



Clean Fuels  
& Products™

## Overview of the Clean Fuels & Products Energy Earthshot™ *Alternative Sources for Carbon-based Products*

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## **Carbon based fuels, chemicals, and products:**

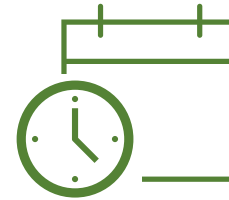
- Enable almost all aspects of modern life
- Drive the nation (>8% of GDP)
- Provide high-quality jobs (10 million+)

**... yet result in the largest single source of GHG emissions within the economy.**

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



Webpage

# 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

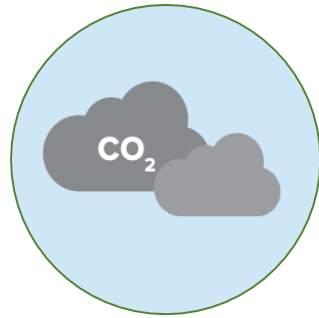
- **Hydrocarbon chemicals**

- **Chemicals** sector is the largest contributor to U.S. industrial GHG emissions and projected to grow
- **Shot Focus:** Clean sources for chemical feedstocks and polymer resins



# Clean Sources and Conversion Technologies are Needed

## 2050 Resource Supply



1,050 MMT  
biomass and  
waste

450 MMT CO<sub>2</sub> ...can be converted into...

>400 MMT\* fuels and  
products

\*This Shot assumes that 50% of marine, rail, off-road, hydrocarbon chemicals and 100% of aviation demand will be met by these hydrocarbon fuels in 2050.



# Pillars/Core Research Areas



## Resource/Feedstock Mobilization

- New technologies to enable low cost, low-emissions feedstocks at scale
- Increased carbon incorporation into biomass

## Carbon-Efficient Conversion Processes

- New carbon-efficient conversion technologies
- Innovation to improve CO<sub>2</sub> catalytic conversion efficiency
- Solar fuels
- Processes using green electricity and hydrogen

## Technology Scaling & Demonstration

- Integrated pilot and demonstration scale facilities to de-risk technology for rapid industry adoption

## Societal Considerations/Impacts

- Energy equity impacts and differentiated regional strategies
- Cradle to grave life-cycle analysis and sustainability modeling to prioritize the most impactful R&D

# Clean Fuels & Products: Crosscutting, All-hands-on-deck Effort

## Foundational Research

## Applied Technology Research, Development, & Demonstration

## Demonstration & Deployment



SC-BER



SC-BES



SC-ASCR



ARPA-E



AMMTO



HFTO



FECM



BETO



IEDO



OCED

DOE National Labs

### Basic research advancing biological, chemical, and computational systems:

Catalysis  
Genomic Modification and Design  
Chemical/Physical Separations  
Materials Science  
Advanced AI, ML, and Data Science Methods

**Leverage scientific user facilities**

### Technology transition across:

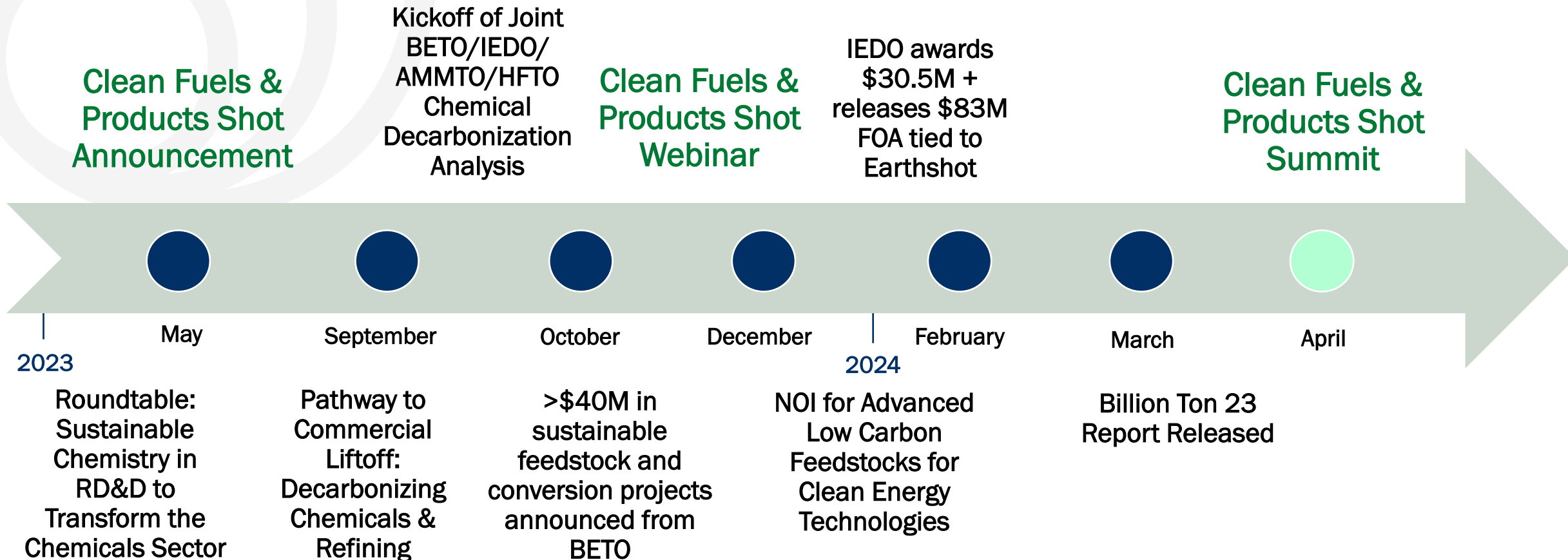
Biomass/Waste/CO<sub>2</sub> Conversion to Fuels/Chemicals  
Sustainable Supply Chains, Processing, and Manufacturing  
Efficient Processes, Circularity, and Environmental Co-benefits  
Decarbonization of Chemical Manufacturing  
Clean H<sub>2</sub> Production, Storage, and Delivery  
Point Source/Direct Air Carbon Capture

**Leverage LCA/TEA modelling**

### Demo projects:

De-risk Technologies, Approaches, and Business Models to Enable Adoption, Replication and Scaling

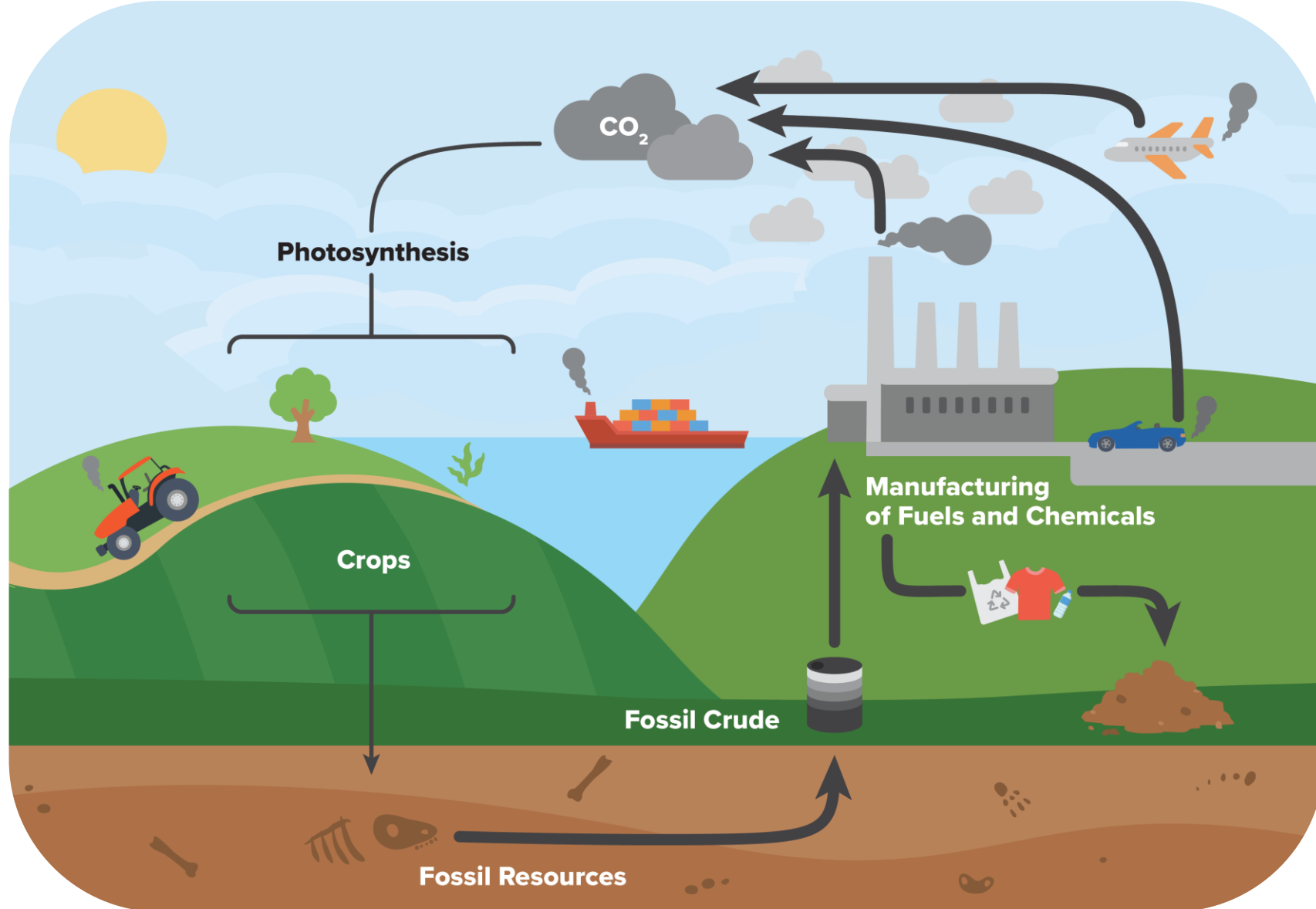
# Action Summary



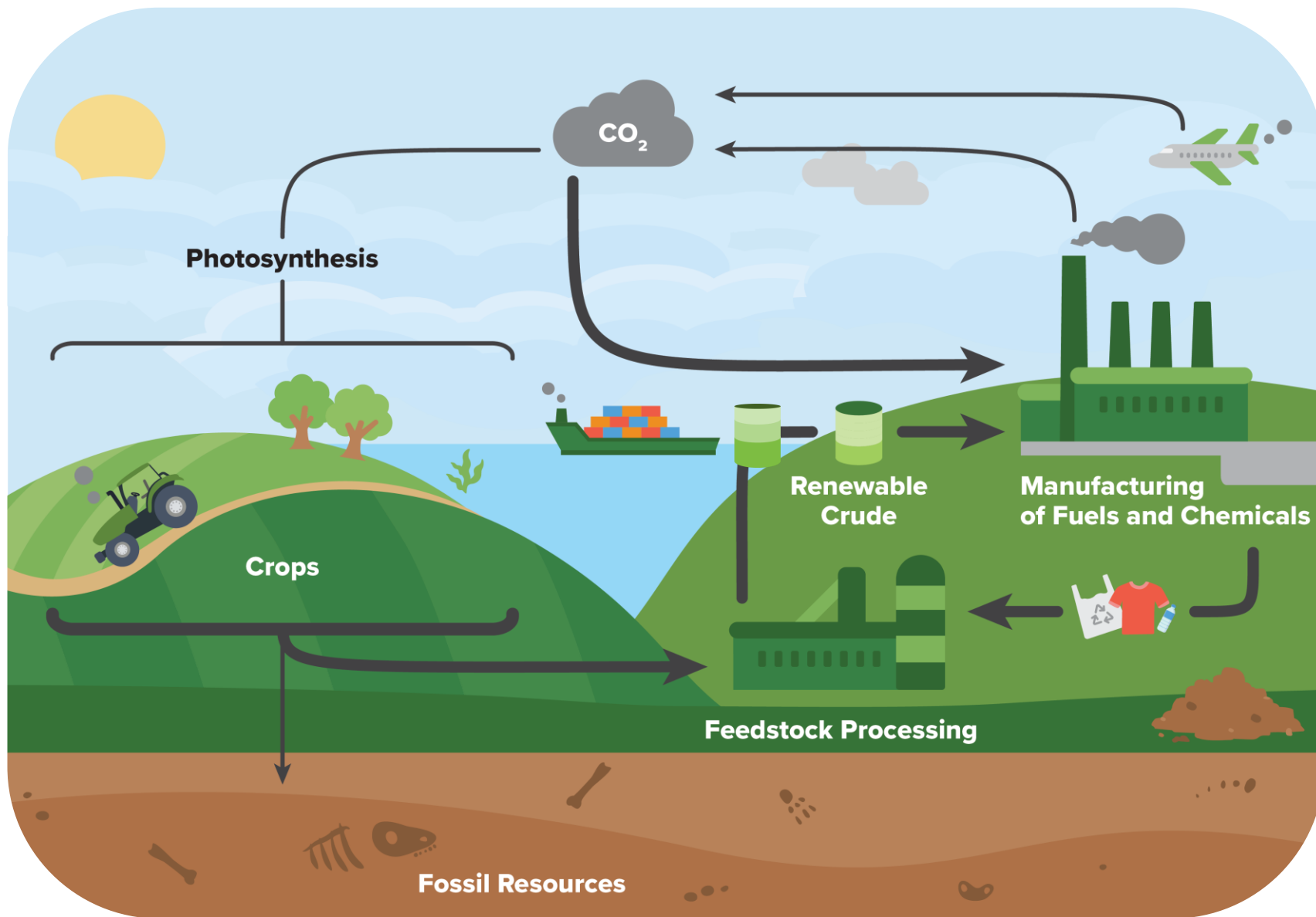


# Backup

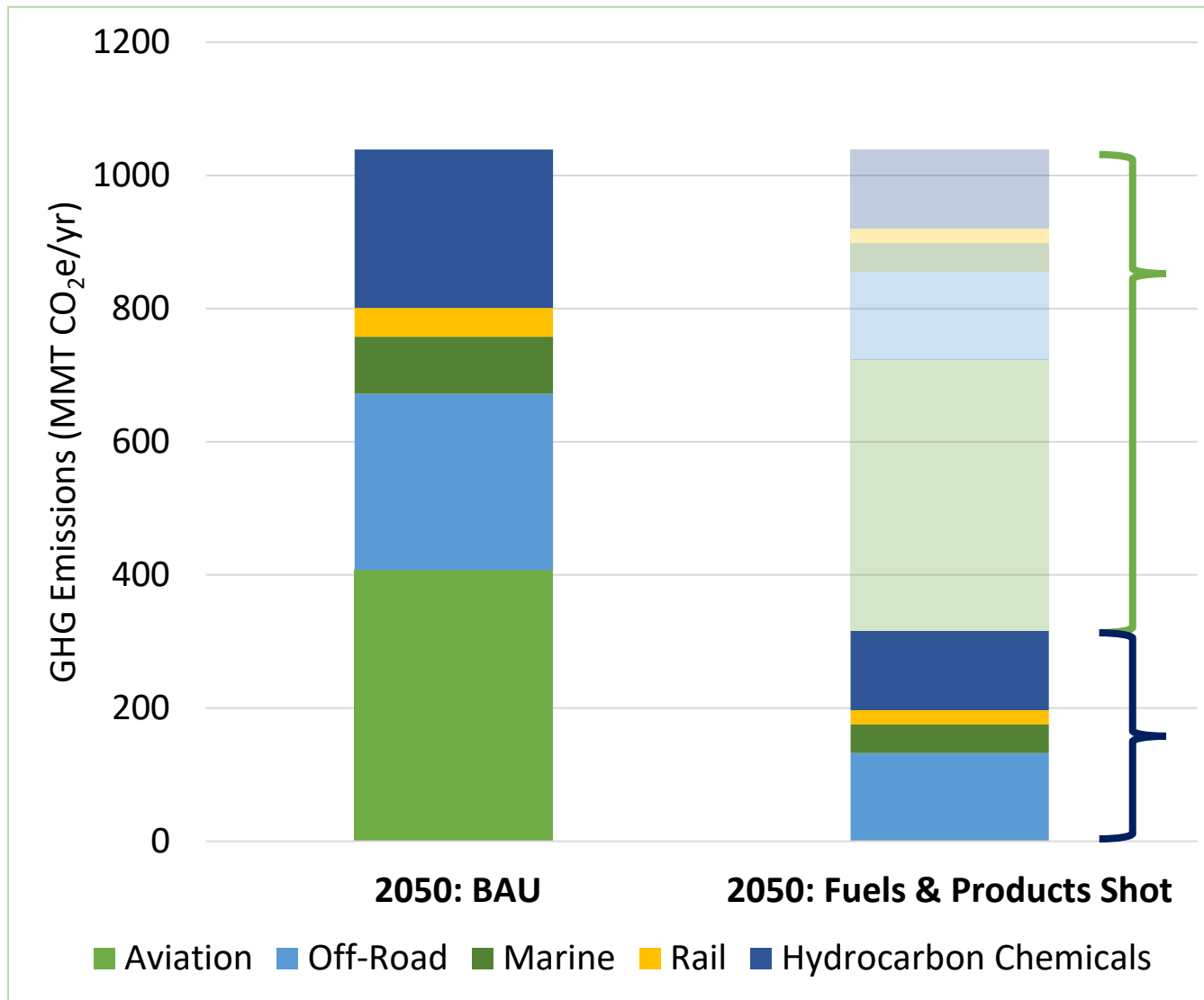
# The Challenge: *The Carbon Cycle is Imbalanced*



# Shot Goal: *Rebalance the Carbon Cycle* for Fuels & Products



# Clean Fuels & Products: Potential Impact



**>650 MMT reduction =  
Over 10% of total 2019 U.S. GHG emissions**

**Address with other technologies  
(electrification, hydrogen, ammonia, etc.)**



Assumes 100% of aviation demand will be met by sustainable liquid fuels. Assumes 50% of fuel demand for off-road, marine, and rail will be met by liquid fuels and 50% of hydrocarbon chemical demand will be met by sustainable sources. GHG emissions for hydrocarbon chemicals estimated by scaling total chemical sector emissions by mass.



# Pathways to Develop Clean Fuels & Products



## Mobilize Renewable Carbon Resources

### Expand and Develop New Feedstocks:

Develop and utilize new technologies to maximize carbon incorporation and retention to generate low-cost, low-emissions biomass, waste, and CO<sub>2</sub> feedstocks at scale

### Examples:

Forest residues, agricultural wastes, municipal solid waste, recycled materials, energy crops, algae, CO<sub>2</sub>



## Carbon-Efficient Conversion

### New Conversion Paradigm:

Develop technologies to maximize conversion of resources into fuels and chemicals utilizing clean power, clean hydrogen, clean heat, and optimized reactor systems

### Examples:

Biomass gasification to SAF, solar fuels, power to liquids, catalytic conversion of CO<sub>2</sub>

**Analysis for accurate and complete carbon accounting through robust lifecycle assessment**



# Other Impacts

## Secure Domestic Supply Chains

- Develop and safeguard domestic supply chains for key fuels and products
- Better insulate U.S. energy markets against geopolitical fluctuations

## Economic Competitiveness

- Lead the world in renewable fuels and hydrocarbon chemical based products
- Create and sustain new, high-paying jobs in domestic manufacturing

## Equity & Environmental Justice

- Alleviate negative health impacts for communities near current refining and petrochemical facilities
- Achieve positive change with expanded economic opportunities in rural and remote communities
- Diversify R&D researcher base and companies so that the workforce is representative of America

