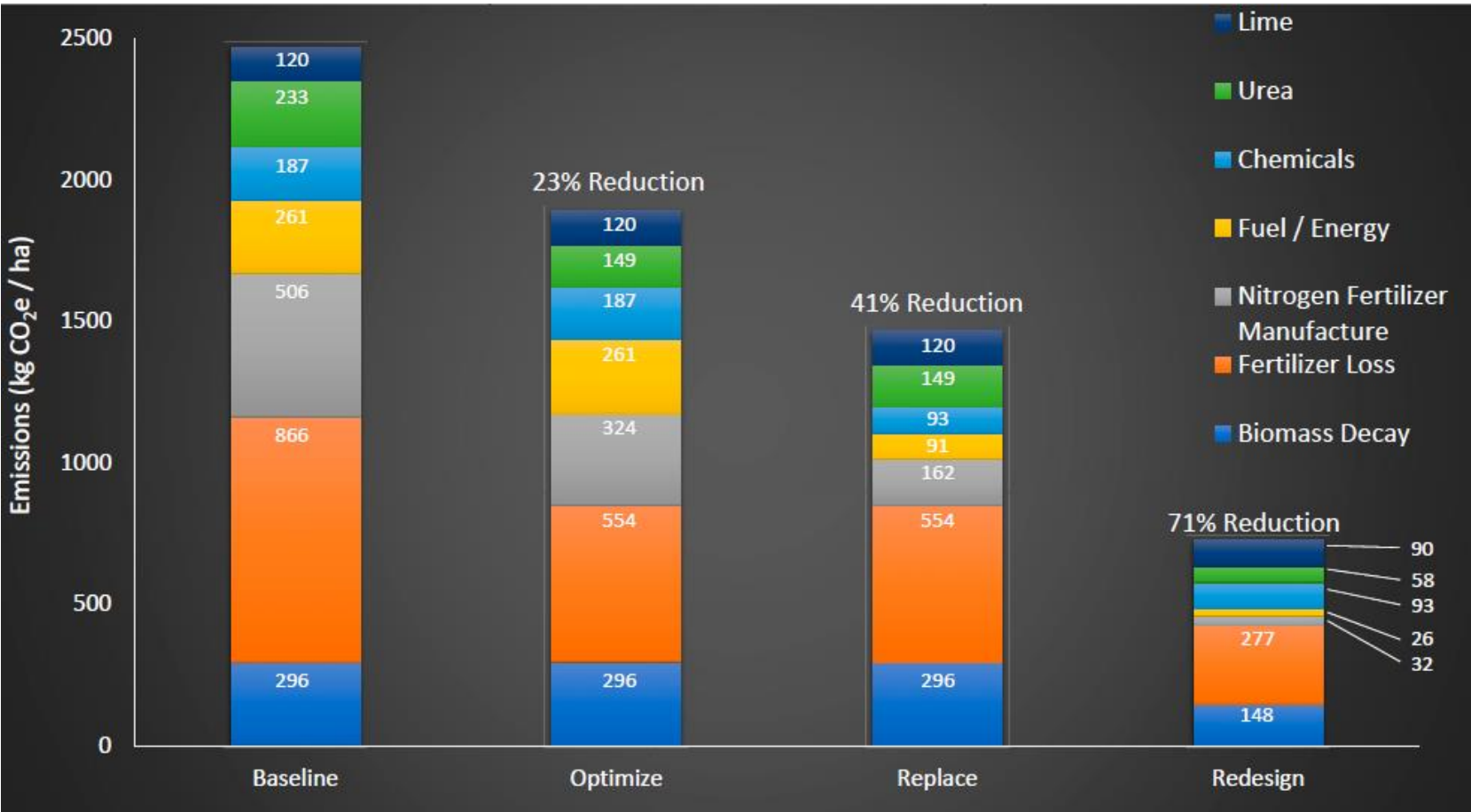
- Workstreams define critical activities within Action Area
- Anticipate 4 to 6 Workstreams per Action Area, ½-1 page each

Action Area: Feedstock Innovation (Example in progress)

Description: *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.*

WORKSTREAM FI.1: Understand resource markets and availability <i>Develop market analysis for commodity and commercially available feedstocks under increase demand for SAF, and assess and analyze the factors effecting the availability of non-commodity/commercial feedstocks</i>
DELIVERABLE: An understanding of the supply and demand dynamics for feedstocks under the proposed production levels for SAF IMPACT: Identification of feedstock limitation for SAF conversion technologies and supply/cost curves KEY THEMES: Reduce cost, Expand production
WORKSTREAM FI.2: Maximize sustainable lipid supply for 2030 (FOGs) <i>Description: Given near term relevance of SAF conversion of lipids to meeting 2030 goals, take a coordinated approach to lipid feedstock R&DDD to support expansion to meet 2030+ goal, development of a lipid multi-generational Project Plan; coordination of USG support for near term lipid crop expansion (e.g. oilseed cover crops)</i>
DELIVERABLE: More lipids available for HEFA conversion pathway IMPACT: Increase the probability for the production of 2-3 BG/year SAF by 2030 KEY THEMES: Expanded SAF production near-term
WORKSTREAM FI.3: Increase production of biomass resources and collection of wastes <i>Provide the R&D to increase the production and collection of biomass resources (besides lipids)</i>
DELIVERABLE: R&D that will lead to the development of technologies and strategies that will increase the availability of biomass and waste resources for use as a biofuel feedstock. IMPACT: More biomass and waste resources are available at an acceptable carbon intensity and price. KEY THEMES: Reduced cost. Expand production

GHG Reduction Potential in Farming



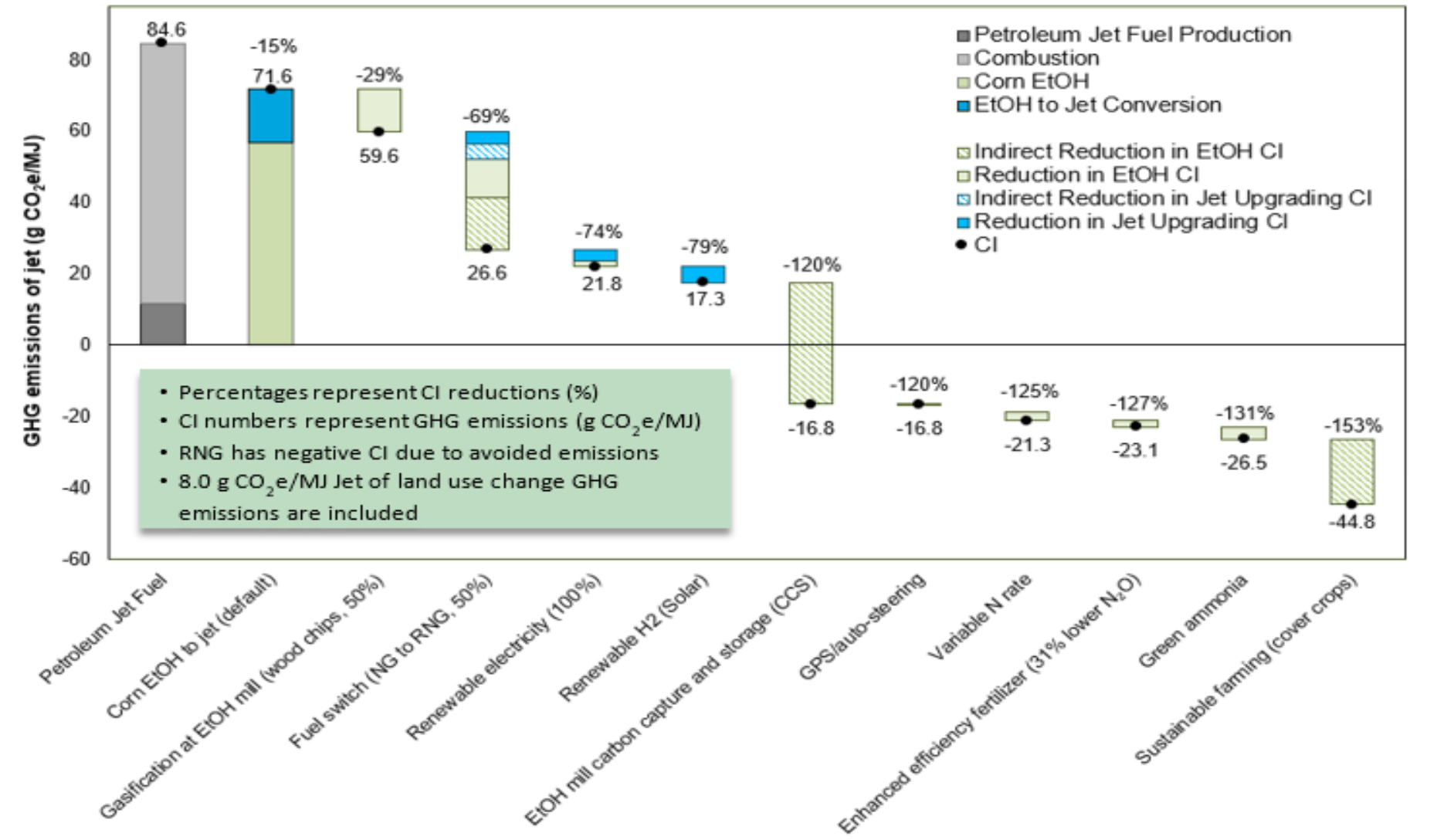
Optimize: Intercropping, rotation, diversification, digital agriculture, precision applicators

Replace: New genetics/expanded breeding targets, electrical or biological nitrogen synthesis, electric tractors

Redesign: Grass crops with nitrogen fixation, dilute fertilizer production on farm, automated implements/robotics

Source: Daniel Northrup, Bruno Basso, Michael Wang, Cristine Morgan, and Philip Benfey, "Novel Technologies for Emission Reduction Complement Conservation Agriculture to Achieve Negative Emissions From Row-Crop Production", Proceedings of the National Academy of Sciences, Vol 118, No. 28, June 2021.

Carbon Neutrality of Corn Ethanol and Ethanol-to-jet Pathways



Source: Jim Spaeth(2021) (<https://www.energy.gov/eere/bioenergy/articles/sustainable-aviation-fuels-low-carbon-ethanol-production>)

FY22 Waste Feedstock and Conversion R&D Funding Opportunity Announcement

- Development of improved organisms and inorganic catalysts to support next generation low-carbon biofuels and bio-products. Improve economic and technical viability for turning waste streams into bioenergy resources.
- Waste streams: municipal solid waste, animal manure, wastewater residuals, and other organic wastes.
- This effort is complementary to the [Sustainable Aviation Fuel Grand Challenge](#), a government-wide effort which aims to achieve a zero-carbon aviation sector by 2050. Funding amount: \$34.5 million.
- FOA has four topic areas: Municipal Solid Waste Feedstock Technologies, Robust Microbial Cells, Robust Catalytic Processes, Community Scale Resource and Energy Recovery from Organic Wastes.
- Concept papers for this FOA are due by April 18, 2022. Applications are due by June 07, 2022. More information about this FOA on [Grants.Gov](#) or [EERE Exchange](#), or email FY22FeedstockConversionFOA@ee.doe.gov with questions.

FY22 Scale-Up of Integrated Biorefineries Notice of Intent

- This FOA will support high-impact R&D focusing on the production of low-GHG fuels for the aviation industry, the long-haul trucking sector, and marine industries by soliciting proposals to scale-up promising technologies.
- The FOA intends to provide a continuation of R&D priorities and strategies identified under BETO's FY21 Scale-up and Conversion FOA (DE-FOA-0002396).
- Area of Interest 1a: Pre-Pilot Scale-Up of Integrated Biorefineries.
- Area of Interest 1b: Pre-Pilot Scale-Up of Integrated Biorefineries: Use of Carbon Dioxide from Ambient Air in Algal Systems.
- Area of Interest 2a: Pilot Scale-Up of Integrated Biorefineries (Preliminary Design and Phased Construction).
- Area of Interest 2b: Pilot Scale-Up of Integrated Biorefineries (Final Design and Construction).
- Area of Interest 3a: Demonstration Scale-Up of Integrated Biorefineries (Preliminary Design and Phased Construction).
- Area of Interest 3b: Demonstration Scale-Up of Integrated Biorefineries (Final Design Construction).