U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

INDUSTRIAL EFFICIENCY & DECARBONIZATION OFFICE

HPC for Industrial Decarbonization

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Industrial Efficiency and Decarbonization Office

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Building a Net-zero, Clean Energy Future

To build a net-zero, clean energy future by 2050, we need to decarbonize the entire U.S. economy:

- ☑ Commercial
- ☑ Residential
- ☑ Transportation
- ☑ Industrial

Building a Net-zero, Clean Energy Future

The U.S. industrial sector (manufacturing, agriculture, mining, and construction) accounts for:

33% of the nation's primary energy use

30% of CO_2 emissions

Anticipated industrial sector energy demand growth of 30% by 2050 may result in a:

17% CO_2 emissions increase*

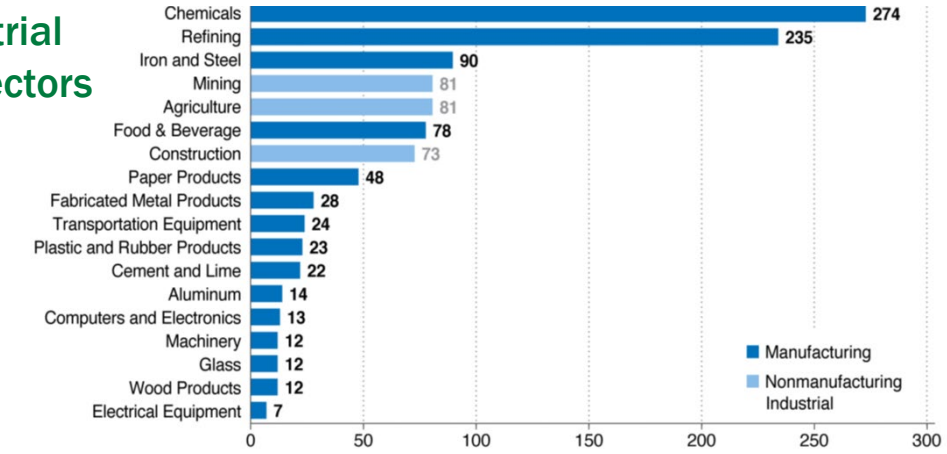
Energy-Related CO_2 Emissions By Sector

*EIA, *Annual Energy Outlook 2021 with Projections to 2050.*

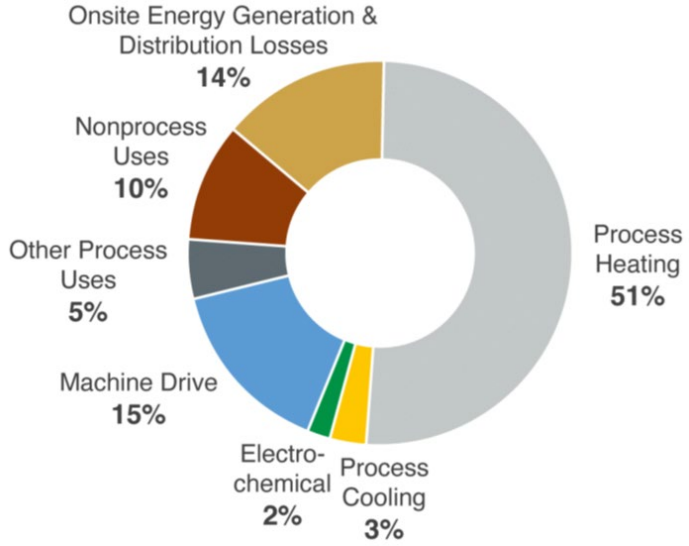
Systemic Barriers to Industrial Decarbonization

No One-Size-Fits-All Solution

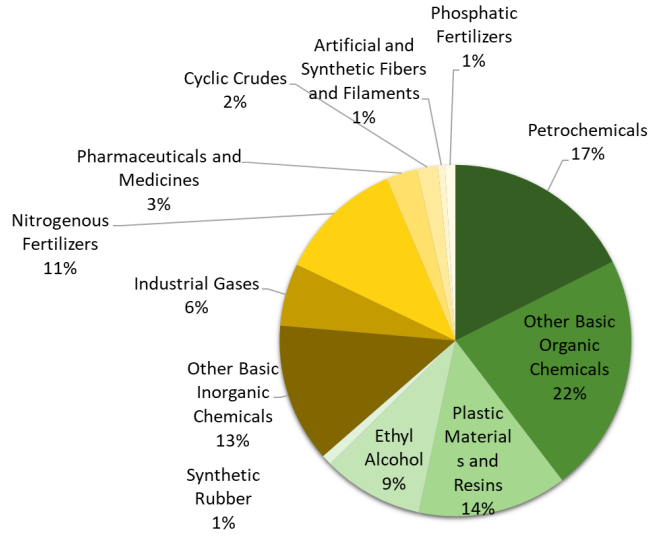
Industrial Subsectors



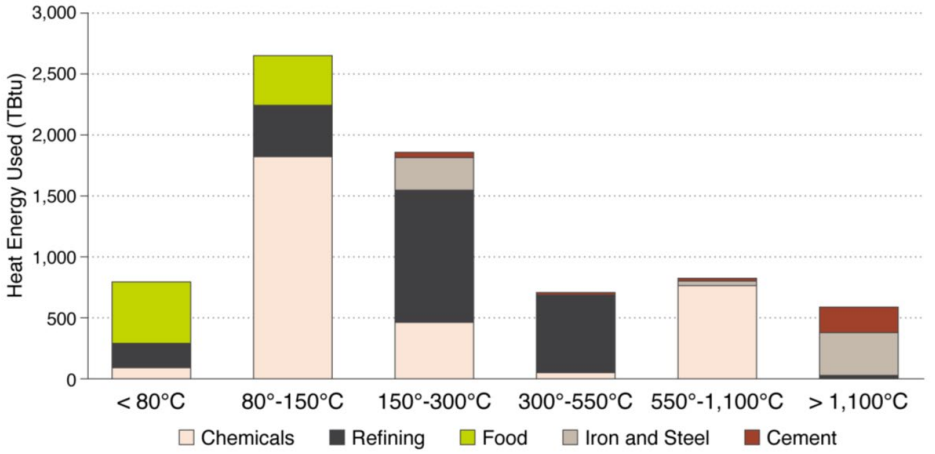
Onsite Energy Use



Chemical Products

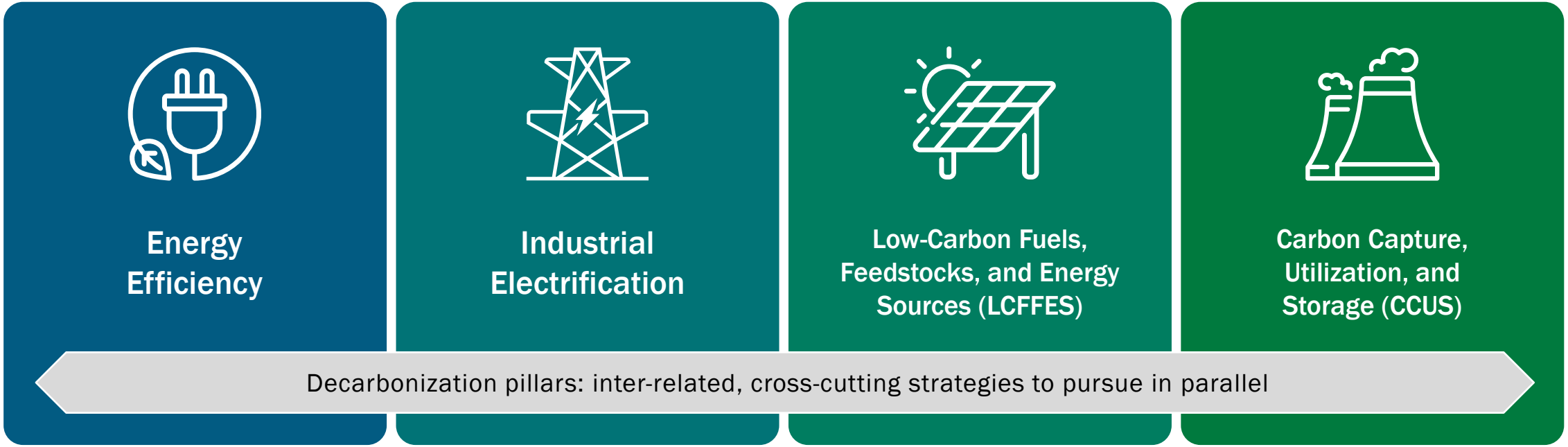


Distribution of Process Heat



DOE Industrial Decarbonization Roadmap

Industrial Decarbonization Pillars




Iron & Steel

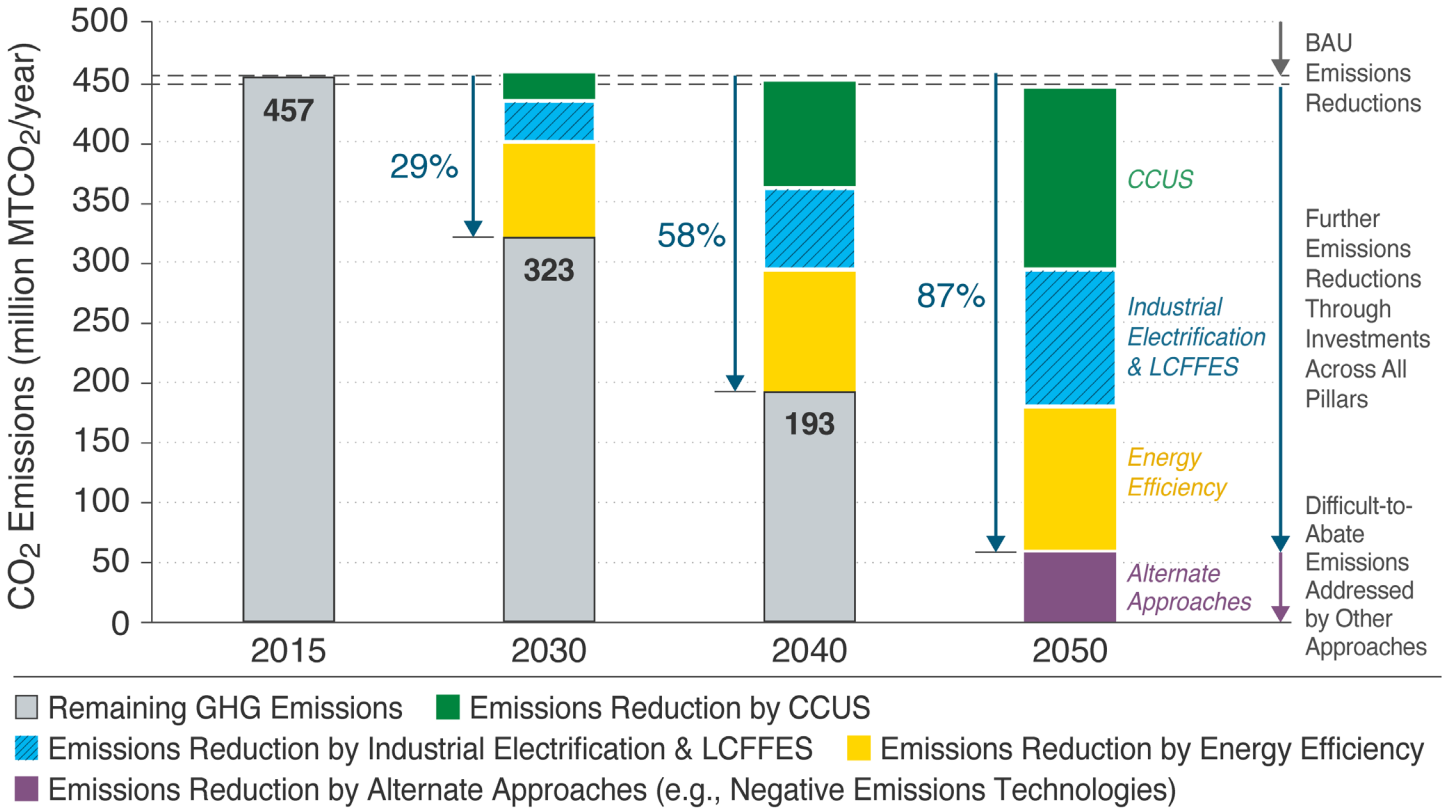

Chemicals


Food & Beverage


Petroleum Refining

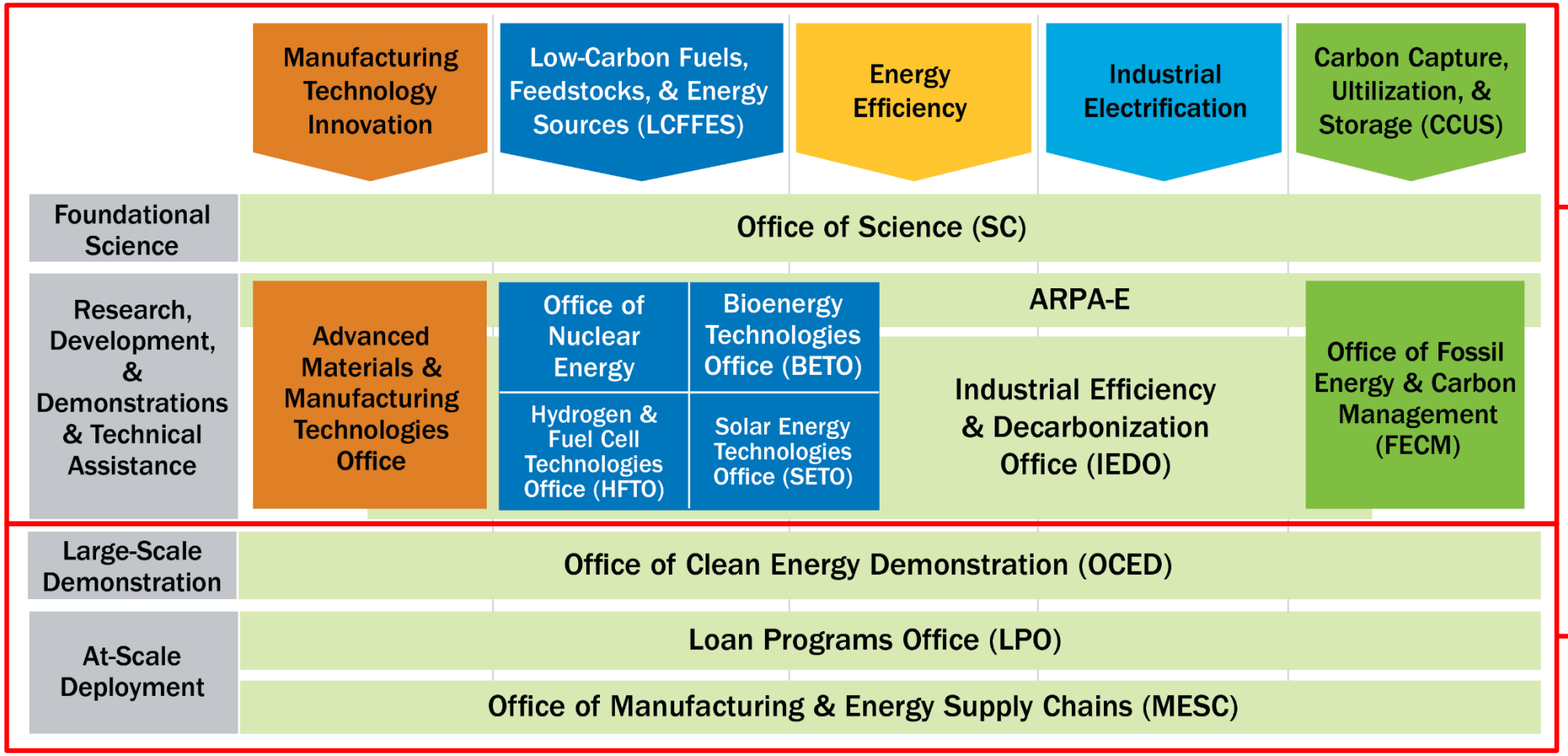

Cement

Path to Net-Zero Emissions by 2050



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

DOE Offices Share a Common Strategic Framework in Industrial Decarbonization



Energy Efficiency

Industrial Efficiency and Decarbonization Office

- *Process intensification*
- *Material efficiency*
- *Combined heat and power*
- *Innovative chemistry*
- *Facility modernization*

Bioenergy Technologies Office

- *Chemical process development*

Advanced Materials and Manufacturing Technology Office

- *Circular economy*
- *Efficient thermal conductors*
- *Smart manufacturing*

Office of Science

- *Innovative chemistry and chemical processes*
- *Next-generation materials development*

RD&D Activities

- Improve process efficiency of heating, steam, and motor systems
- Smart manufacturing and advanced data analytics
- Demonstrations of plant automation systems

Industrial Electrification

Industrial Efficiency and Decarbonization Office

- *Electrified process heating*
- *Electrochemical synthesis*
- *Iron ore reduction*
- *Electrified process scale-up*
- *Electrolyzer integration*

Advanced Manufacturing and Materials Technology

- *Power Electronics*

Hydrogen and Fuel Cells Technology Office

- *Electrolyzer manufacturing*
- *Iron ore reduction*

Office of Science

- *Electrochemical synthesis*

RD&D Activities

- Scale-up of electrified technologies and development of modular size-matched systems for application needs
- Durability and reliability of electrified services
- Integration with intermittent energy sources (e.g., efficient control systems and interfaces)
- Hybrid and dual-source process heating (e.g., hybrid boilers)

Process heating represents **>60%** of manufacturing energy use, but **less than 4% of process heating is electrified.**

30% of process heating demand is low temperature (<150°C) – **prime candidate for electrification.**

Low-Carbon Fuels, Feedstocks, and Energy Sources (LCFFES)

Industrial Efficiency and Decarbonization Office

- *Thermal process heating*
- *Industrial hydrogen integration*
- *Energy storage for industry*

Advanced Materials and Manufacturing Technology

- *Materials for Harsh Service Conditions*

Hydrogen and Fuel Cells Technology Office

- *Hydrogen generation*
- *Industrial use of Hydrogen*

Solar Energy Technologies Office

- *Thermal process heating*
- *Thermal energy storage*

Bioenergy Technologies Office

- *Renewable fuels and feedstocks*

Office of Nuclear Energy

- *Thermal process heating*
- *Thermochemical process integration*

Office of Fossil Energy and Carbon Management

- *Hydrogen generation*

Office of Science

- *Hydrogen generation and utilization*
- *Renewable fuels production*
- *Fundamental science underlying energy conversion*

RD&D Activities

Clean hydrogen

- Electrolyzer development
- Fossil/waste reforming with CCS
- Photochemical, thermochemical or biological H_2 production
- Hydrogen infrastructure

Bioenergy, biofuels, and bio-feedstocks

- Conversion of low-carbon feedstocks to fuels.
- Coordination across sectors & industries for GHG accounting

Other low-carbon energy sources

- Further integration of CHP with renewable energy
- Rapid switching for hybrid approaches (e.g., dual gas-electric boilers)
- Low-carbon thermal energy (e.g., nuclear, solar thermal, geothermal)

Carbon Capture, Utilization, and Storage (CCUS)

Office of Fossil Energy and Carbon Management

- *Carbon capture systems*
- *Carbon utilization and conversion into fuels, chemicals and materials*
- *Carbon storage*

Industrial Efficiency and Decarbonization Office

- *Carbon utilization in industrial processes*

Office of Science

- *Fundamental science to understand materials and chemistry relevant to CCUS*

RD&D Activities

- Improved catalysts and process design
- System-level techno-economic optimization of integrated carbon capture components, for nominal and specific use cases
- FEED and pre-FEED system-level studies
- Pilot-scale demonstrations for CCUS of emissions from heavy industries
- Continued advancement of other mitigation options, such as direct air capture and forest preservation

Manufacturing Technology Innovation

Advanced Materials and Manufacturing Technology Office

- Next generation processes and digitization
- Critical materials
- High-performance materials development

Office of Fossil Energy and Carbon Management

- Critical materials

Office of Science

- Next-generation materials development
- Insights for innovative chemical processes

RD&D Priorities

- New manufacturing processes to deliver the technologies needed for industrial decarbonization and facility energy management
- Computational optimization of manufacturing processes for efficiency, quality, and repeatability
- Advancements in manufacturing related to critical materials, such as for rare earth magnets needed for efficient motors.
- Material design, discovery, and manufacturing for industrial equipment and facility energy management.