



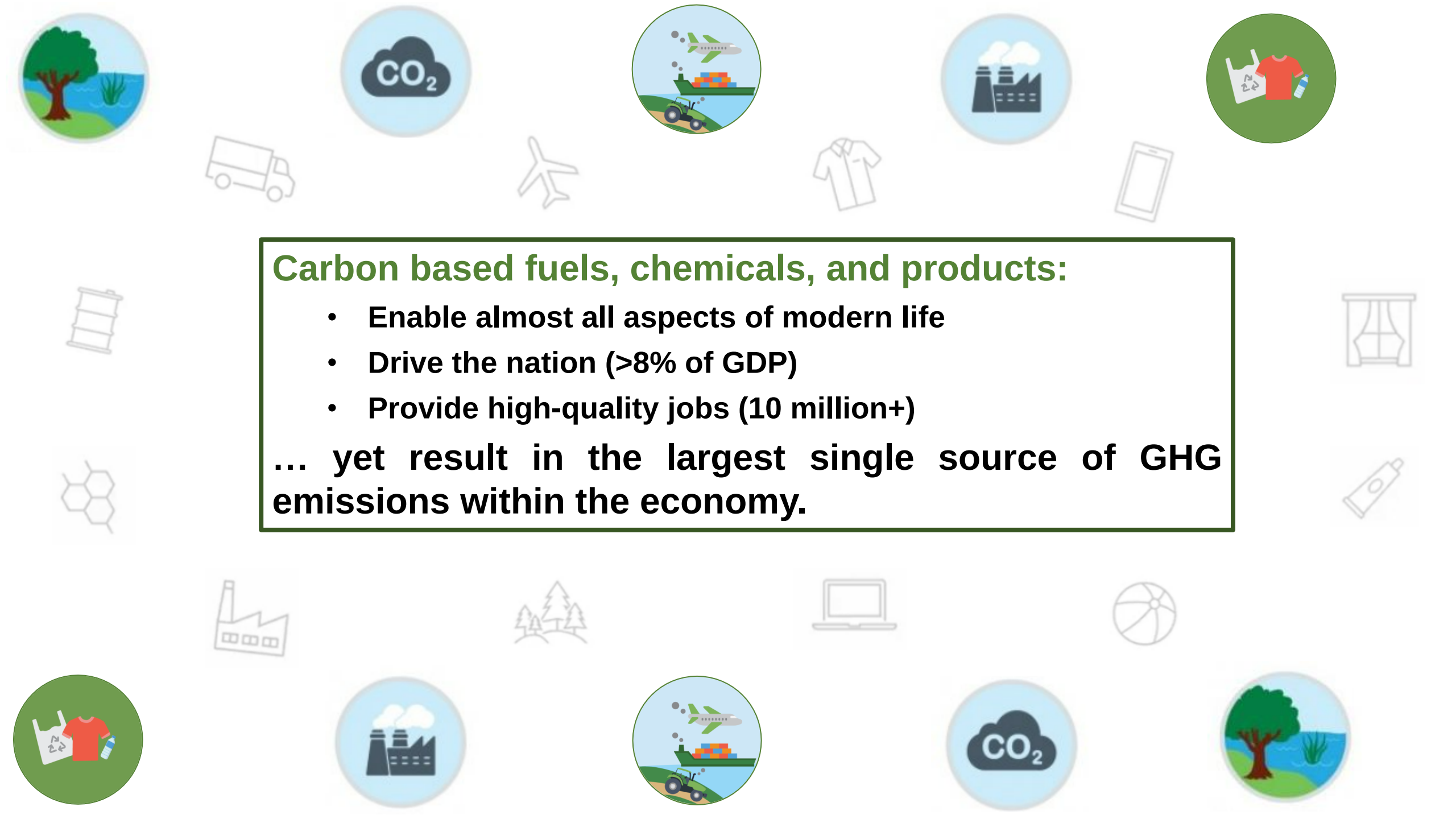
Clean Fuels
& Products™

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

Presented By:

Office of Energy Efficiency and Renewable Energy

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Carbon based fuels, chemicals, and products:

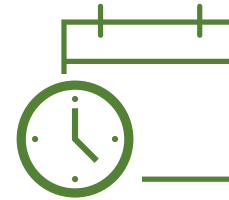
- Enable almost all aspects of modern life
- Drive the nation (>8% of GDP)
- Provide high-quality jobs (10 million+)

... 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

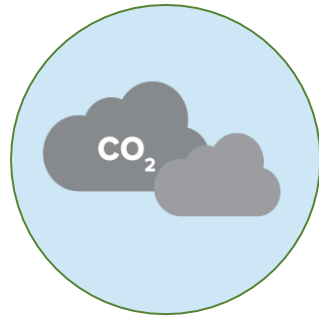
- **Hydrocarbon chemicals**

- **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 CO₂ ...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 CO₂ 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



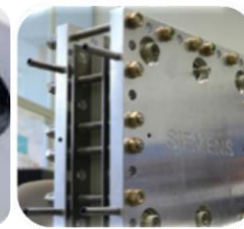
ARPA-E



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:

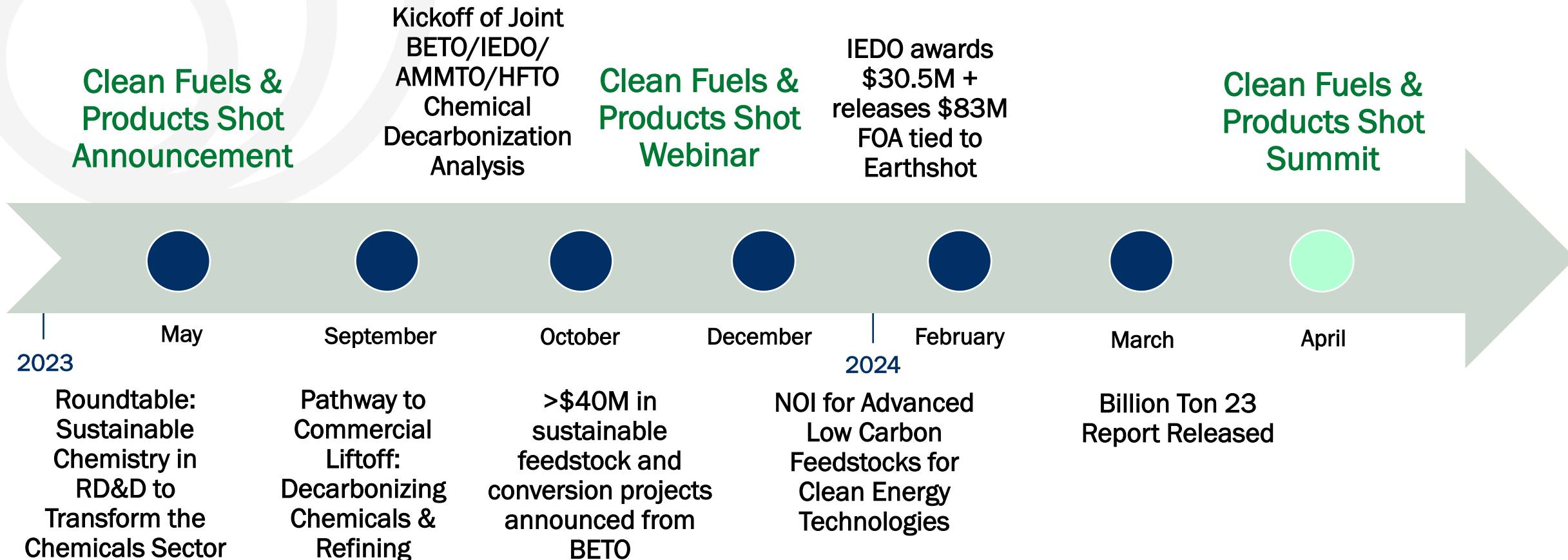
Biomass/Waste/CO₂ Conversion to Fuels/Chemicals
Sustainable Supply Chains, Processing, and Manufacturing
Efficient Processes, Circularity, and Environmental Co-benefits
Decarbonization of Chemical Manufacturing
Clean H₂ Production, Storage, and Delivery
Point Source/Direct Air Carbon Capture

Leverage LCA/TEA modelling

Demo projects:

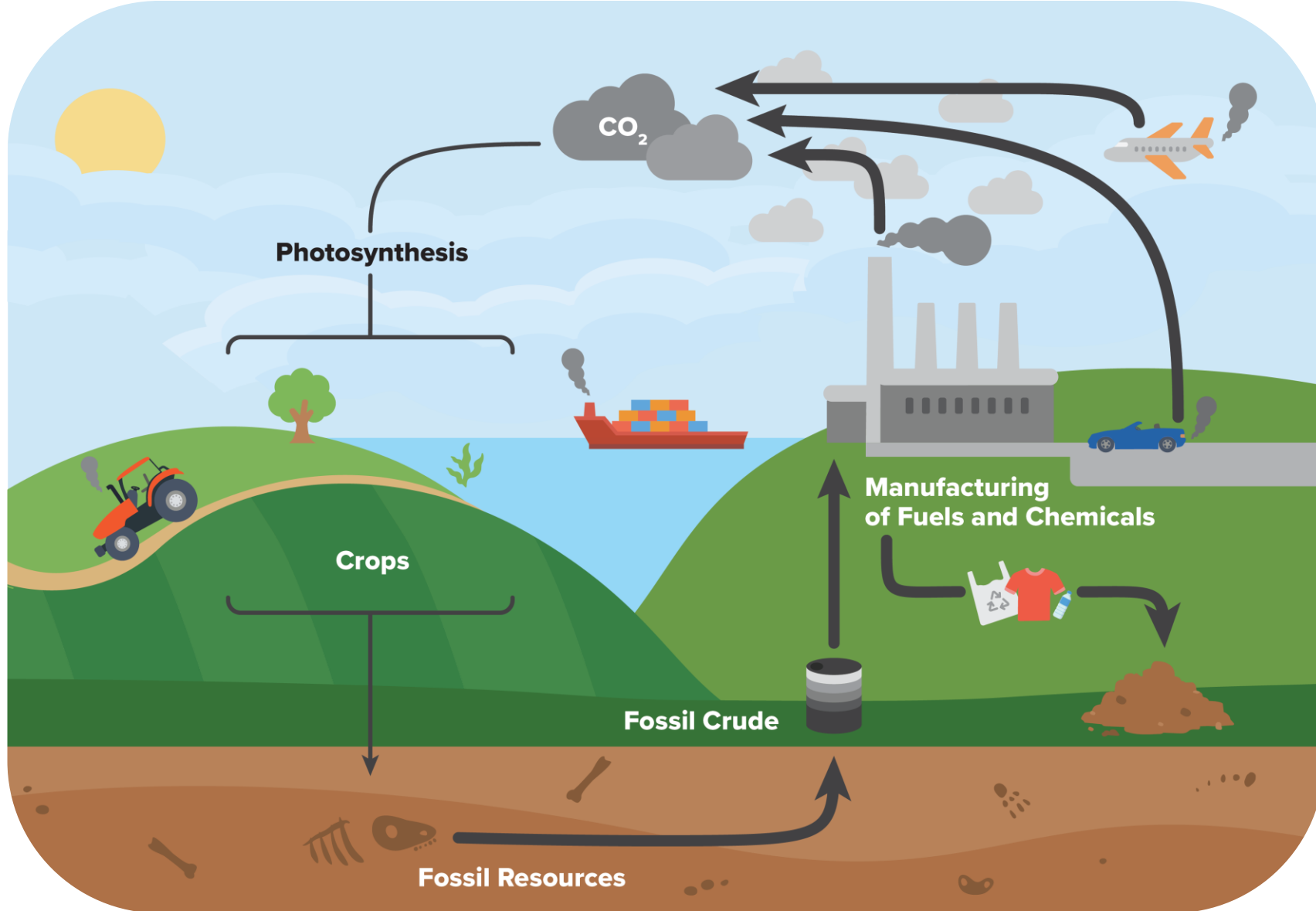
De-risk Technologies, Approaches, and Business Models to Enable Adoption, Replication and Scaling

Action Summary

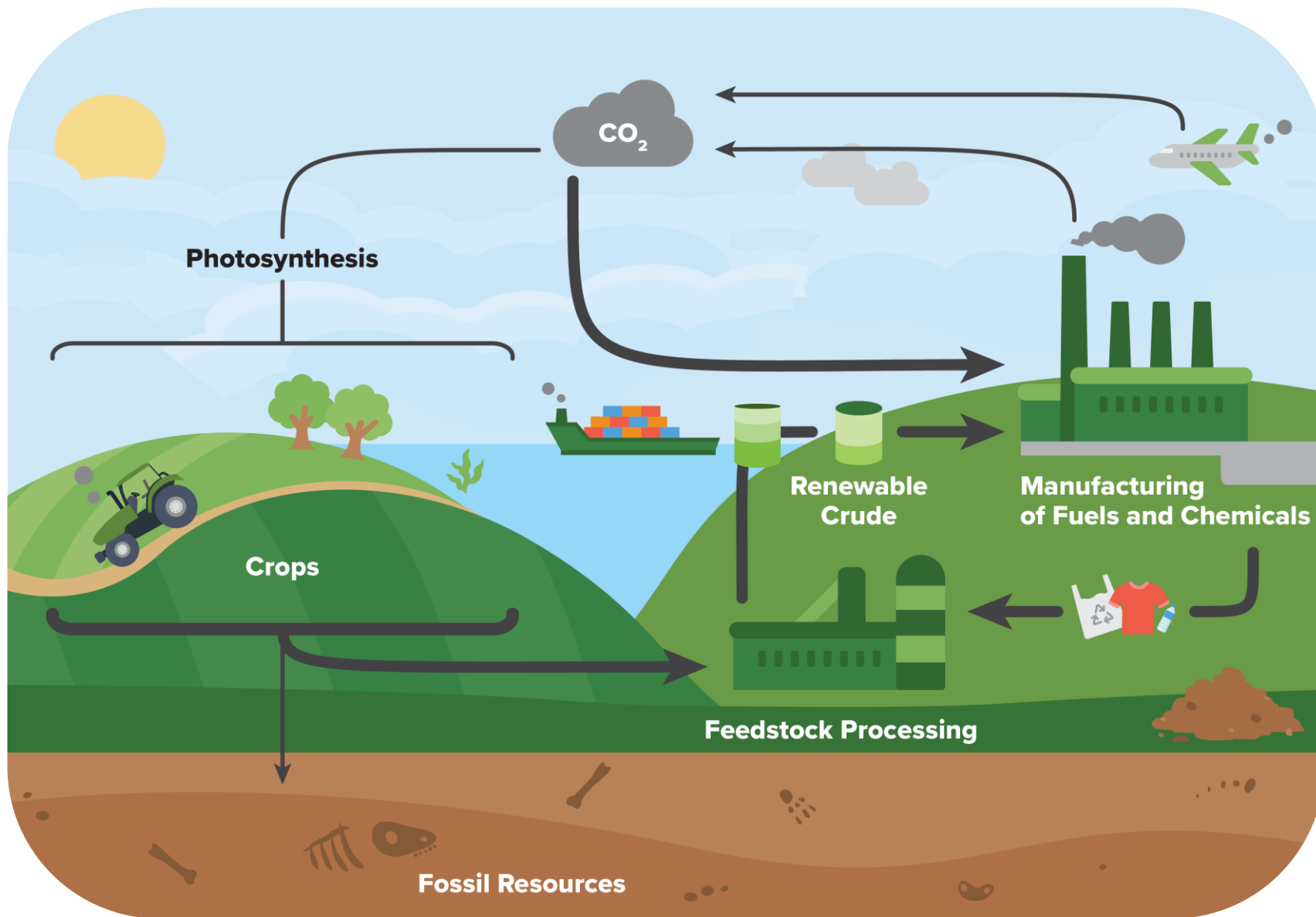


Backup

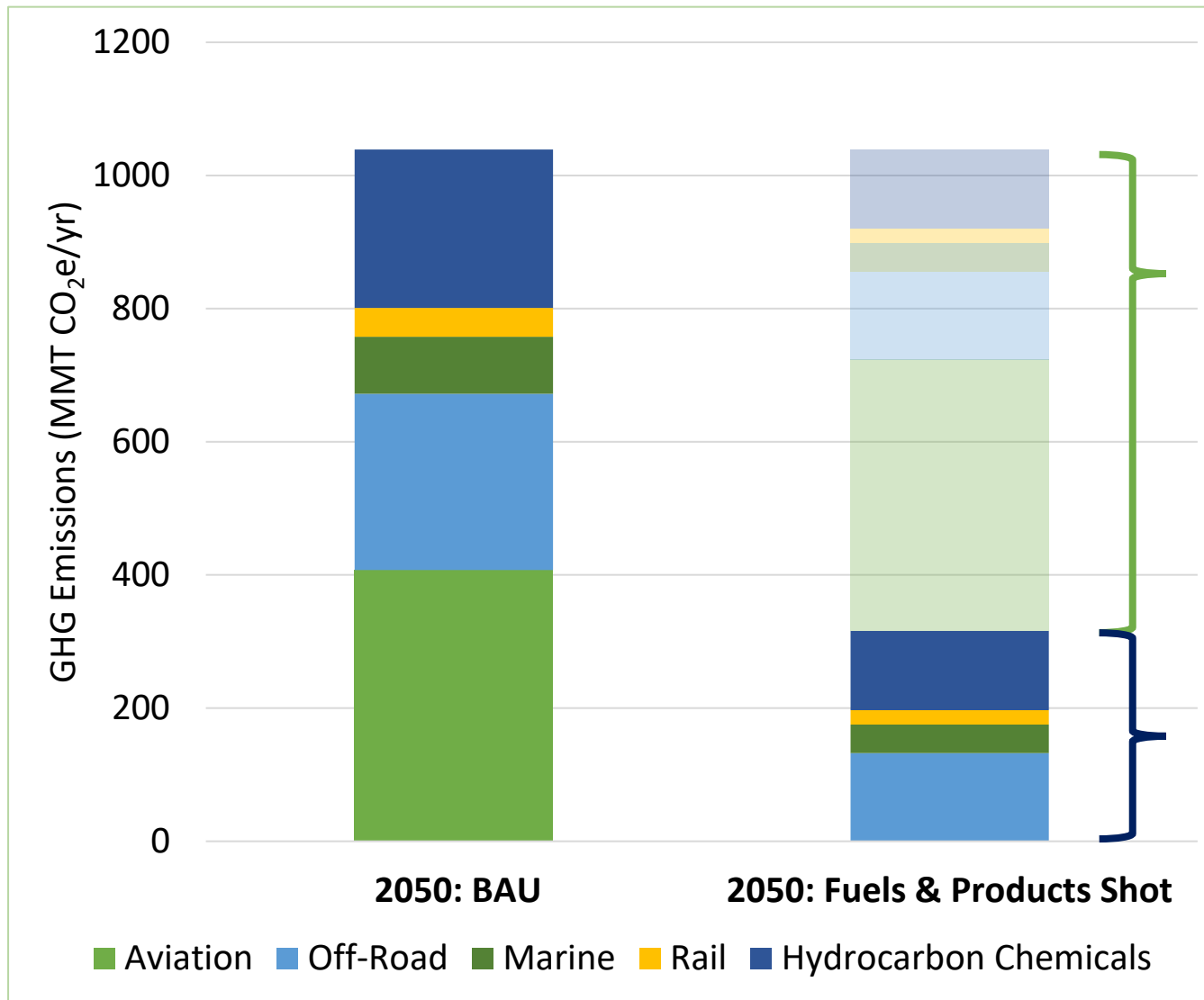
The Challenge: *The Carbon Cycle is Imbalanced*



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 CO₂ feedstocks at scale

Examples:

Forest residues, agricultural wastes, municipal solid waste, recycled materials, energy crops, algae, CO₂



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 CO₂

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

