Webinar

ENERGY earthshots | Clean Fuels & Products™

U.S. Department of Energy

Clean Fuels & Products Shot™

Path Forward for Decarbonizing the Nation's Fuels and Products

NOVEMBER 28, 2023
4:00 PM ET

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Visit the Bioenergy Technologies Office website to register: energy.gov/eere/bioenergy/beto-webinars

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Energy Earthshots | Clean Fuels & Products™

November 28, 2023

Presented By:

Office of the Under Secretary for Science and Innovation

Devinn Lambert

Office of Energy Efficiency and Renewable Energy

Jay Fitzgerald, Bioenergy Technologies Office

Felicia Lucci, Industrial Efficiency & Decarbonization Office

Office of Fossil Energy and Carbon Management

Emily Connor, Carbon Dioxide Removal and Conversion

Office of Science

Todd Anderson, Biological and Environmental Research

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Introduction to the Energy Earthshot™ Initiative

Presented By:
Office of the Under Secretary for Science and Innovation
Devinn Lambert, Deputy Director, Crosscuts and Energy Earthshots

A Call to Action

“…I’ve asked the Secretary of Energy…to speed the development of critical technologies to tackle the climate crisis. No single technology is the answer on its own because every sector requires innovation to meet this moment.”

"Over the coming weeks…DOE will be announcing new goals for bold, achievable leaps in next-generation technologies—

This is our generation’s Moonshot.”

Energy Earthshots™: Necessary and Urgent

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"All hands-on-deck" effort targeting the ***remaining, major RD&D breakthroughs*** we know ***must be achieved in the next decade*** to solve the climate crisis and achieve the Biden Administration's goal of a Net-zero carbon economy by 2050.

- Make a major impact to **reduce GHG emissions**
- Address the **most difficult-to-solve technology barriers**
- Set **highly ambitious targets** that are **compelling, bold, and inspirational**
- Significantly **engage stakeholders**

Leverage Past Success
SunShot
U.S. Department of Energy

Energy Earthshots™ Portfolio

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Generation & Grid

- Floating Offshore Wind
- Enhanced Geothermal
- Long Duration Storage

Industry

- Industrial Heat
- Clean Fuels & Products
- Hydrogen

Transportation

Buildings

- Affordable Home Energy

Removing Carbon — **Carbon Negative**

Achieving the Energy Earthshot™ can save $850 billion and avoid ~3.9 Gt CO_2

Independent analysis by Third Way for the *Cumulative and Combined Impacts* (2021-2050) *(Published before CFP and AHE Shots)*

Announced June 2021- October 2023

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HYDROGEN SHOT

The first Energy Earthshot – **Hydrogen Shot™** – was announced on June 7, 2021, and sets an ambitious yet achievable cost target to accelerate innovations and spur demand of clean hydrogen by reducing the cost by 80%.

1 dollar

1 Kilogram

1 decade

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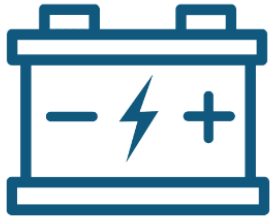
LONG DURATION STORAGE SHOT

The second Energy Earthshot – **Long Duration Storage Shot™** – was announced on July 14, 2021, and aims to achieve affordable grid storage for clean power - anytime, anywhere - by reducing the cost of grid-scale energy storage by 90% for systems that deliver 10+ hours of duration within the decade.

Reduce storage costs by **90%**...



…In storage systems that deliver **10+** hours of duration

In **1** decade

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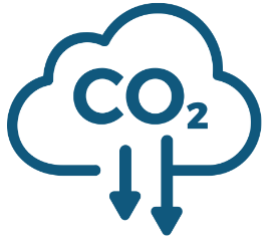
CARBON NEGATIVE SHOT

The third Energy Earthshot – **Carbon Negative Shot™** – was announced on November 5, 2021, and is the all-hands-on-deck call for innovation in technologies and approaches that will remove CO_2 from the atmosphere and durably store it at meaningful scales for less than $100/net metric ton of CO_2-equivalent (CO_2e).

<100 dollars



…**1** ton

1 decade

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ENHANCED GEOTHERMAL SHOT

The fourth Energy Earthshot – **Enhanced Geothermal Shot™** – was announced on September 8, 2022, and is a department-wide effort to dramatically reduce the cost of enhanced geothermal systems by 90%, to $45 per megawatt hour by 2035.

90%...Reduction

2035

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FLOATING OFFSHORE WIND SHOT

The fifth Energy Earthshot – **Floating Offshore Wind Shot™** – was announced on September 15, 2022 with the goal of driving down costs to $45 per megawatt hour by 2035 to spur U.S. leadership in floating offshore wind technology, accelerate decarbonization, and deliver benefits for coastal communities.

>70% Reduction

2035

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INDUSTRIAL HEAT SHOT

The sixth Energy Earthshot – **Industrial Heat Shot™** – was announced on September 21, 2022 and is a Department-wide initiative to develop cost-competitive industrial heat decarbonization technologies with at least 85% lower greenhouse gas emissions by 2035.

85% Reduction

2035

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CLEAN FUELS & PRODUCTS SHOT

The seventh Energy Earthshot – **Clean Fuels & Products Shot™** – was announced on May 24, 2023, and is a Department-wide initiative focused on decarbonizing the fuel and chemical industry through alternative sources of carbon to advance cost-effective technologies.

>85% net reduction vs. fossil-based sources

2035

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AFFORDABLE HOME ENERGY SHOT

The eighth Energy Earthshot – **Affordable Home Energy Shot™** – was announced on October 12, 2023, and is a Department-wide initiative focused on accelerating breakthroughs of more abundant, affordable, and reliable clean energy solutions to ensure that households in the greatest need will benefit from decarbonization solutions and lower greenhouse gas emissions by 2035.

20% lower cost

>50% technology cost reduction

1 decade

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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

Jay Fitzgerald, Bioenergy Technologies Office

Carbon based fuels, chemicals, and products:

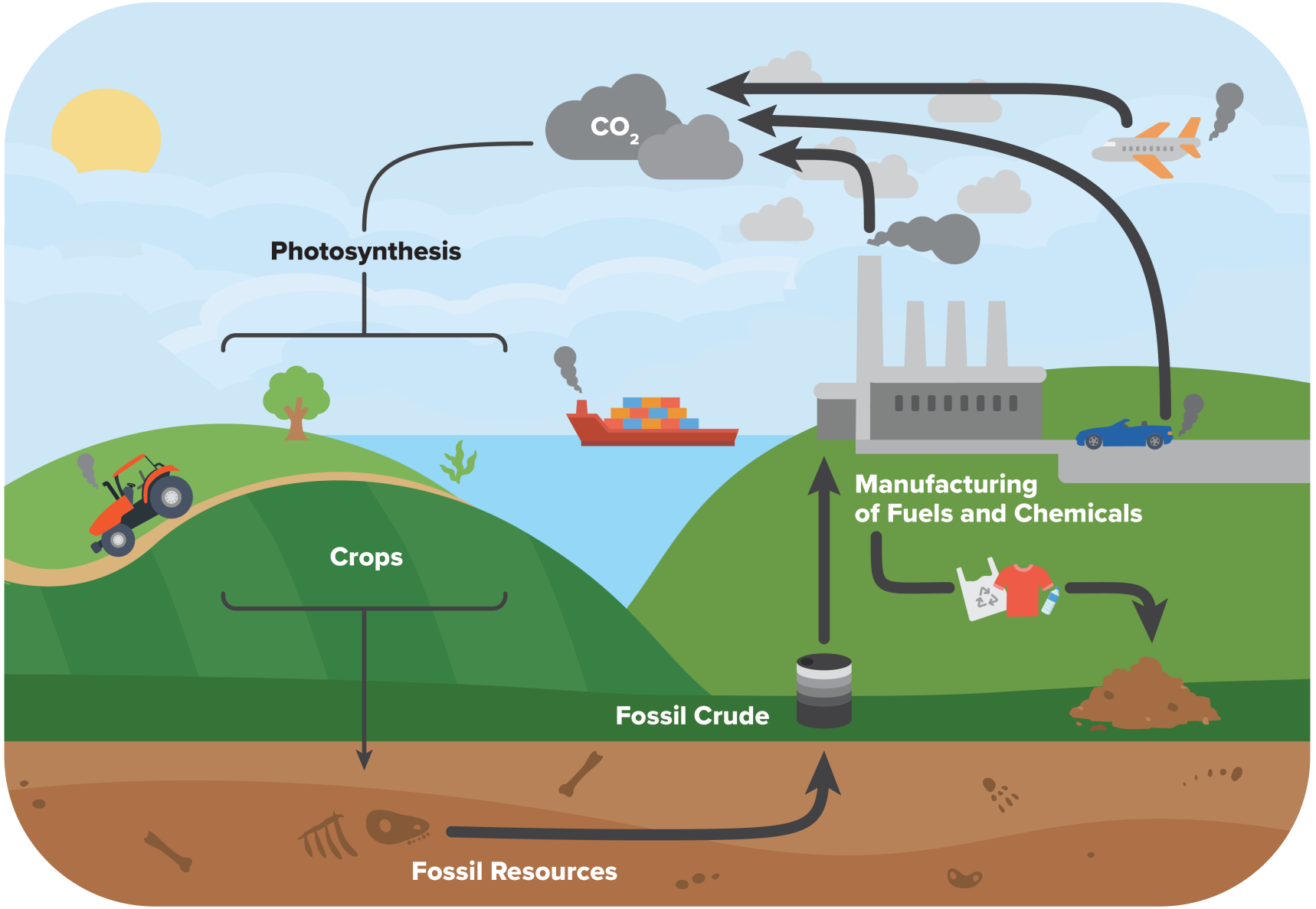
- **Enable almost all aspects of modern life**
- **Drive the nation (>8% of GDP)**
- **Provide high-quality jobs (10 million+)**

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

"Success [of the Energy Earthshot] would mean cutting over 650 million metric tons of carbon dioxide equivalent each year by 2050. That would be roughly the same impact as taking more than half of all the gas-powered cars, vans, SUVs, and pickup trucks we have in the U.S. today off the road. That would be a huge deal!"

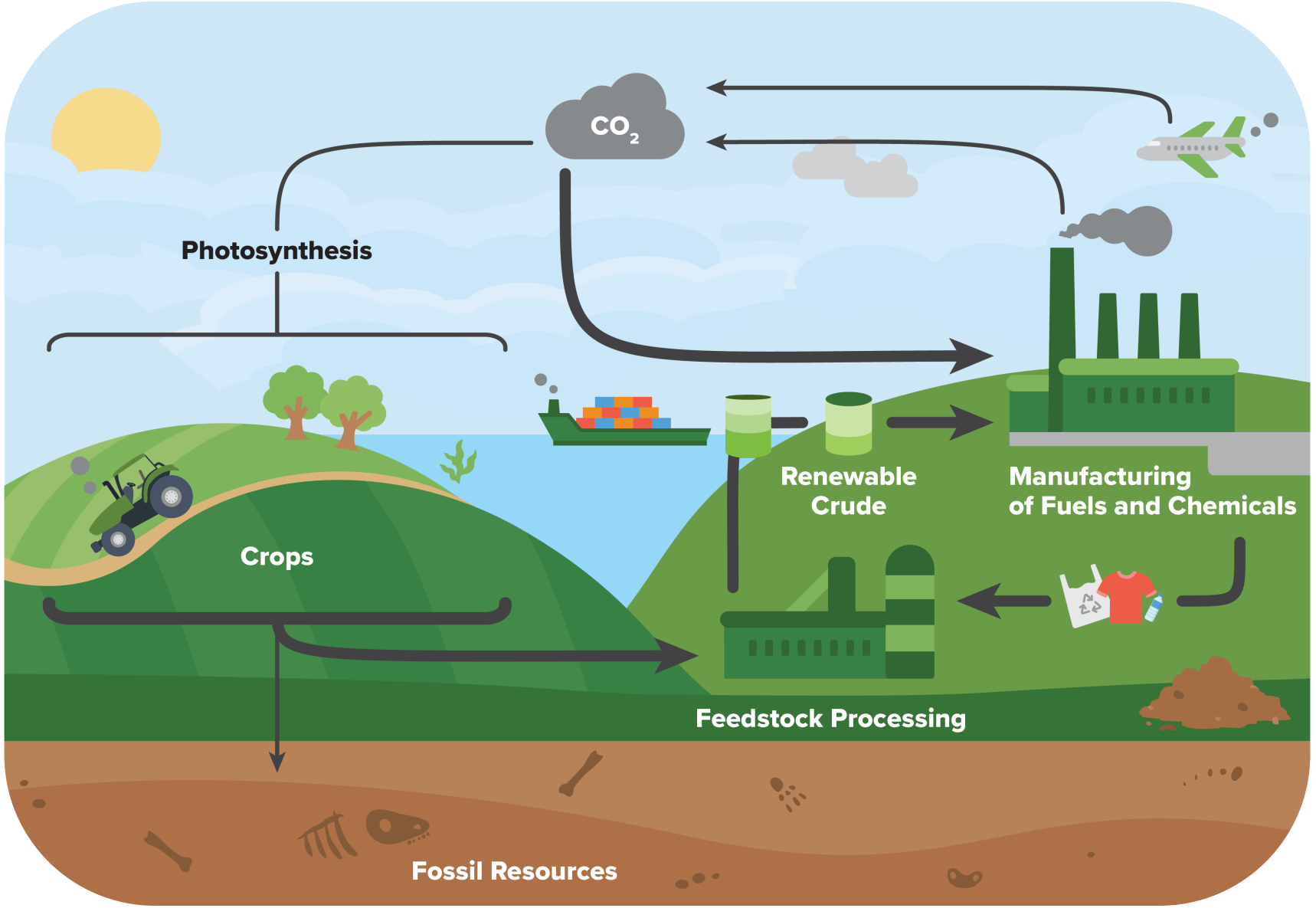
U.S. Secretary of Energy Jennifer Granholm, announcing the Clean Fuels & Products Energy Earthshot™ on May 24th at Idaho National Lab in Idaho Fall, ID.

The Challenge: *The Carbon Cycle is Imbalanced*



Los Alamos National Laboratory approves the unlimited public release of the graphics under LA-UR-22-30426.

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



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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

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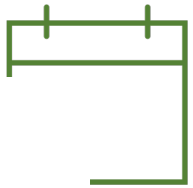
Clean Fuels & Products™

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

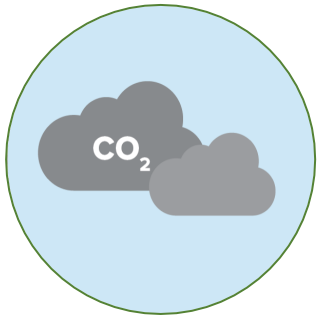
Webpage

[Clean Fuels & Products Energy Earthshot Website]

Clean Sources and Conversion Technologies are Needed

2050 Resource Supply

1,050 MMT biomass and waste



450 MMT CO_2

...can be converted into...

2050 Projected Hydrocarbon Demand

>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.

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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_2 feedstocks at scale

Examples:
Forest residues, agricultural wastes, municipal solid waste, recycled materials, energy crops, algae, CO_2

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_2

Analysis for accurate and complete carbon accounting through robust lifecycle assessment

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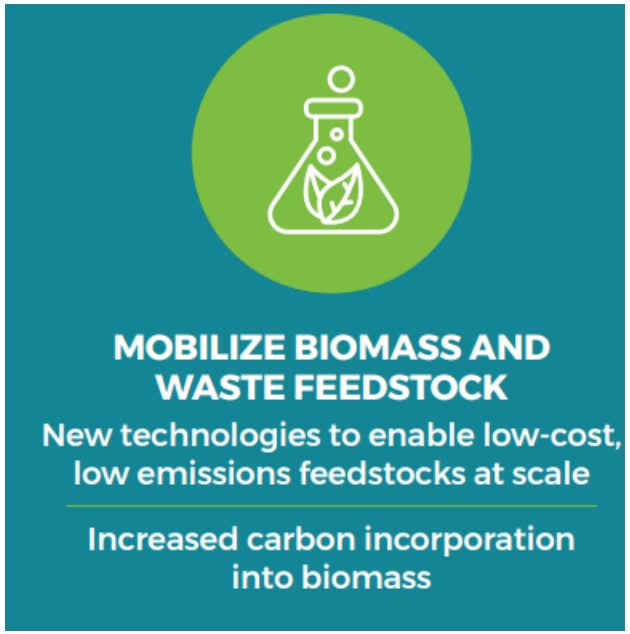
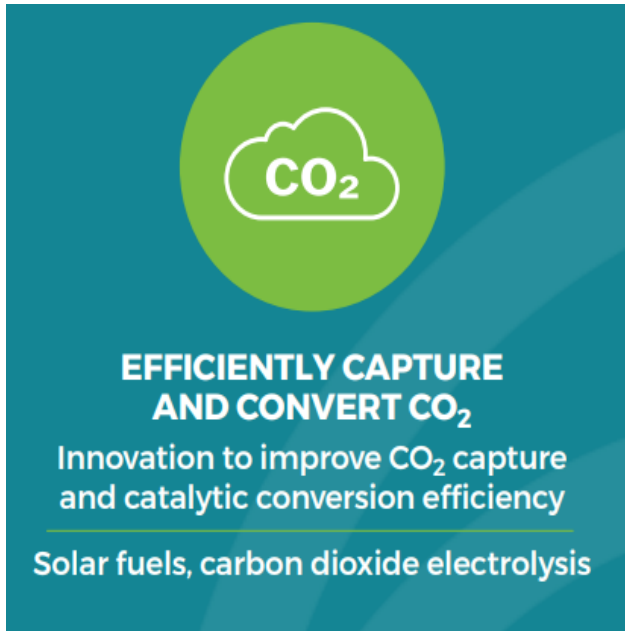
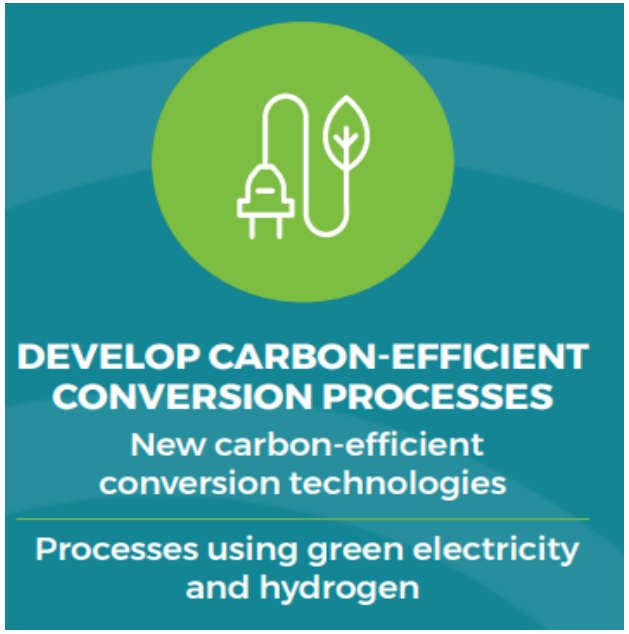
Five Critical Research Areas







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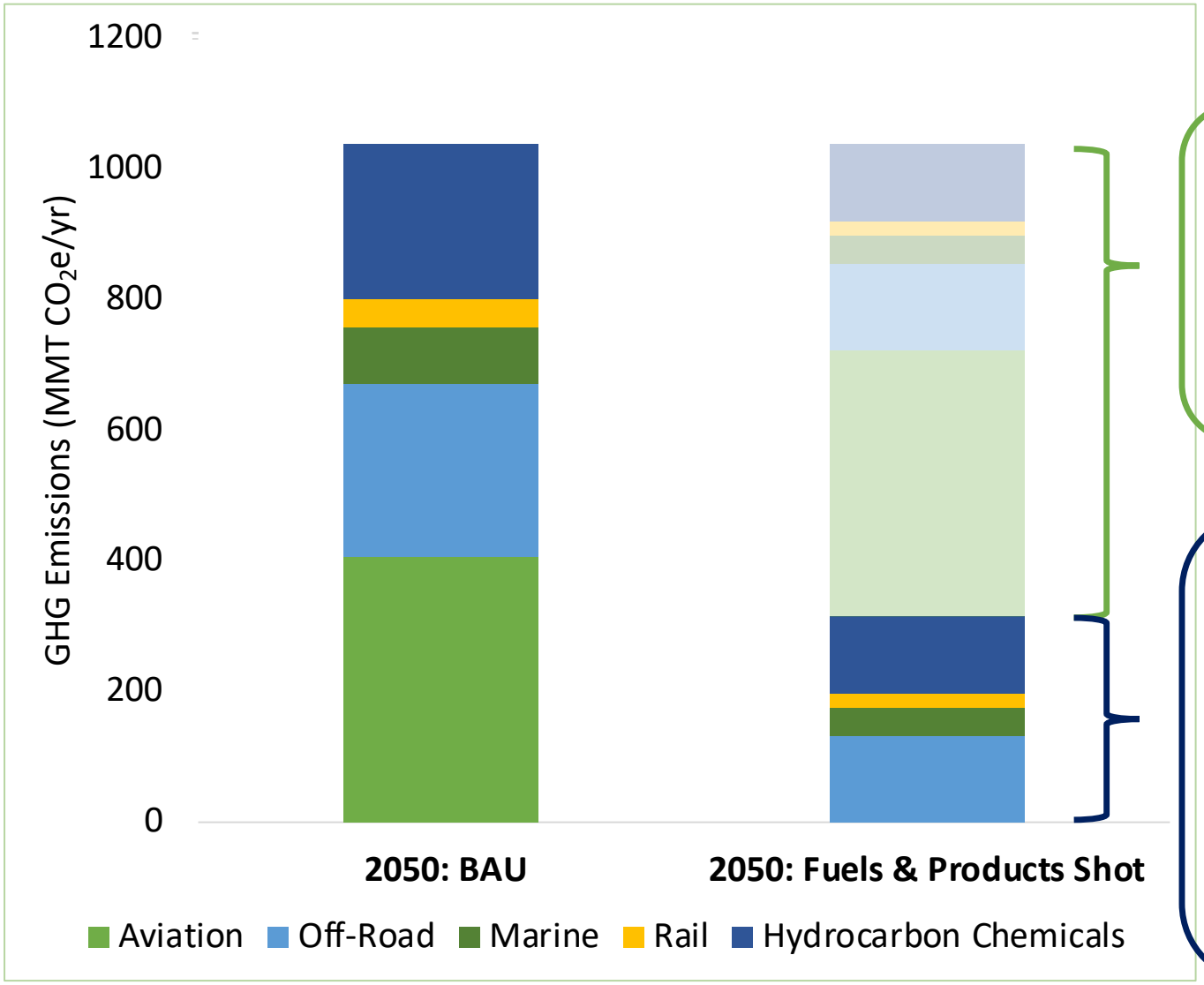
Clean Fuels & Products: Potential Impact



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

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

ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Carbon Negative™

ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Hydrogen

ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Industrial Heat™

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.

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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

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Clean Fuels & Products™

All-hands-on-deck DOE Perspective of the Clean Fuels & Products Energy Earthshot™

Presented By:

Devinn Lambert, Office of Under Secretary for Science and Innovation
Jay Fitzgerald, Bioenergy Technologies Office
Felicia Lucci, Industrial Efficiency & Decarbonization Office
Emily Connor, Office of Fossil Energy and Carbon Management
Todd Anderson, Office of Science





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

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Foundational Research

Applied Technology Research, Development, & Demonstration

Demonstration & Deployment








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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_2 Conversion to Fuels/Chemicals
Sustainable Supply Chains, Processing, and Manufacturing
Efficient Processes, Circularity, and Environmental Co-benefits
Decarbonization of Chemical Manufacturing
Clean H_2 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

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

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Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Biomanufacturing for Clean Fuels and Products

Bioenergy Technologies Office

Jay Fitzgerald, Chief Scientist

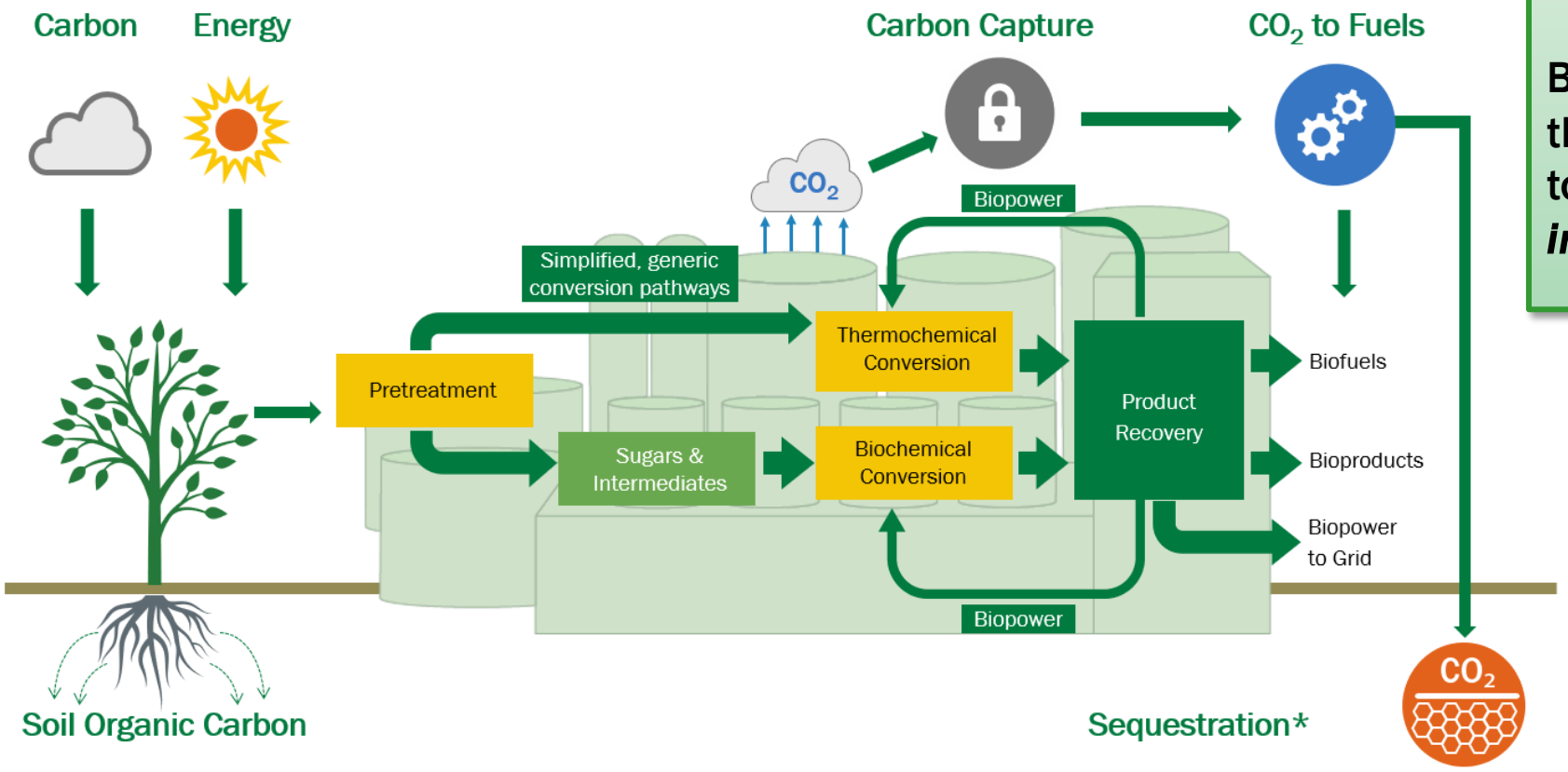
Email: jay.fitzgerald@ee.doe.gov

November 28, 2023

Feedstock | Algae | Conversion | Systems | Data

The Bioenergy Technologies Office (BETO) develop technologies to produce fuels and chemicals from renewable resources, primarily biomass

- **Biomass** includes food waste, municipal solid waste, agricultural and forest wastes, animal wastes, and energy crops.
- **Bioenergy** is the conversion of biomass to energy that can replace fossil fuels.



Bioeconomy: An economy based on products, services, and processes derived from biological resources (e.g., plants and microorganisms) and encompassing multiple sectors.

Bioenergy is a key component of the U.S. bioeconomy and contributor to ***decarbonizing transportation, industry, and agriculture***.

** Office of Fossil Energy R&D on technologies of relevance to bioenergy industry.*

BETO Strategic Goals – 2023 Multi-Year Program Plan

Decarbonize Transportation

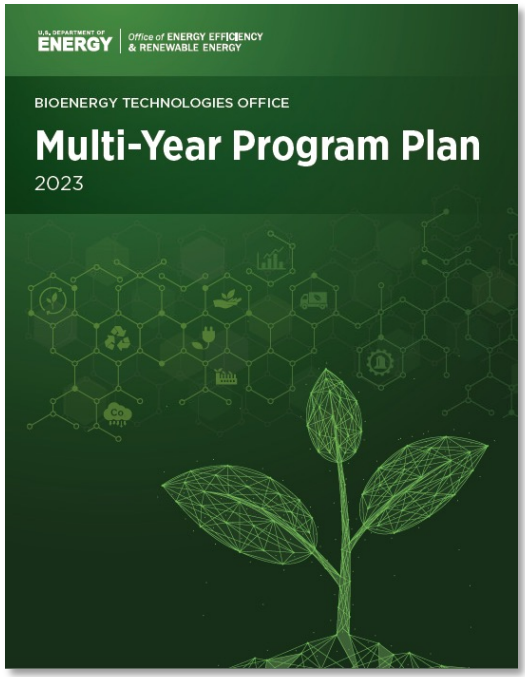
Decarbonize the sector through R&D to produce cost effective **sustainable aviation** and other **strategic fuels**

Decarbonize Industry

Decarbonize the sector through R&D to produce cost effective **sustainable chemicals, materials and processes** utilizing biomass and waste resources

Decarbonize Communities

Develop **cost-effective, sustainable biomass and waste utilization technologies** and innovative approached contributing to the **decarbonization of agricultural** sector, generating **carbon negative power**, developing **carbon drawdown strategies** or other beneficial uses



Applied R&D
TRL 2-5

Pilot R&D
TRL 4-6

Demonstration Scale
TRL 4-6

Decarbonize Transportation: Example

Sustainable aviation fuel reduces greenhouse gas emissions by >85% versus jet A fuel

Conventional: Jet A Fuel

- Sourced from petroleum
- High GHG emissions (84 g CO_2e/MJ)
- High temperature distillation
- Exhaust soot causes cloud formation

Innovative: Corn Stover Fermentation & Alcohol to Jet

- Sourced from agricultural residues
- Low GHG emissions (12.5 g CO_2e/MJ to -27.5 g CO_2e/MJ with added CCS)*
- Novel ATJ catalysts and cellulosic sugar fermentation
- Decreased aviation-induced cloudiness

*Modeled emissions reduction from Net Zero Tech Team, in review

Decarbonize Industry: Example

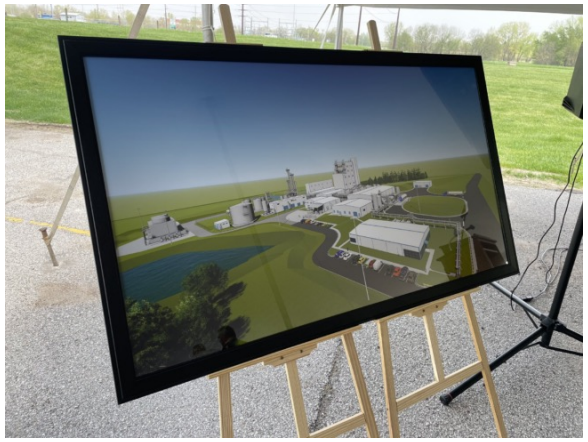
Reduces greenhouse gas emissions by 93% vs conventional 1,4-butanediol (BDO) for renewable textiles

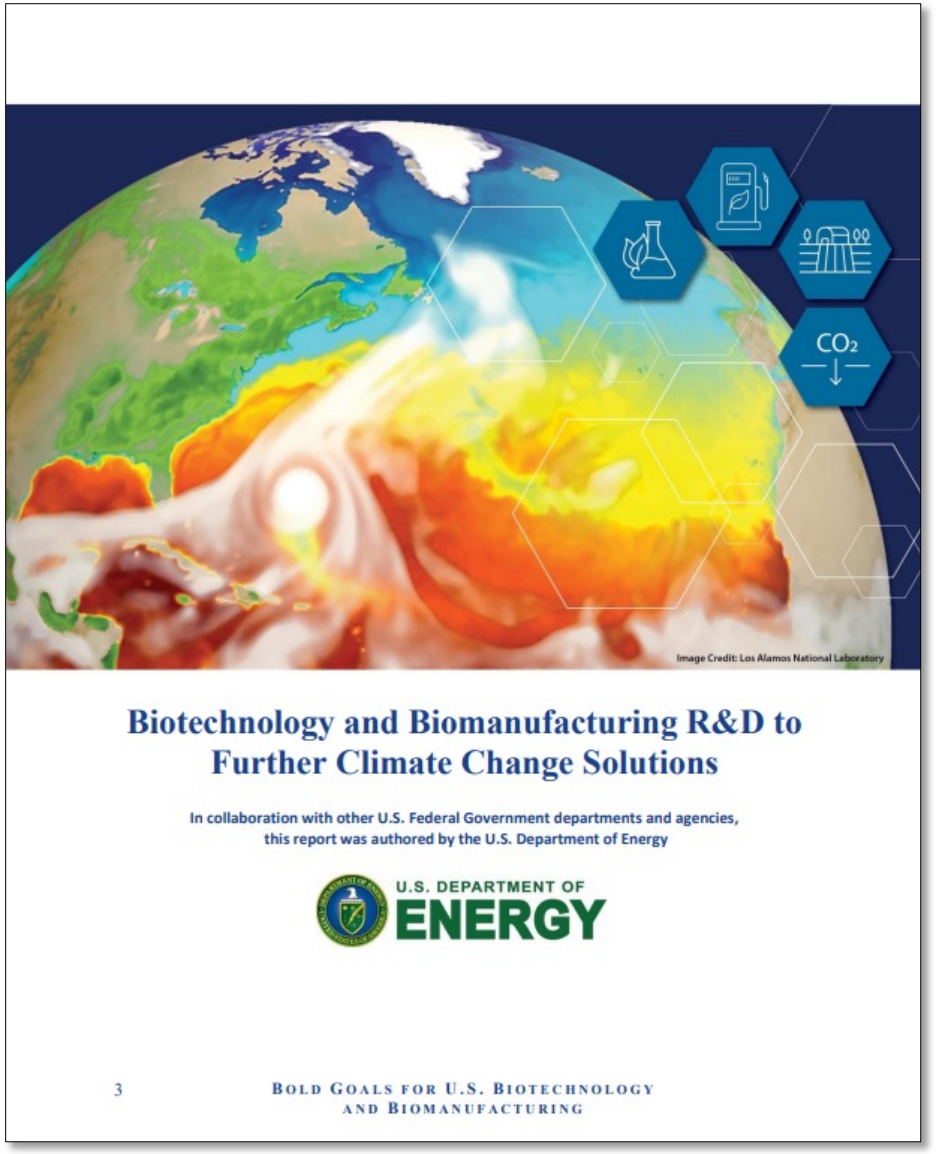
Conventional: BDO

- Sourced from petroleum
- High GHG emissions (4.4 kg CO_2e/kg)
- Energy-intensive process
- Toxic reactant

Innovative: Bio-BDO

- Sourced from plant sugars
- Low GHG emissions (0.3 kg CO_2e/kg)
- Novel microbial fermentation pathway to BDO





Theme 1: Transportation and Stationary Fuels

- Goal 1.1: Expand Feedstock Availability
- Goal 1.2: Produce Sustainable Aviation Fuel (SAF)
- Goal 1.3: Develop Other Strategic Fuels

Theme 2: Chemicals and Materials

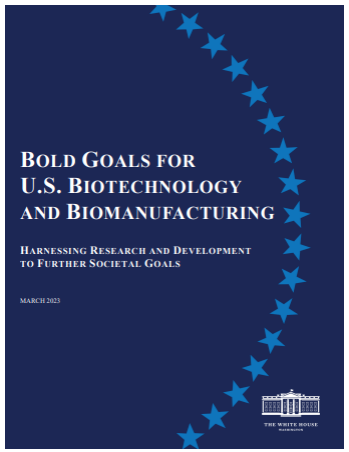
- Goal 2.1: Develop Low-Carbon-Intensity Chemicals and Materials
- Goal 2.2: Spur a Circular Economy for Materials

Theme 3: Climate-Focused Agricultural Systems and Plants

- Goal 3.1: Develop Measurement Tools for Robust Feedstock Production Systems
- Goal 3.2: Engineer Better Feedstock Plants
- Goal 3.3: Engineer Circular Food Protein Production Systems

Theme 4: Carbon Dioxide Removal

- Goal 4.1: Develop Landscape-Scale Biotechnology Solutions
- Goal 4.2: Enable Biomass with Carbon Removal and Storage (BiCRS)



Summary of Recent Funding Opportunities

Biomass feedstocks can lower the lifecycle GHG emissions of carbon-based fuels and products, supporting a circular and sustainable bioeconomy. Keep an eye out for upcoming funding opportunities!

FY24

- R&D: NOI for WASTE: Waste Analysis and Strategies for Transportation End-uses

FY23

- R&D: Conversion R&D FOA, gasification cleanup and biochemical scale-up (**$16.7M**)
- R&D: Reducing Agricultural Carbon Intensity and Protecting Algal Crops (**$25.5M**)

FY22

- Pilot and Demo: Scale-Up of Integrated Biorefineries and Greenhouse Gas Reduction in First Generation Ethanol Production (**$118M**)

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

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DOE National Labs

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Advanced AI, ML, and Data Science Methods

Leverage scientific user facilities

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Demo projects:

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

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Presented By:

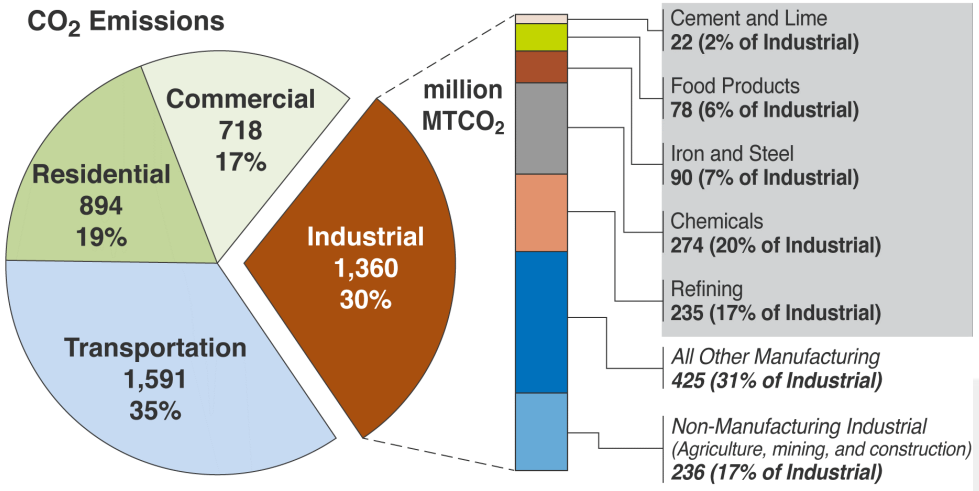
Felicia Lucci, Industrial Efficiency & Decarbonization Office

Email: felicia.lucci@hq.doe.gov

IEDO's Focus on Energy Intensive Manufacturing Subsectors

Mission: Accelerate the innovation and adoption of cost-effective technologies to increase energy efficiency and reduce greenhouse gas (GHG) emissions in the U.S. industrial sector.

Energy Related CO_2 Emissions Across U.S. Industry



DOE Industrial Decarbonization Roadmap

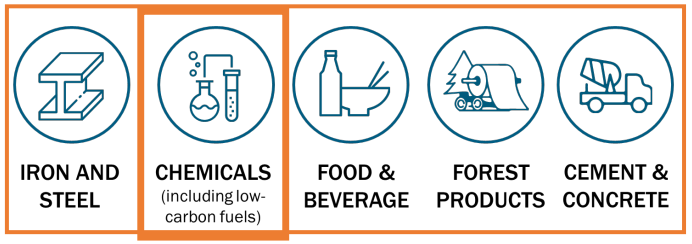
Industrial Decarbonization Pillars

- Energy Efficiency
- Industrial Electrification
- Low-Carbon Fuels, Feedstocks, and Energy Sources (LCFFES)
- Carbon Capture, Utilization, and Storage (CCUS)

Decarbonization pillars: inter-related, cross-cutting strategies to pursue in parallel

Data source: Energy Information Administration (EIA) *Annual Energy Outlook 2021 with Projections to 2050* and other EIA and EPA source

Technology Structured Program



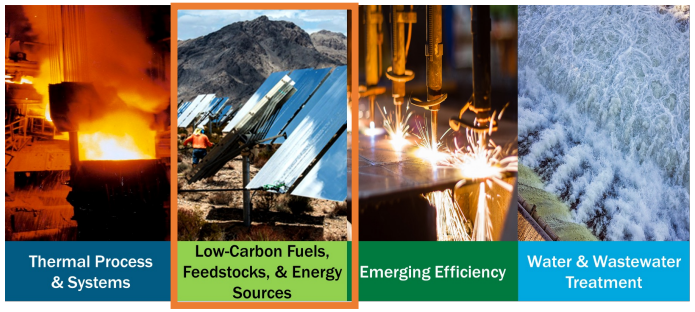
ENERGY- AND EMISSIONS-INTENSIVE INDUSTRIES (EEII)

Accelerates the readiness of emerging, industry-specific technologies to decarbonize the most energy- and emissions-intensive industrial subsectors.

Chemicals & Refining | Iron & Steel| Cement & Concrete| Forest Products | Food & Beverage

CROSS-SECTOR TECHNOLOGIES (CST)

Accelerates the readiness of energy- and emissions-reducing components, systems, and operational technologies, across a broad range of industries.



TECHNICAL ASSISTANCE AND WORKFORCE DEVELOPMENT (TAWD)

Technical Assistance: Partners with and enables industry to accelerate the adoption of technologies, programs, and best practices that improve efficiency and decarbonization.

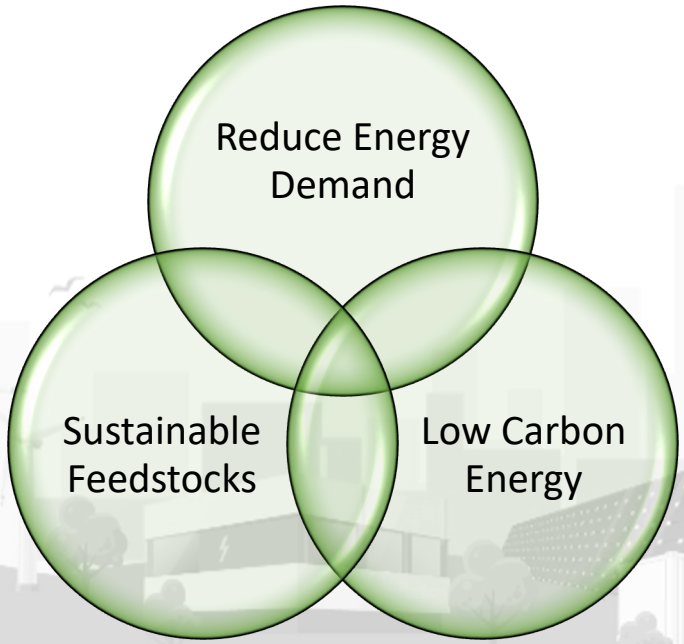
Workforce Development: Promotes the development of a diverse mix of new workers and upskills existing workers for the industrial jobs of today and the future.

ONSITE ENERGY | PROGRAM 50001 | READY & SEP 50001 | WORKFORCE DEVELOPMENT

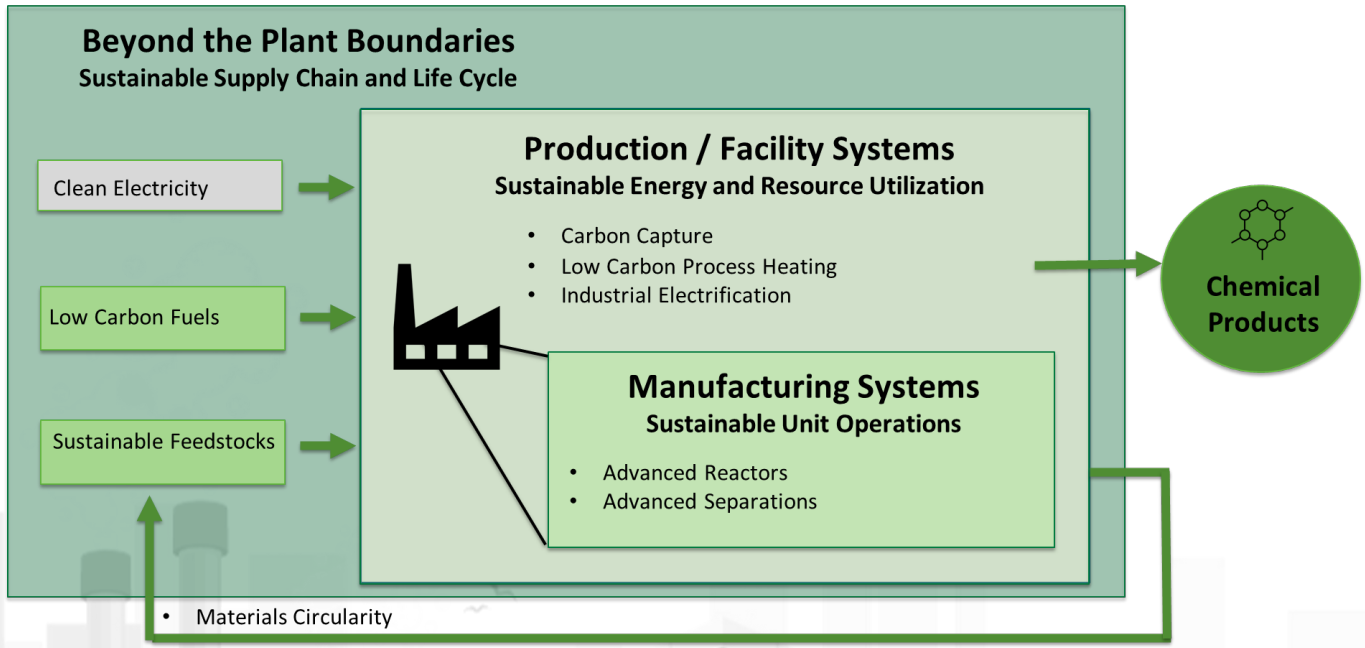
IEDO's Chemicals and Fuels RD&D

Next generation process technologies capable of transforming chemicals and fuels production.

- Full value chain of high-volume, energy intensive, high emissions chemicals
- Reducing emissions by more than 50%



Holistically decarbonizing chemicals manufacturing facility from unit operations to supply chains.



IEDO Supports Applied R&D & First-of-a-Kind Pilots & Demonstrations

- IEDO funds $70M+ for advanced processes to enable conversion of sustainable feedstocks.
- Advanced reactor systems for usage of waste gases (CO_2, CO), industrial waste, plastics, and biomass to produce or reduce demand of high-volume chemicals

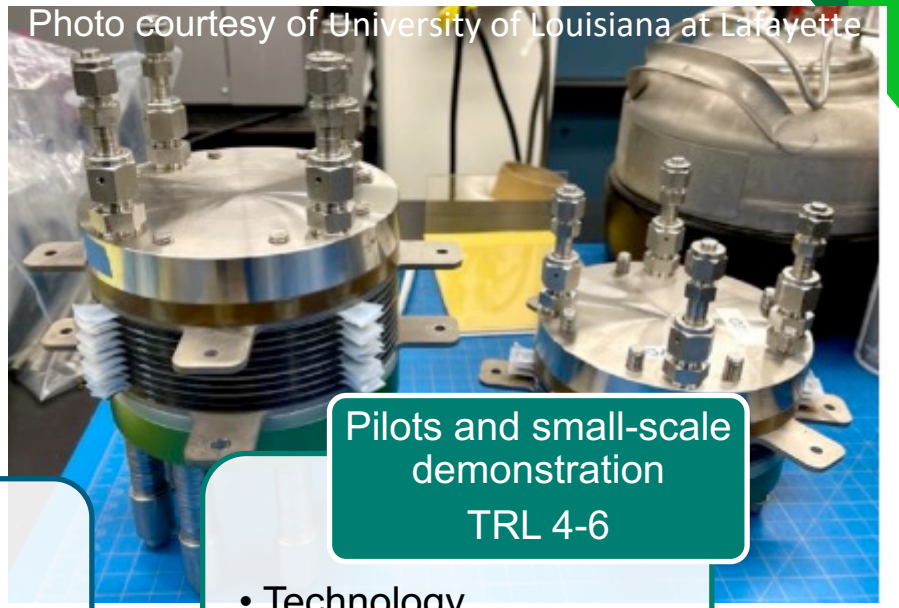


Photo courtesy of University of Louisiana at Lafayette

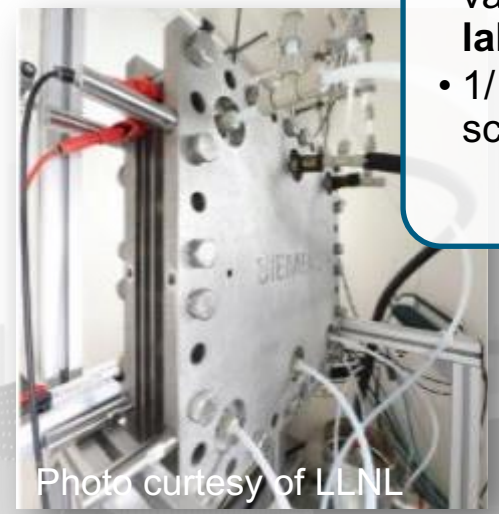


Photo curtesy of LLNL

Applied R&D
TRL 3-5

- Technology components validation in **laboratory**
- 1/100th commercial scale

Pilots and small-scale demonstration
TRL 4-6

- Technology components validation in a **relevant environment**
- 1/50th commercial scale

Photo curtesy of LLNL

Upcoming Funding Opportunities

Cross Sector Technologies Funding Opportunity Announcement (CST FOA)

- $38 million to accelerate innovative, cross-sector technologies required to create a clean energy economy
    - Focus on high-impact, applied RD&D projects
    - Concept papers due December 18, 2023

Energy- and Emissions- Intensive Industries Notice of Intent (EEII NOI)

- $83 million to decrease emissions in the hardest to decarbonize industrial subsectors: chemicals and fuels; iron and steel; food and beverage; building and infrastructure materials; and forest products
    - Sector-specific opportunities for seedling research, applied R&D, and first-of-a-kind pilots
    - Chemicals focus on advanced processes to enable conversion of sustainable feedstocks for hydrocarbons and fuels
    - Joint topic with Hydrogen and Fuel Cell Technology Office (HFTO) and Office of Fossil Energy and Carbon Management (FECM) focused on pre-Front End Engineering and Design (pre-FEED) studies that support the development of decarbonized industrial processes

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

ENERGY earthshots
U.S. DEPARTMENT OF ENERGY

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_2 Conversion to Fuels/Chemicals
Sustainable Supply Chains, Processing, and Manufacturing
Efficient Processes, Circularity, and Environmental Co-benefits
Decarbonization of Chemical Manufacturing
Clean H_2 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

ENERGY earthshots | Clean Fuels & Products™

U.S. DEPARTMENT OF ENERGY

Presented By:

Emily Connor, Office of Fossil Energy and Carbon Management

Email: emily.connor@hq.doe.gov

Carbon Management Overview: FECM Mission- Deep Decarbonization and Environmental Justice

Minimize environmental and climate impacts of fossil fuels from extraction to use

Priority Technology Areas

1. Point source carbon capture
2. Carbon dioxide (CO_2) removal
3. **CO_2 conversion into products**
4. Reliable CO_2 storage
5. Hydrogen production

Office of Carbon Management
(FECM-20)

6. Critical mineral production from industrial and mining waste
7. Methane mitigation

Office of Resource Sustainability
(FECM-30)

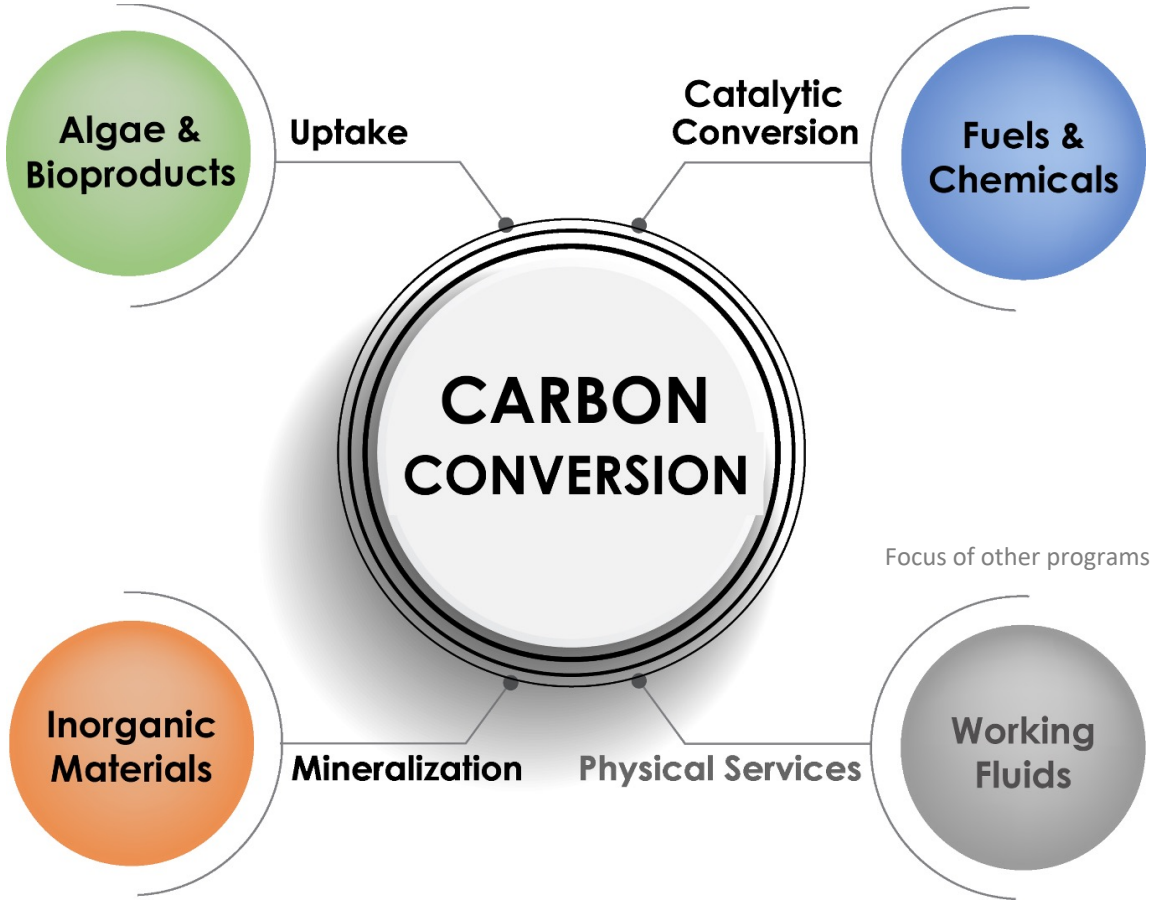
Enacting Justice and Supporting Legacy Communities

- Good-paying jobs
- Job growth acceleration
- Healthy economic transitions
- Improve community conditions

Address hardest-to-decarbonize applications in the electricity and industrial sectors

Pathways for CO_2 Conversion to Products

FECM Carbon Conversion Program Structure



- FECM includes two areas of focus:
  - Carbon management
  - Resource sustainability

- **Office of Carbon Management:**
  - ~$450M annual budget
  - Typical focus on TRL 3-5 grant funding:
    - ❑ Engineering studies
    - ❑ Benchtop research
    - ❑ Small pilots and demos

Source: *United States Department of Energy, Office of Fossil Energy and Carbon Management, "Strategic Vision: The Role of Fossil Energy and Carbon Management in Achieving Net-zero Greenhouse Gas Emissions," 2022.*

FECM Strategic Alignment with the Earthshots

Program Initiatives

- Supporting catalytic R&D including catalytic conversion of CO_2
- CO_2 conversion to fuels and chemicals
- Point source carbon capture and direct air capture
- H_2 with CCS and through gasification

Additional synergies with projects developed under the Carbon Negative Earthshot & FECM Areas efforts in CDR:

- Biomass with Carbon Removal and Storage
- Direct Air Capture (DAC)
- Direct Ocean Capture (DOC)
- Accelerated Weathering and Mineralization

ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Carbon Negative™

Current Funding Opportunities

Funding Opportunities and Research Efforts

- FOA 2614 on Carbon Management
  - Periodic releases with new areas of interest
- FECM to work with EERE- BETO on joint upcoming funding opportunities
- Additional BIL-funded opportunities forthcoming in FY24

Opportunities in Carbon Conversion

Building Materials

- CO_2 -cured cement
- CO_2 -based aggregates
- Clinker replacement

Plastics & Products

- CO_2 -derived polyethylene carbonates (PEC) for heat insulation foams, polyurethane plastics
- CO_2 -derived polypropylene carbonate (PPC) for polyurethane plastics

Fuels

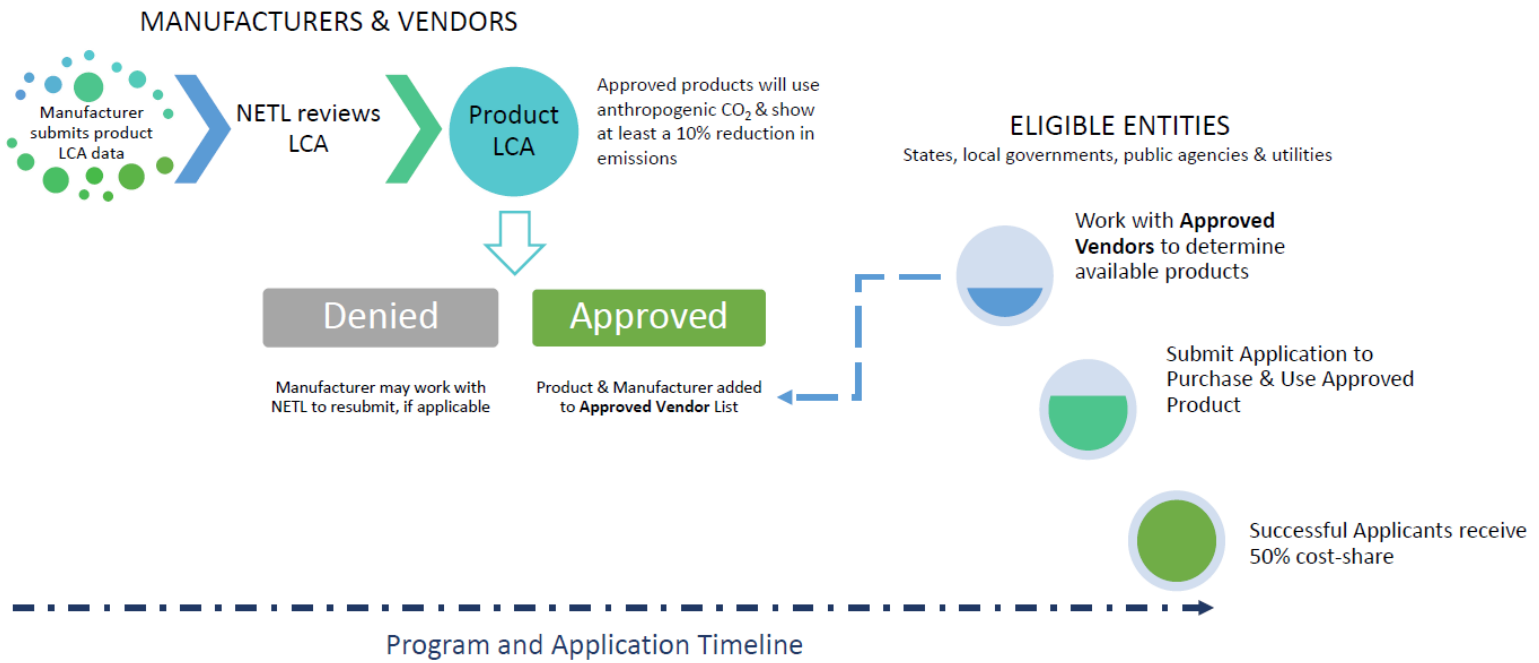
- Electrolysis: syngas to produce synthetic fuel (e.g., diesel)
- Thermo-catalysis: liquid fuels (gasoline, diesel etc.) from CO_2 and hydrogen
- Fischer-Tropsch: syngas into liquid hydrocarbons through a catalytic chemical reaction
- CO conversion: Non-Fischer-Tropsch conversion of gases containing CO into liquid fuels and chemicals

Adapted from US DOE Pathways to Commercial Liftoff: Carbon Management Report 2023.

Current Funding Opportunity: UPGrants Program

Supporting Products Made from CO_2

- $100 million available to states, local governments, and public agencies & utilities to purchase products derived from converted carbon emissions
- Products must demonstrate at least 10% reduction in emissions compared to incumbent products
- Product LCAs are reviewed and approved by DOE's National Energy Technology Laboratory (NETL)



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

ENERGY earthshots
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DOE Office of Science

Basic Research Underpinning
Clean Fuels & Products

Todd Anderson Ph.D.
Division Director
Biological Systems Sciences
Office of Biological and Environmental
US DOE Office of Science

U.S. DEPARTMENT OF ENERGY | Office of Science

SC Mission:

Delivery of scientific discoveries and major scientific tools to transform our understanding of nature and advance the energy, economic, and national security of the United States.

More than **29,000** Researchers supported at more than **300** Institutions and **17** DOE Labs

Steward **10** of the 17 DOE National labs

More than **37,000** Users of **28** SC Scientific Facilities

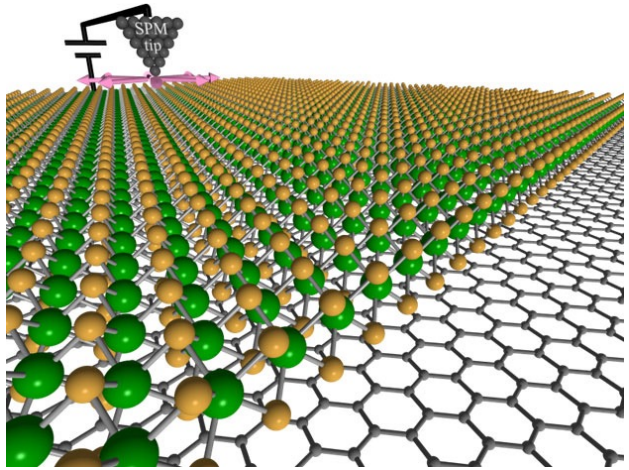
$8.1B
(FY 23 enacted)

Office of Science Research Portfolio

Advanced Scientific Computing Research	• Delivering world leading computational and networking capabilities to extend the frontiers of science and technology
Basic Energy Sciences	• Understanding, predicting, and ultimately controlling matter and energy flow at the electronic, atomic, and molecular levels
Biological and Environmental Research	• Understanding complex biological, earth, and environmental systems
Fusion Energy Sciences	• Supporting the development of a fusion energy source and supporting research in plasma science
High Energy Physics	• Understanding how the universe works at its most fundamental level
Nuclear Physics	• Discovering, exploring, and understanding all forms of nuclear matter
Isotope R&D and Production	• Supporting isotope research, development, production, processing and distribution to meet the needs of the Nation
Accelerator R&D and Production	• Supporting new technologies for use in SC's scientific facilities and in commercial products

Computational Science Supporting a Broader Bioeconomy

- Basic research that lays the groundwork for scientific discoveries
  - **Applied Mathematics and Computer Science foundations** to advance the understanding of natural and engineered systems and to reveal scientific insight from high end simulations, models, and data.
  - **Advanced Computing** to prepare for the future of science based on emerging advanced computing technologies, artificial intelligence and microelectronics.



Advanced computing for autonomous investigations

- Strategic partnerships that enable scientific breakthroughs and advance America's economic competitiveness
  - World-leading programs in **interdisciplinary research** like SciDAC enable scientific applications including sustainable chemistry take full advantage of computing and networking capabilities that push the frontiers.
  - Unique models of partnerships accelerate the competitiveness of **American computing technologies, advanced manufacturing,** and **high-tech companies -** large and small**.**

Fundamental Chemical and Materials Science Supporting a Broader Bioeconomy

Discovery, design, and understanding of materials and of chemical and biochemical processes can provide foundational knowledge to benefit the bioeconomy.

- A mechanistic understanding the biochemistry, chemistry, and biophysics of energy capture, conversion, and storage can reveal principles that underlie pathways for the production of specific molecules and the design of structures with specific architectures and capabilities such as self-repair.
  - Insights into mechanisms of light harvesting and energy transport in natural photosynthesis and of redox and active site protein chemistry controlling energy and molecular conversions by enzymes could inspire new bio-based strategies for energy capture, and conversion, and storage.
  - Research on energy and molecular conversion processes (e.g. catalysis and photochemistry) can help provide a foundation for development of bio-inspired, biohybrid and biomimetic systems.
- Understanding of biomolecular materials can guide the creation of robust and scalable materials and systems that work with the extraordinary effectiveness of molecules and processes of biology.

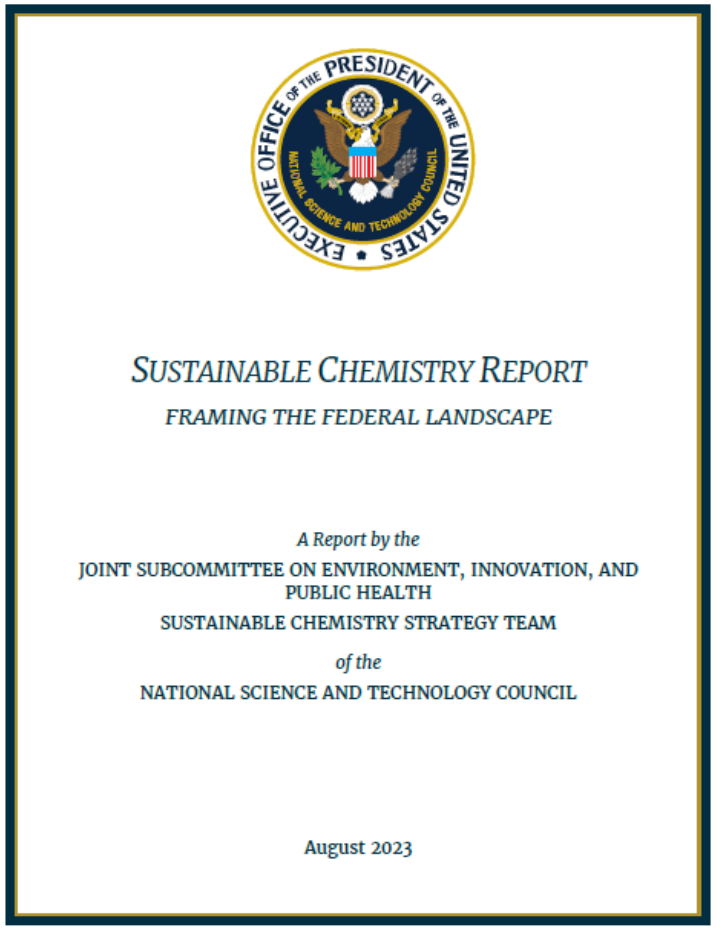
Sustainable Chemistry Report

Chemistry that produces compounds or materials from building blocks, reagents, and catalysts that are readily-available and renewable, operates at optimal efficiency, and employs renewable energy sources.

- Includes intentional design, manufacture, use, and end-of-life management of chemicals, materials, and products across their lifecycle that do not adversely impact human health and environment
- Promotes circularity, meets societal needs, contributes to economic resilience, and aspires to use elements, compounds, and materials without depletion of resources or accumulation of waste.

Sustainable Chemistry Report
Framing the Federal Landscape

https://www.whitehouse.gov/wp-content/uploads/2023/08/NSTC-JCEIPH-SCST-Sustainable-Chemistry-Federal-Landscape-Report-to-Congress.pdf

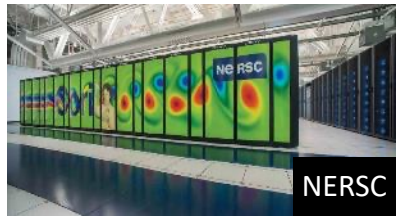


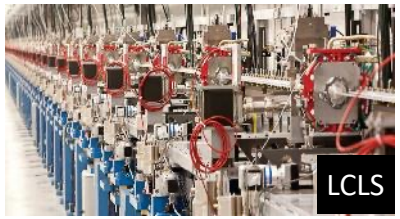
Biological Science Supporting a Broader Bioeconomy

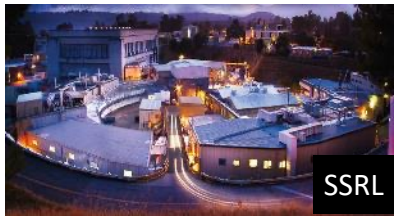
- Clean Energy products from Plant Biomass
  - Fuels
  - Chemicals
  - Materials
- Carbon Negative Applications
  - Soil Sequestration mechanisms
  - Plant-microbe interactions
- Synthetic Biology
  - Gene/genome editing techniques
  - Broadening diversity of platform organisms
  - Coding re-design of organisms/molecules
- Gaining new insights from the Natural World
  - Metagenomics/viral ecology
  - Plant and Microbial genome sequencing
  - Fungal and Algal sequencing

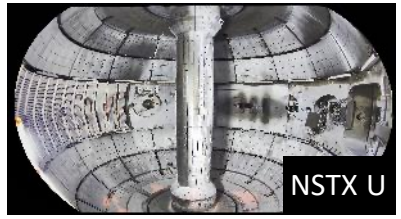
Office of Science User Facilities

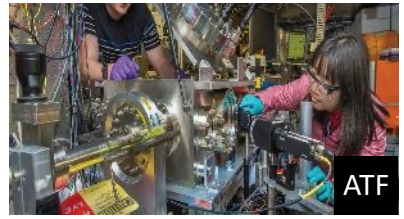
FY 2023
28 scientific
user facilities
>37,000 users











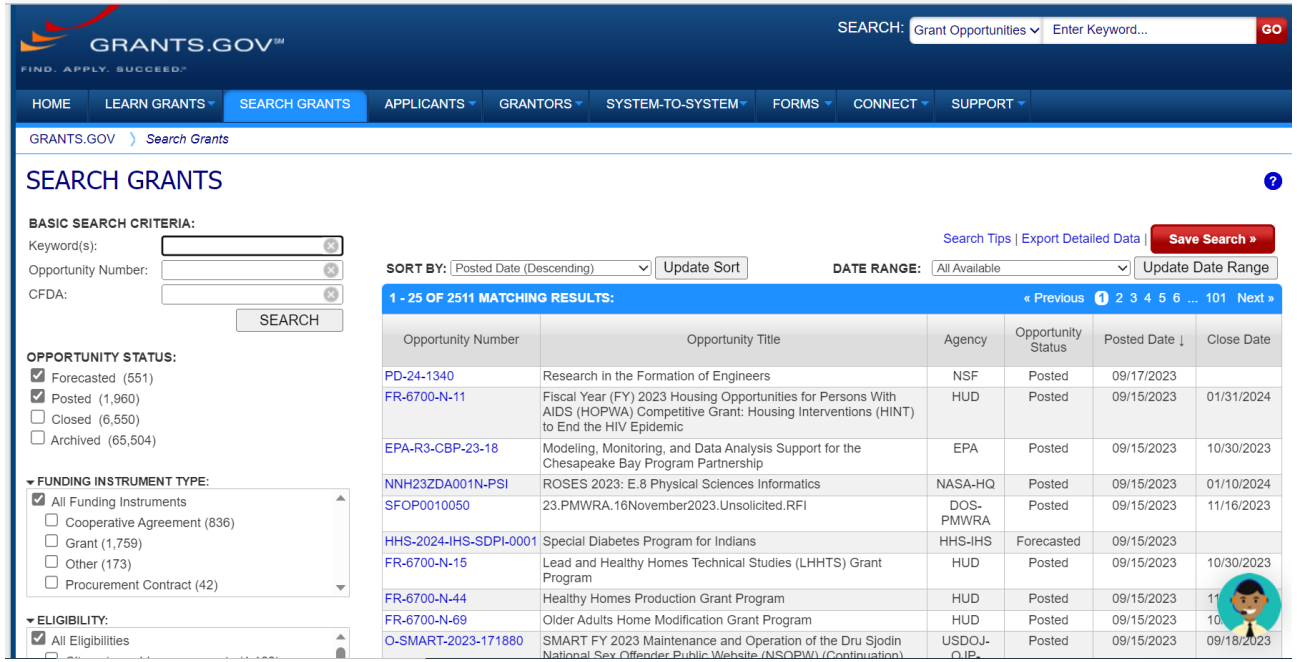
U.S. DEPARTMENT OF ENERGY
Office of Science

Funding Modalities Within the Office of Science

Funding Opportunities to:

- DOE National Laboratories
- Academic Community
- SBIR/STTR Funding Opportunities

User Facility Support



Grants.gov

[Tab] Department of Energy – Office of Science


THANK YOU!

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U.S. DEPARTMENT OF ENERGY

Clean Fuels & Products™

Q & A

Email future questions to:
CleanFuelsandProductsEnergyShot@ee.doe.gov
Or
Eere_bioenergy@ee.doe.gov

Further Engagement and Call to Action

Clean Fuels & Products Energy Earthshot™ Summit, Early 2024 (Date TBD)

Topics:

1. Representative experts spanning government, industry, policy, stakeholders, and academia.
2. Updates on DOE activities and projects in the Clean Fuels & Products space.
3. Information exchange on priority areas, cost and performance metrics, policy considerations, etc.

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Clean Fuels & Products™

Thank You!

Webpage