U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Sustainable Aviation Fuel Strategy at the Bioenergy Technologies Office

Dr. Valerie Sarisky-Reed, Acting Director, BETO

Zia Haq, Senior Analyst, BETO

August 26, 2021

Webinar Housekeeping

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- Audio connection options:
  - Computer audio
  - Dial in through your phone (best connection)
- Technical difficulties? Contact us through the chat section, lower right of your screen
- Use the Q&A window to ask questions
- Today's webinar will be recorded and posted to "BETO Webinars": energy.gov/eere/bioenergy/beto-webinars

About the Bioenergy Communicators (BioComms) Working Group

Sponsor:

- U.S. Department of Energy (DOE) Bioenergy Technologies Office (BETO)

BETO & DOE National Laboratory Members:

- Bioenergy communicators, laboratory relationship managers, BETO tech team, and education and workforce development professionals

Purpose:

- Communications strategy for BETO-funded bioenergy research and development

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Today's Agenda

I. Dr. Valerie Sarisky-Reed presents:
   I. About the Bioenergy Technologies Office
   II. BETO's Sustainable Aviation Fuel Strategy

II. Zia Haq presents:
   III. Aviation Sector and SAF Commitments
   IV. SAF Technologies and Research

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BETO Leadership Presenting Today

Dr. Valerie Sarisky-Reed

Acting Director, BETO

Zia Haq

Senior Analyst, BETO

I. About the Bioenergy Technologies Office

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BETO Overview

BETO supports groundbreaking technologies to produce fuels and products from renewable sources of biomass and waste resources.

Helps develop the U.S. Clean Energy Economy

Grow America's Energy Future








Bioenergy Delivers Unique Value

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BETO research and development (R&D) enables:

- National security
- Jobs
- Economic growth
- Investment
- Competitiveness
- Resources
- Quality of life

BETO Critical Program Areas

Production and Harvesting

Feedstock Technologies

Lower cost, improve quality, and increase types of renewable carbon feedstock intermediates available for conversion.

Advanced Algal Systems

Increase algae productivity through algal strain improvement and efficient cultivation.

Conversion and Refining

Conversion Technologies

Reduce costs of deconstructing feedstock into intermediate products (such as sugars, intermediate chemicals, bio-oils, or gaseous mixtures).

Upgrading intermediates into liquid biofuels, bioproducts, and biopower.

Distribution and End Use

Systems Development and Integration

Systems research to combine tech components, unit operations, or subsystems developed by R&D programs into integrated processes.

Integrated processes tested (pre-pilot to demo scale) to identify further R&D needs or verify readiness for scale-up and commercialization.

Crosscutting

Data, Modeling, and Analysis

Track technology progress and identify opportunities and challenges related to economic/environmental impact of advanced bioenergy systems.

II. BETO's Sustainable Aviation Fuel Strategy

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Challenges with Petroleum-Based Jet Fuels

- Aviation produces approximately two percent of human-caused CO_2 emissions:
  - Aviation sector contributes to 9%–12% of U.S. transportation greenhouse gas (GHG) emissions.
  - Addressing GHG emissions will require a global approach.
- Demand for mobility in the United States projected to grow with population and economy:
  - Aviation: +70% by 2050.
- Energy use for "hard-to-electrify" aircraft is projected to reach ~35 B gallon in 2050.

Source: U.S. Energy Information Administration , Annual Energy Outlook 2021, Reference Case, Table 11.

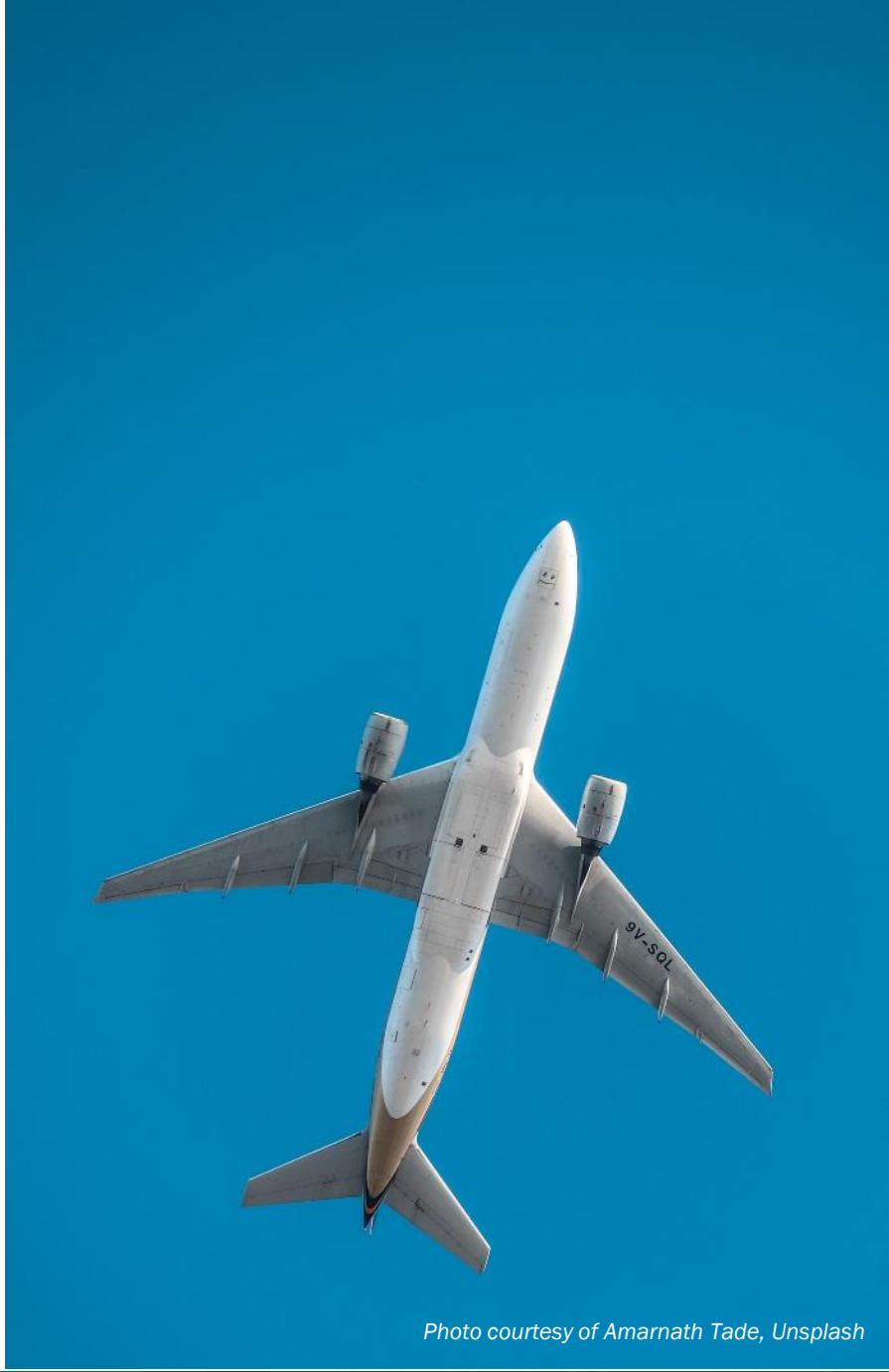


Photo courtesy of Amarnath Tade, Unsplash

What Are Sustainable Aviation Fuels?

Sustainable Aviation Fuel (SAF) Definition:

- Renewable or waste-derived biofuel used to power aircraft that has similar properties to conventional jet fuel but with a smaller carbon footprint on a life cycle basis (50% minimum reduction in CO_2).

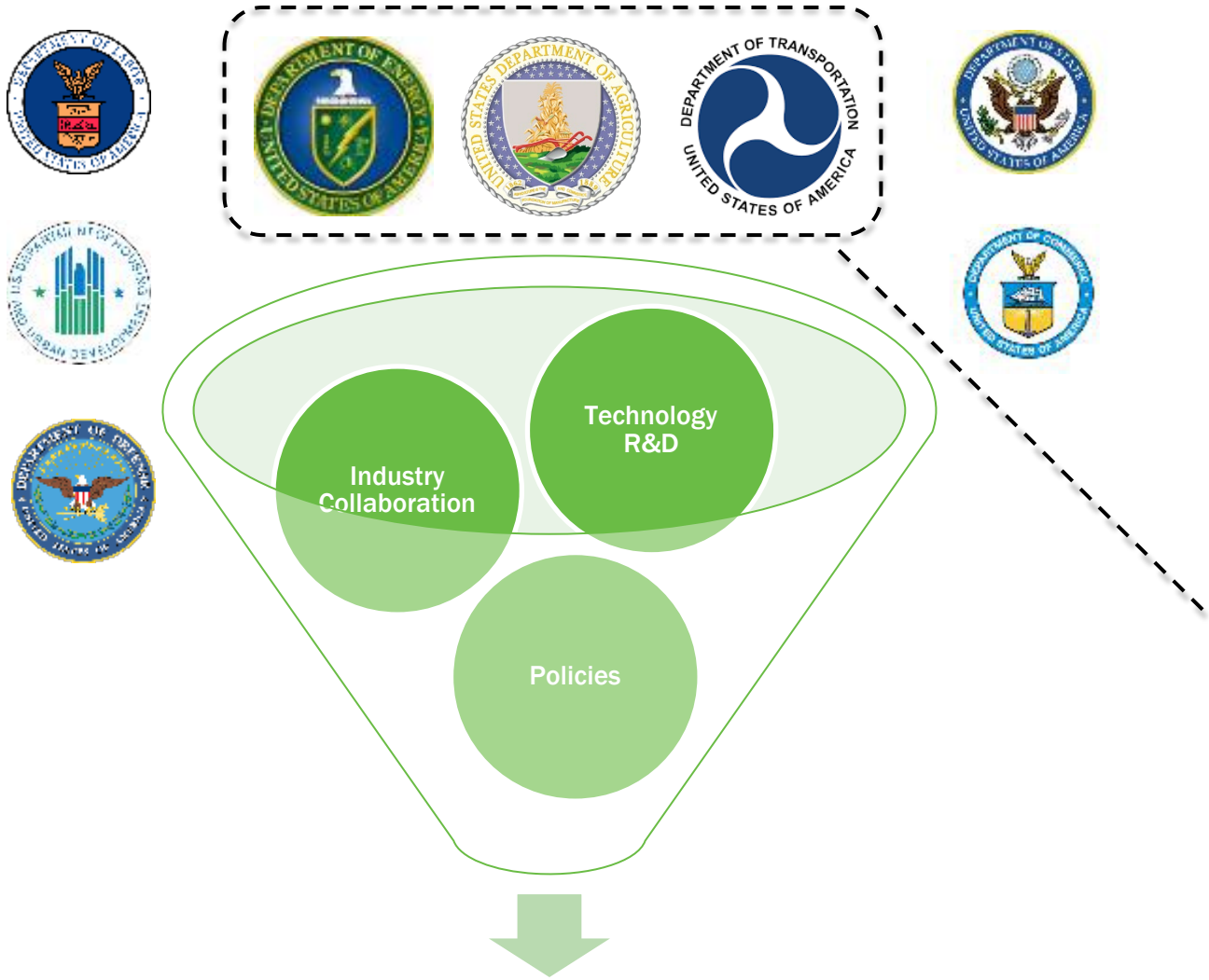
Photo courtesy of iStock

Benefits of Sustainable Aviation Fuels

- **Lower GHGs than petroleum/fossil-based counterparts**
- **SAF can be made with a variety of technologies:**
  - Biological and thermochemical
  - Break down biomass and waste resources
  - Recombine into energy dense hydrocarbons
- **Extra revenue for farmers:**
  - Earn money during off-seasons
  - Secure environmental benefits for farms
- **Environmental services:**
  - Erosions control from biomass crops
  - Improve water quality and quantity
  - Increase biodiversity
  - Waste reduction
- **Improved aircraft performance:**
  - Fewer aromatic components
  - Enables aircraft engines to burn cleaner

Photo courtesy of Dan Myers, unsplash.com

Multi-Agency Collaboration



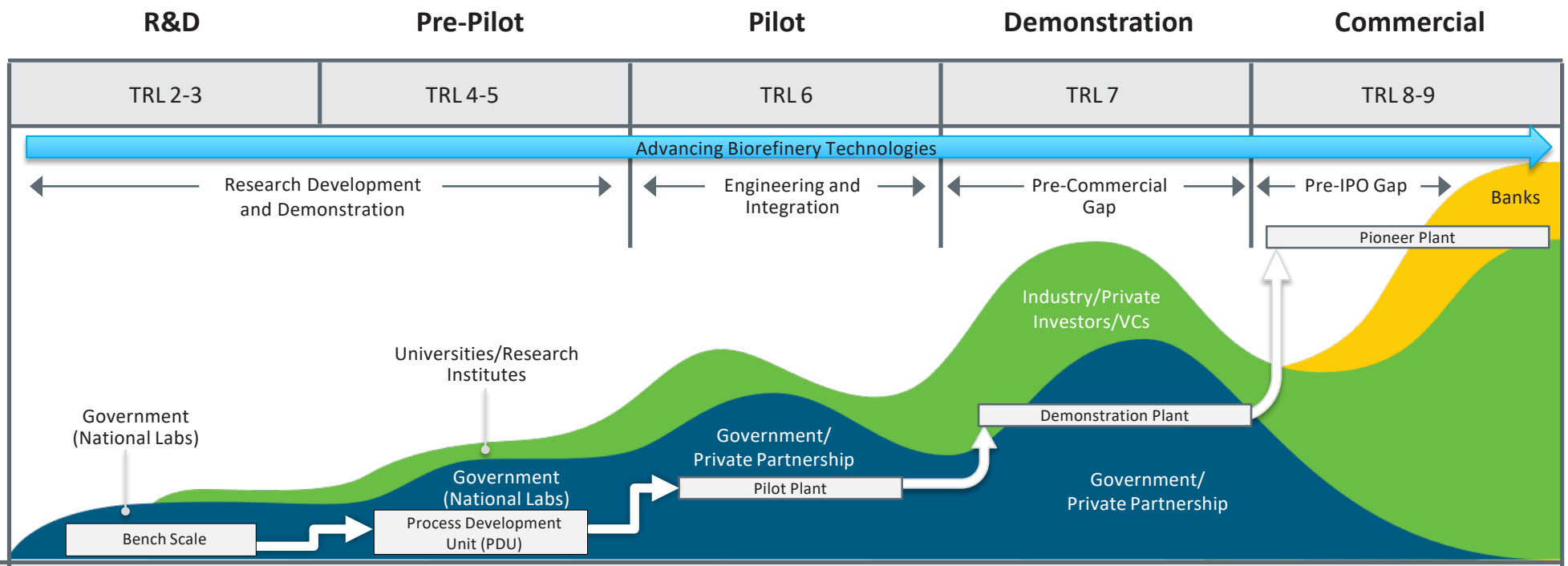
Aviation Sector Solutions

Collaboration between federal agencies will accelerate:

- Decarbonization and action

U.S. Department of Energy (DOE)	U.S. Department of Agriculture (USDA)	U.S. Department of Transportation (DOT)
DOE	USDA	DOT
Technical, analytical capabilities for sustainable solutions	Feedstock development and production and Climate-Smart Agriculture	Regulatory, policy, and infrastructure planning and deployment

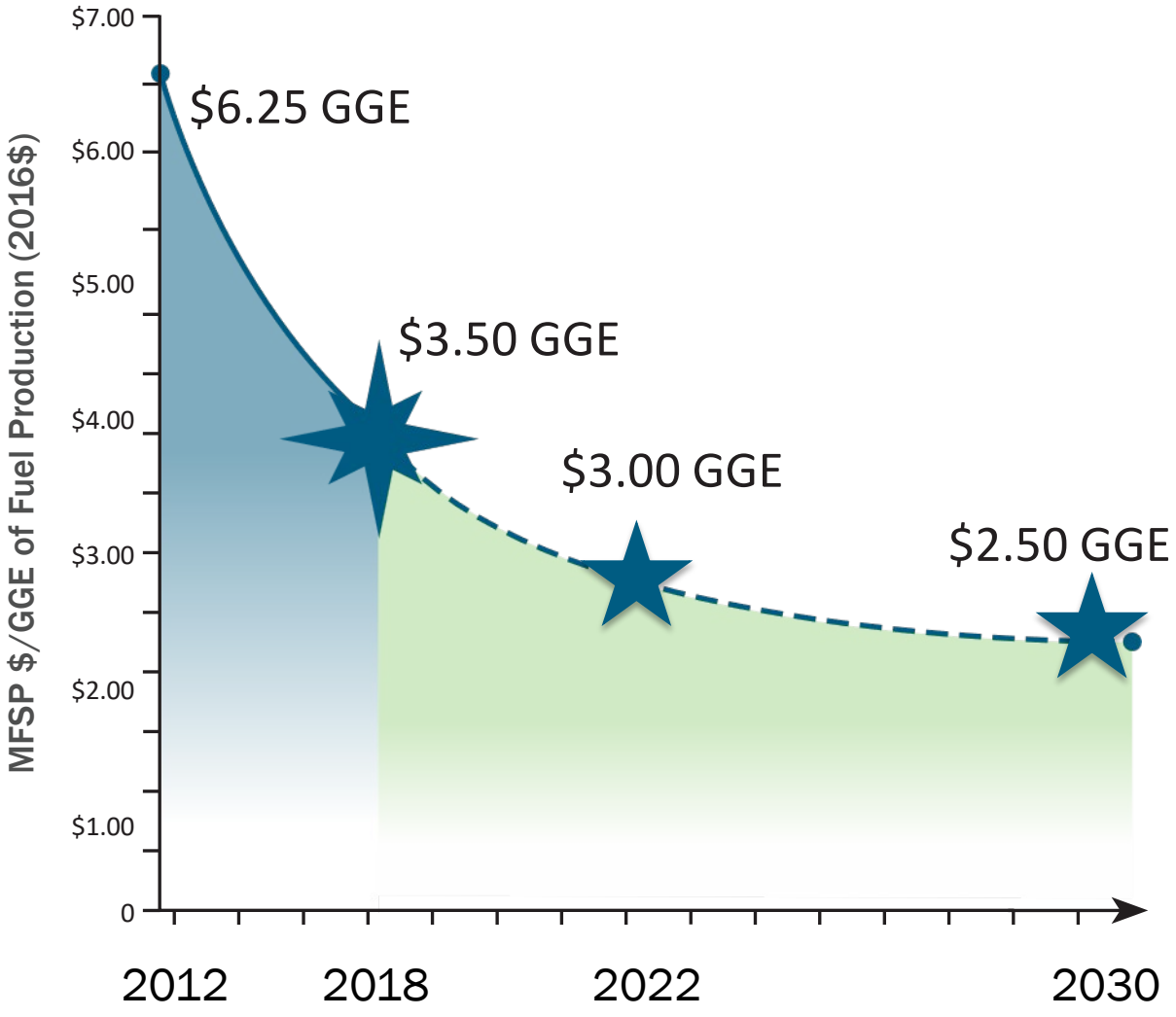
BETO's Role in SAF: De-Risk and Accelerate Commercialization



	R&D	Pre-Pilot	Pilot	Demonstration	Commercial
Average Total Project Cost	$1–$5 Million	$5–$10 Million	$25–$50 Million	$100–$500 Million	$250–$500 Million
Average Biomass Throughput	Grams/Day	Kilograms/Day	<50 Tonnes/Day	50–250 Tonnes/Day	+250 Tonnes/Day
Production Volumes	mL/L (batch)	Liters/Gallons (batch)	0.1–1 M GPY (campaign)	1–10 M GPY (extended campaign continuous)	50 M GPY (continuous)

Government Project Recipients and Partners Banks

BETO SAF Goals and Impact



MFSP = minimum fuel selling price | GGE = gallon gas equivalent

GOALS

Cost Reduction with Maximum CO_2 Reduction

2022	• $3.00/GGE, 60% GHG reduction
2030	• $2.50/GGE, 70% GHG reduction

Increase Commercial Supply of SAF

2030	• Demonstrate as many as 10 feedstock/technology pathways at engineering scale to reduce risk for commercial build out • Equip traditional biofuel industry to transition to SAF with GHG reductions of >70%
2050	• Aggressive industrial build-out resulting in 35B gal SAF in market (100% projected aviation needs)

Long-Term Impacts

2030	• 3B gal SAF (70% GHG reduction)
2050	• 60B gal renewable hydrocarbon fuels • 40B pounds of renewable chemicals • >450 million tons CO_2 reduced annually • 1 million direct jobs

BETO SAF Funding Opportunities

- $61 Million BETO Scale-Up and Conversion Funding Opportunity
- $34 Million BETO Waste and Algae Bioenergy Technology

energy.gov/eere/bioenergy/bioenergy-technologies-office-funding-opportunities

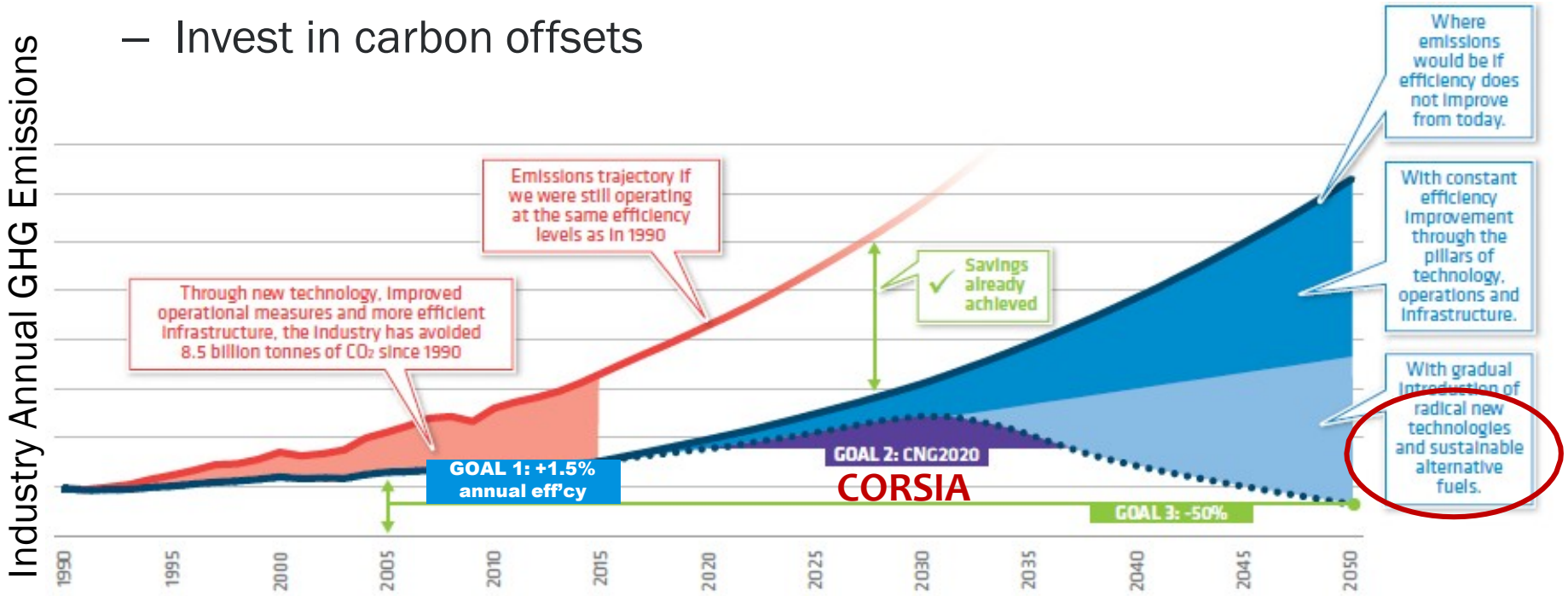
Photo courtesy of Werner Slocum, NREL

III. Aviation Sector and SAF Commitments

Photo courtesy of L Filipe C Sousa, Unsplash.com

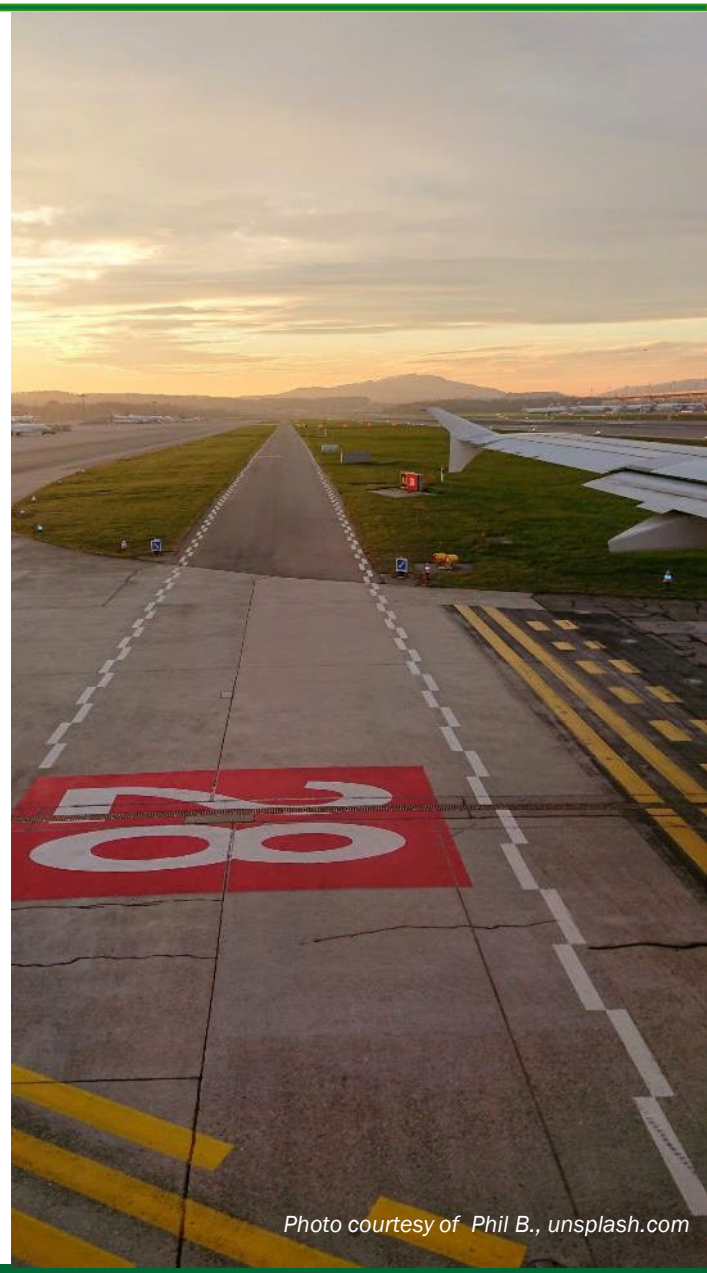
Airline Industry Commitment to Decarbonize

- **By 2050 cut net CO_2 emissions to 50% of 2005 levels**
  - Airframe technology
  - Improvements in operations and infrastructure
  - Deploy sustainable aviation fuels
  - Invest in carbon offsets



SAF a key component of the Technology Pillar; enabler for GHG containment strategy.

Source: Air Transport Association Group (ATAG)



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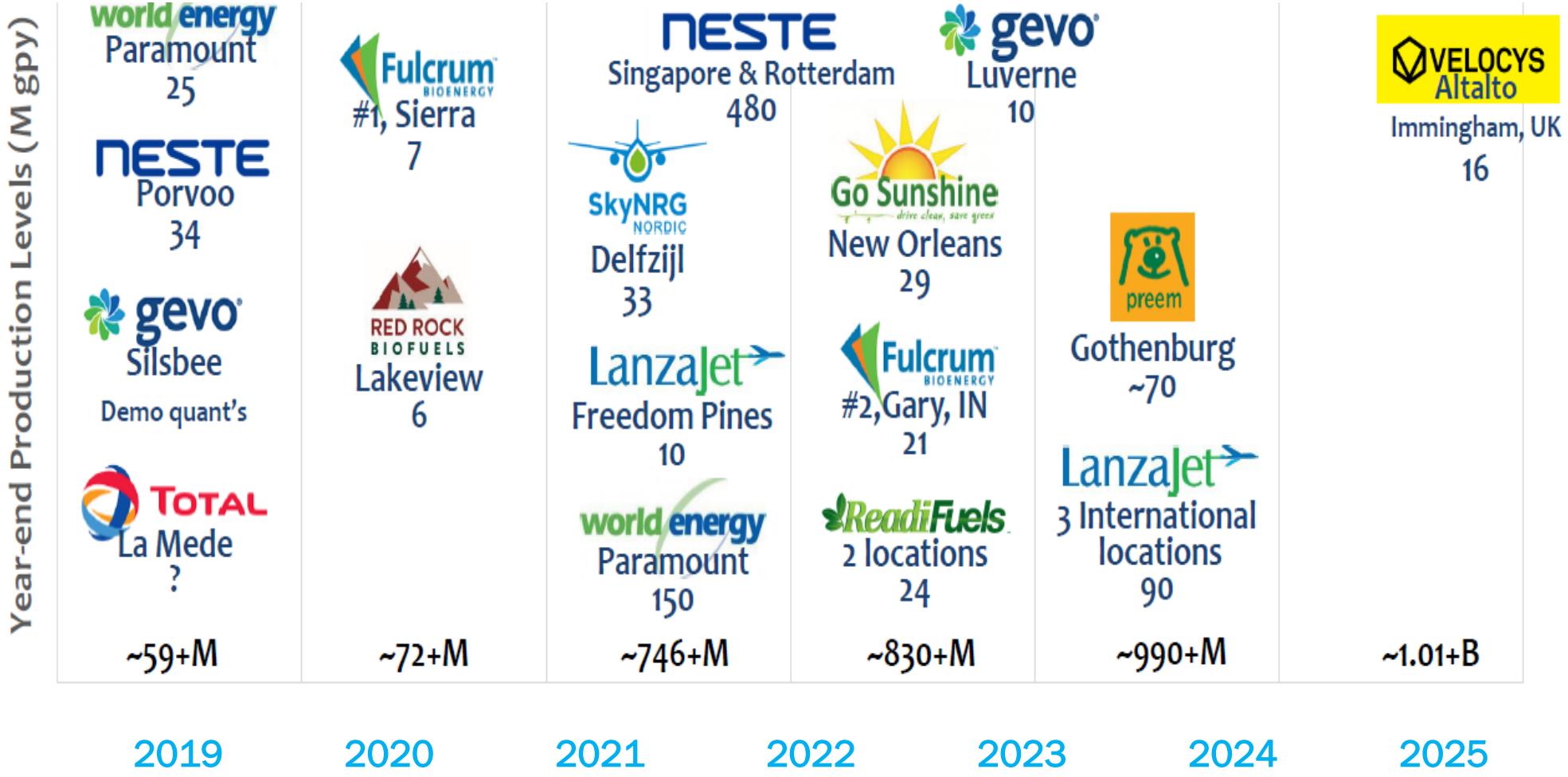
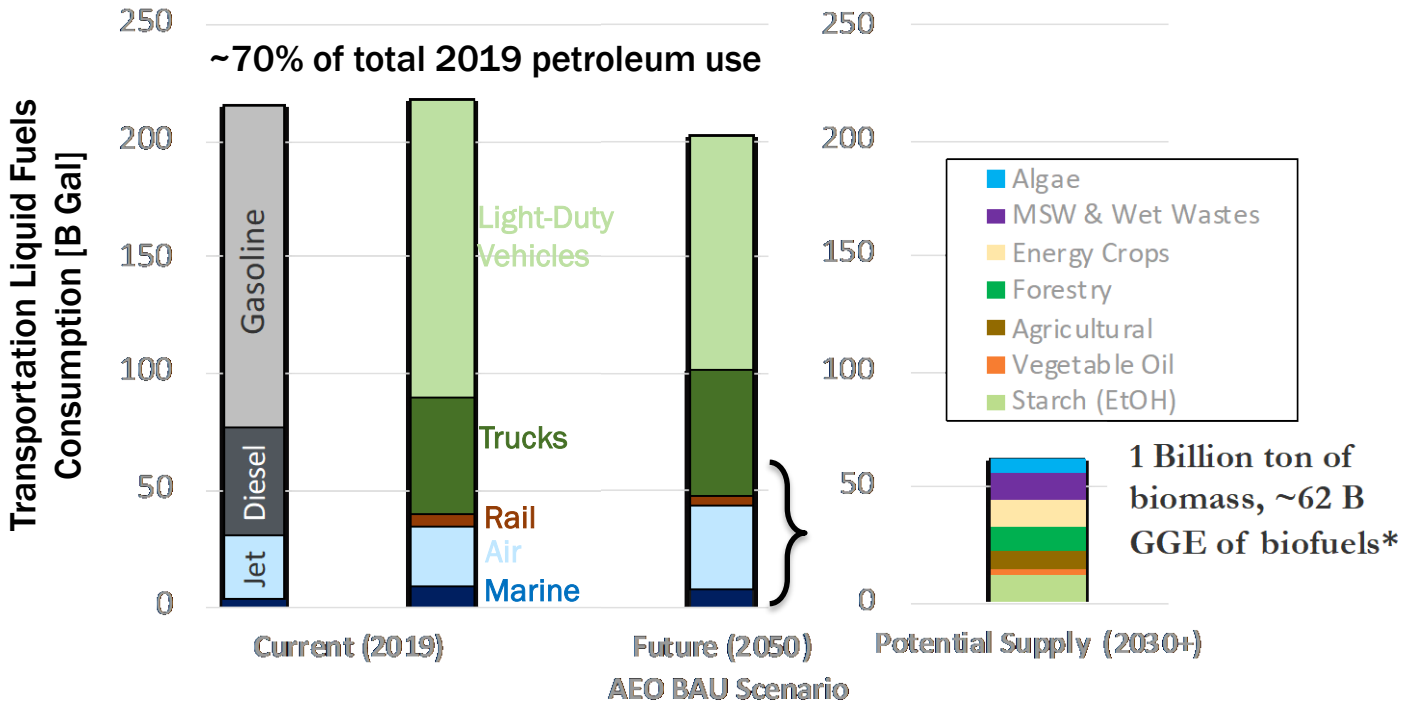
Key SAF Players and Production Projection (Announced)



Source: Commercial Aviation Alternative Fuels Initiative

SAF Markets for Biomass



* Gal = gallons | MSW = municipal solid waste | GGE = gasoline gallon equivalent | AEO BAU = Annual energy outlook, business as usual

- 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 fuel** (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.
- **CO_2-to-fuels** remains to be explored.

IV. SAF Technologies and Research

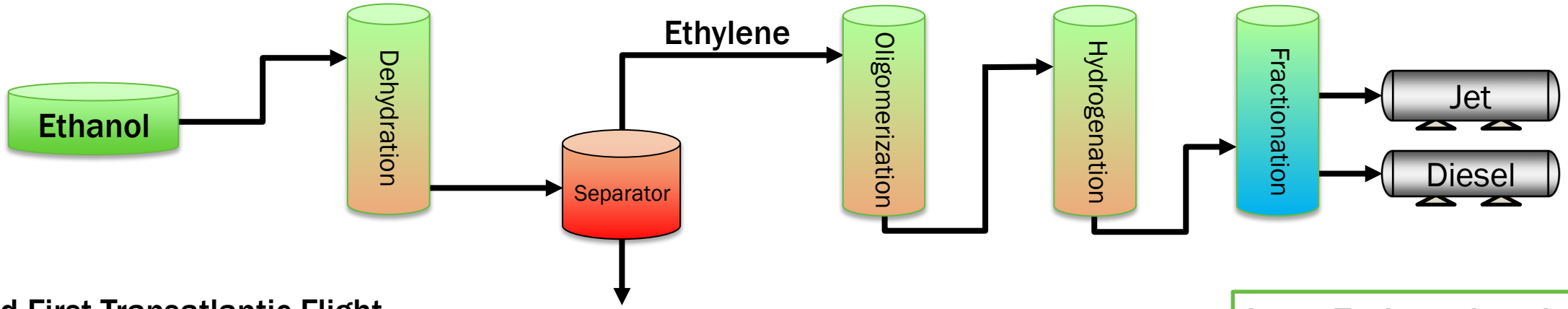
Photo courtesy of iStock

Conversion Technologies for SAF Production

Photo courtesy of Skyler Smith, Unsplash.com

- **Hydro-processed esters and fatty acids (HEFA)**
- **Alcohol-to-jet and other biochemical processes**
  - Industrial waste gases (steel mill, refinery waste gases, landfill gas, renewable natural gas)
  - Solids (corn, corn stover, biomass)
- **Gasification Fischer-Tropsch**
- **Pyrolysis**
- **Hydrothermal liquefaction (wet wastes and algae)**
- **Electrochemical conversion for CO_2 utilization technologies**

The U.S. Department of Energy Has Developed Multiple SAF Pathways



World First Transatlantic Flight
October 3, 2018

LanzaTech produced:
- ✓ 4,000 gallons jet
- ✓ 600 gallons diesel

Feedstock flexibility:
- Waste gases (CO_2, CO, H_2)
- Corn ethanol
- Cellulosic ethanol

Special Event Coming Soon…

White House with DOE, USDA, FAA, and NASA planning a virtual roundtable with public and private sector leaders to discuss decarbonizing the aviation sector while incorporating technologies like sustainable aviation fuels.

Key stakeholders attending:

- Aviation
- Manufacturing
- Fuel
- Labor
- Agriculture

Photo courtesy of Pascal Meier, Unsplash.com

Thank you!

Questions for the BETO team?

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Learn more about BETO: energy.gov/bioenergy

BETO Webinar Recording: energy.gov/eere/bioenergy/beto-webinars

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