

Bioenergy Technologies Office: Decarbonization of Transportation and Industry

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Biden Administration Guiding Principles

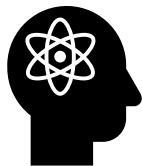
Accelerate the research, development, demonstration, and deployment (RDD&D) of innovative technologies that will transition Americans to a 100% clean energy economy no later than 2050 and ensure the clean energy economy benefits all Americans.

EERE Mission

Keys to Ensure the Greatest Impact



Environmental
Justice and Equity



Diversity in STEM



Workforce
Development



State and Local
Partnerships

EERE Program Priorities

100% decarbonized
electric grid by
2035

Decarbonize
transportation
across all modes

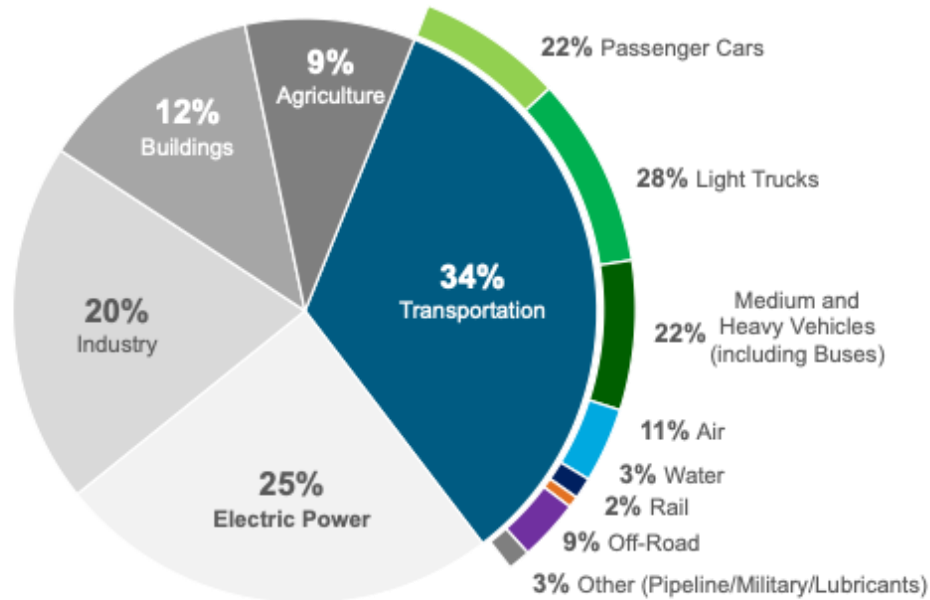
Decarbonize energy
intensive industries

Reduce the carbon
footprint of
buildings

Enable a net-zero
agricultural sector

Transportation Pillar: Sustainable Aviation Fuels

2019 U.S. GHG Emissions

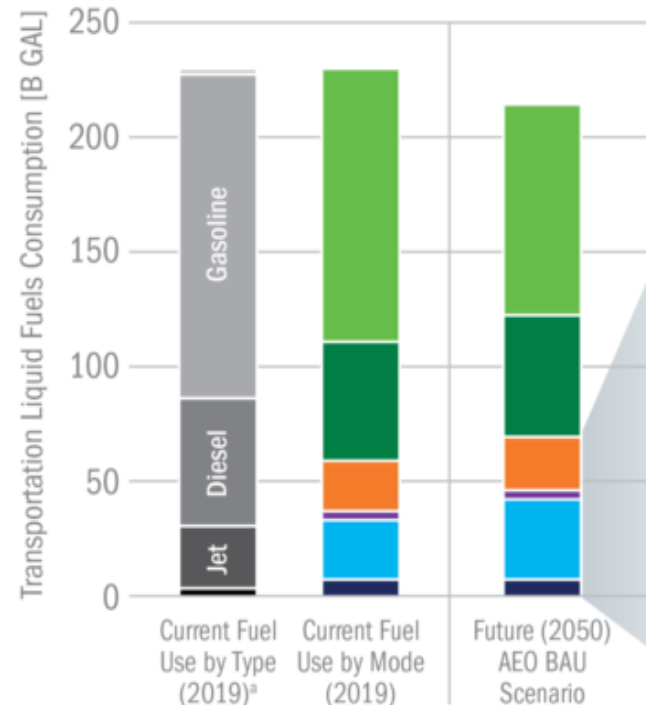


Air and water include emissions from international bunker fuels. Fractions may not add up to 100% due to rounding.

Focus areas for Biofuels

- Passenger Cars : Ethanol
- Air, Marine, Rail : “Drop In” Renewable Diesel/SAF

Current and Projected Transportation Fuel Use

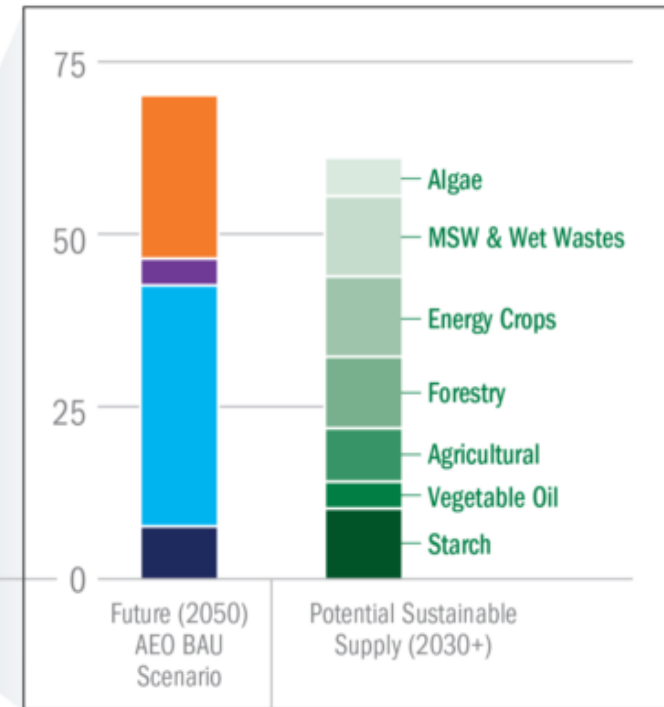


^a ~72% of total 2019 petroleum use

Fuel Use by Mode: Light-Duty Vehicles, Medium-/Heavy-Duty Vehicles, Off-Road, Aviation, Rail, Marine

Projected Liquid Transportation Fuel Demand and Sustainable Biomass Supply

1 billion tons of biomass, ~62 B GGE of biofuels
CO₂-to-fuel remains to be explored

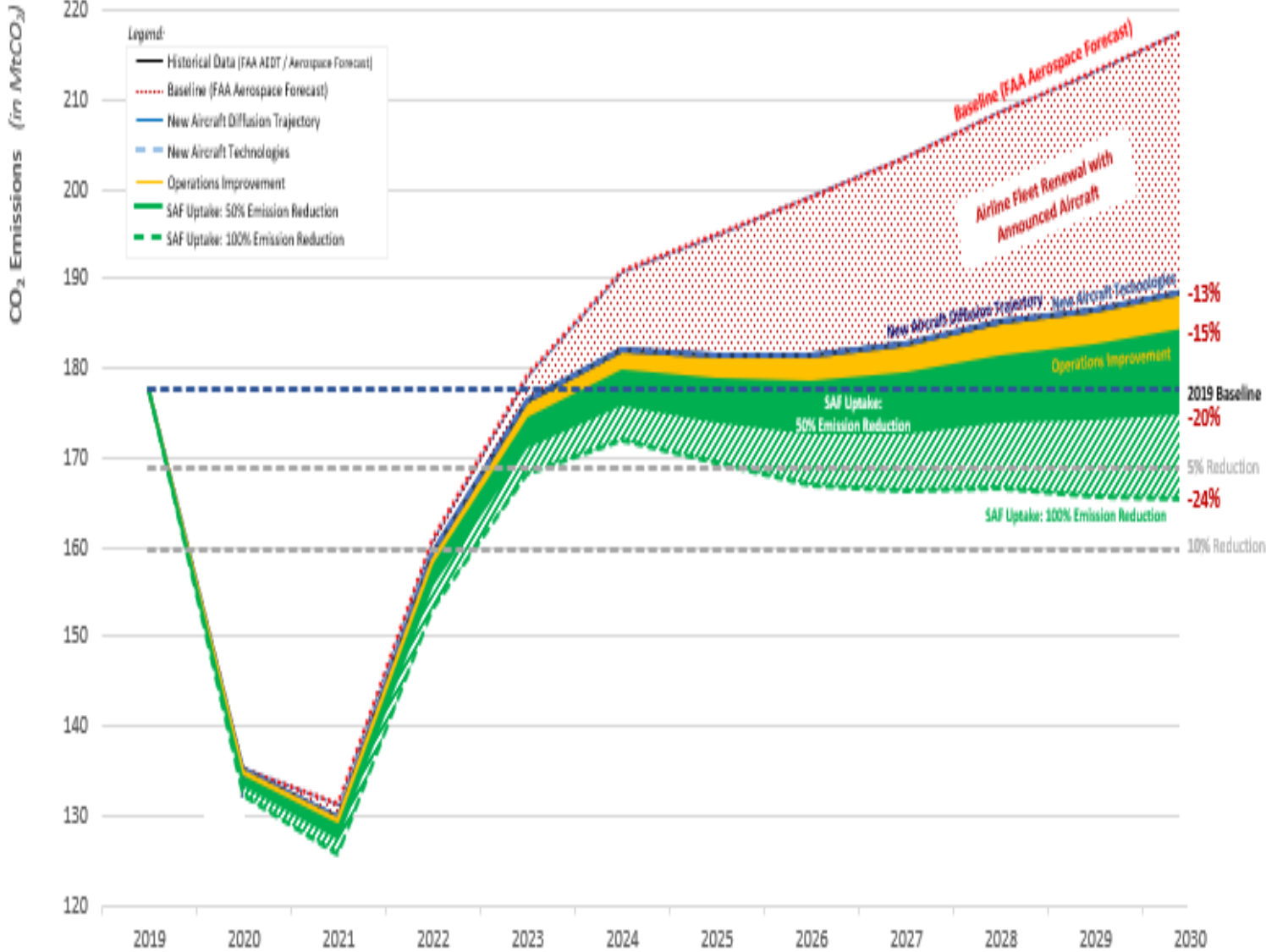


AEO = annual energy outlook | BAU = business as usual | GGE = gasoline gallon equivalent | MSW = municipal solid waste

Government-Wide Sustainable Aviation Fuel Grand Challenge

Sustainable Aviation Fuel Grand Challenge

- Part of Overall **Net Zero Aviation Sector Decarbonization Strategy**
- Minimum of a 50% reduction in lifecycle greenhouse gas (GHG) (>70% is average)
- Near Term Goal – 3B gallons by 2030 (20% CO2 reduction)
- 35B gallons by 2050
- Will require doubling of domestic capacity yearly



Agricultural Waste



CAFO Manure



Municipal Solid Waste



Timberland



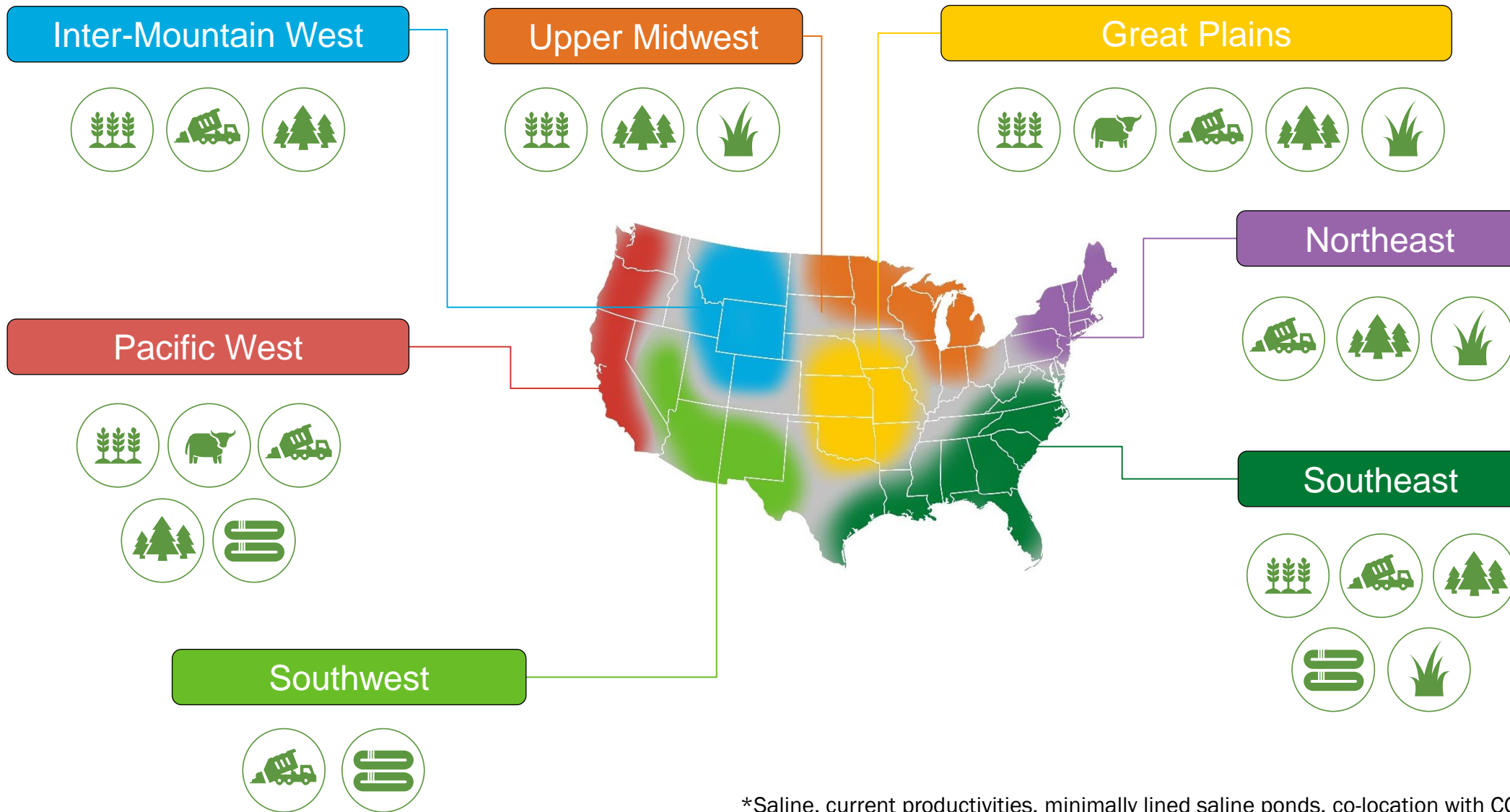
Algae*



Energy Crops**



Feedstock supply will come from regions across the United States



\$60/ton, product density > 50 tons/square mile

*Saline, current productivities, minimally lined saline ponds, co-location with CO₂ from coal, natural gas, and ethanol plants at prices from \$755-\$2,889 per dry ton (\$2014)
 **Energy crops derived from 2040 dataset, all other biomass from 2017 dataset

What Does Making 35 Billion Gallons of SAF Mean?

Major benefits across the United States

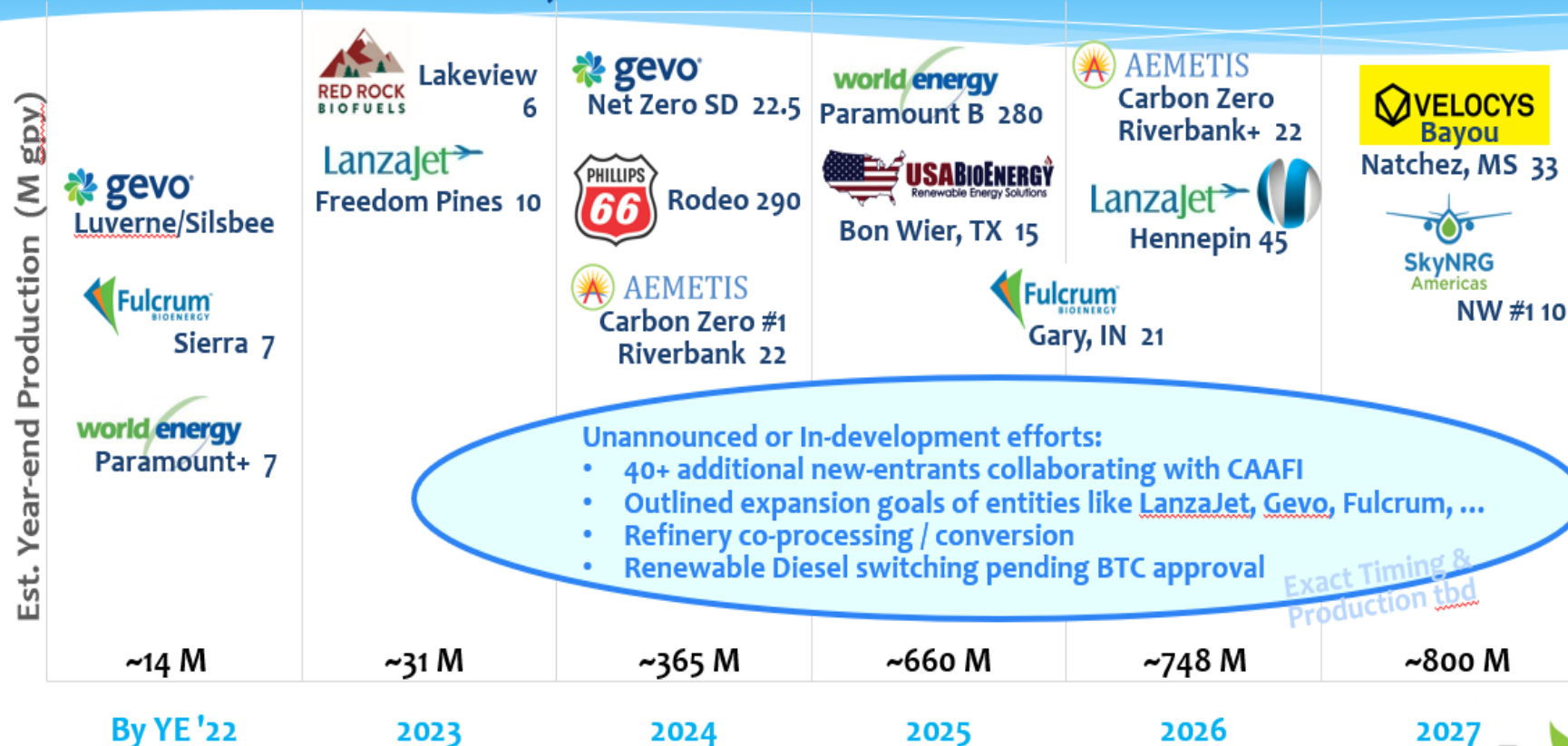
- **Create jobs in green industries** – The corn ethanol industry created about 68,000 jobs. SAF will maintain the corn ethanol industry and will be over 11 times larger.
- **Invest in communities and help manage waste disposal** – Farmers will be able to sustainably produce and collect new crops and residues while communities will have less waste going to landfill.
- **Achieve lasting carbon reductions across our economy** – A variety of SAF conversion technologies will be used to convert biomass and waste to SAF. These feedstock/technologies will reduce CO₂ emissions from 55% to over 165% depending on the combination.
 - CO₂ is removed from the air during biomass growth
 - Carbon in the form of fossil fuels stays sequestered in the Earth



Photo courtesy of FDC Enterprises

State of Industry

U.S. SAF production forecast Announced intentions, neat*



URGENT expansion of emerging industry needed to meet:

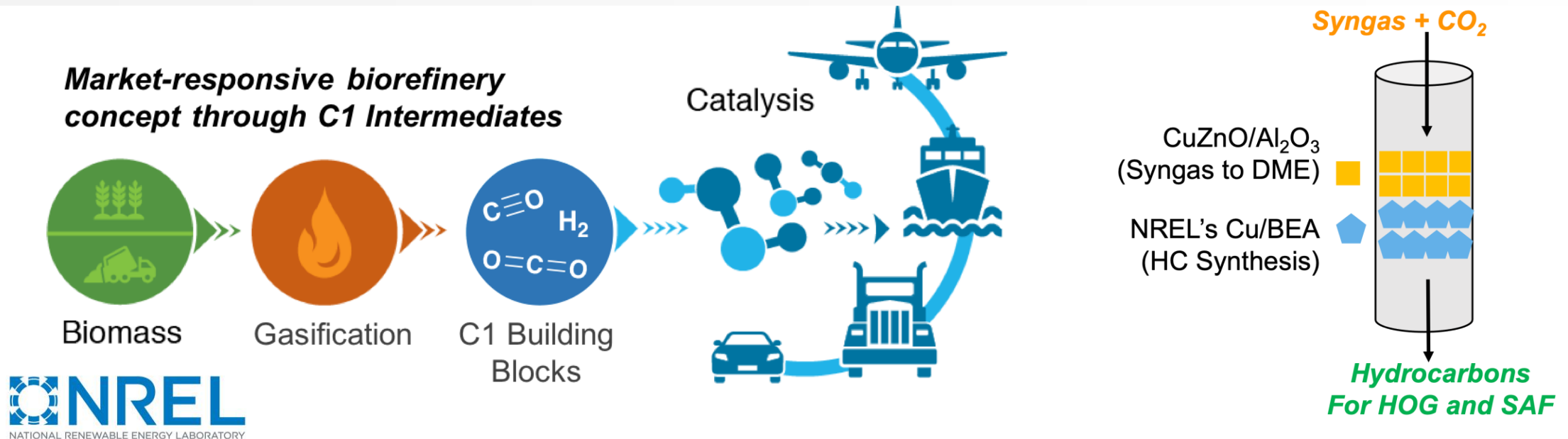
- Government-Industry goal of 3B gal by 2030, doubling SAF production each year through 2030
- U.S. Government Sustainable Aviation Fuel Grand Challenge of 35B Gal by 2050, meeting 100% of aviation fuel demand
- Requires 400–500 refineries in the United States, more than double today's current fuel ethanol industry

- Not comprehensive; CAAFI estimates (based on technology used & public reports) where production slates are not specified. Does not include various small batches produced for testing technology and markets.
- Does not include fractions of substantial Renewable Diesel capacity (existing and in-development) that can be shunted to SAF based on policy support



Applied R&D Examples - Syngas-to-Hydrocarbons in a Single Reactor

- Energy-dense hydrocarbon product using NREL's Cu/BEA zeolite catalyst
- Success for high-octane gasoline (HOG) from dimethyl ether (DME) motivated SAF target
 - Year-over-year HOG improvements – MFSP \$3.40/GGE, **>70% GHG reduction**
 - Exploring HOG commercialization with industrial partner
- Transitioned process to target SAF product
- Comparable activity and selectivity in 1-step compared to 3-steps
- Demonstrated co-conversion of CO₂ with syngas to **increase overall carbon efficiency**



Key Take Aways

- **Biomass can play a significant role in decarbonizing several sectors of the economy**
- **Biomass offers opportunities for good jobs, new economic opportunities and environmental benefits for all states and regions in the US.**
- **Diversity of feedstock means a diversity of conversion methodology**
- **Near term deployment is driven by strong market pull**
 - **Continued investments in technology and scale-up demonstration are needed to ensure access to all feedstocks in all regions and meet decarbonization goals**
- **Focus on sustainability is essential**