U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY & RENEWABLE ENERGY

Industrial Decarbonization of Energy Intensive Sectors

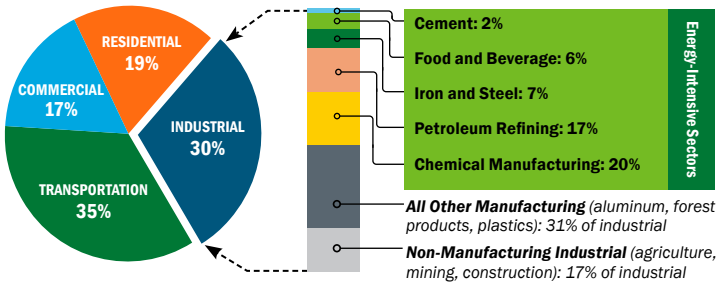
Industrial Decarbonization is the phasing out of atmospheric greenhouse gas (GHG) emissions from all aspects of the industrial sector. There are a number of industrial decarbonization strategies, including energy efficiency, electrification, the use of low carbon fuels, and carbon capture.

To support achieving net zero GHG emissions by 2050, EERE Advanced Manufacturing is investing in research and supporting demonstrations and deployment of new technologies across multiple industries.

EERE Advanced Manufacturing has identified five energy-intensive subsectors important for overall decarbonization:

- Chemical Manufacturing
- Petroleum Refining
- Iron and Steel
- Food and Beverage
- Cement

U.S. Energy-Related Carbon Dioxide Emissions



These five subsectors together account for over 50% of the energy-related carbon dioxide (CO_2) emissions in the U.S. industrial sector, which represents 30% of energy-related CO_2 emissions in the U.S. overall.

Chemical Manufacturing

The U.S. chemical manufacturing industry is incredibly diverse and has seen significant growth over the last decade.

To help achieve net-zero goals, the Chemical Manufacturing sector can:

- Develop low thermal budget process heating solutions and improve the effectiveness of thermal energy use to increase energy efficiency of whole systems
- Expand advanced reactions, catalysts, and reactor systems to improve reaction performance in addition to reducing carbon emissions and improving energy efficiency
- Electrify processes and use hydrogen, biomass, or waste as fuel and feedstocks for manufacturing
- Improve materials efficiency and increase materials circularity

Petroleum Refining

Most U.S. refinery CO_2 emissions are from five large energy-consuming processes: hydrocracking, atmospheric distillation, catalytic cracking, steam methane reforming, and regenerative catalytic reforming. These processes represent the most cost-effective RD&D opportunities for refineries to reduce CO_2 emissions.

To help achieve net-zero goals, the Petroleum Refining sector can:

- Improve energy efficiency both in processes and on-site steam and power generation
- Lower the carbon footprint of energy sources and feedstocks by using lower-carbon fossil energy and introducing low-fossil carbon sources such as nuclear heat and electricity, clean electricity, clean hydrogen, or biofuels
- Capture CO_2 for either long-term storage or utilization

Iron and Steel

Iron and steel manufacturing is one of the most energy-intensive industries worldwide. The use of coal as a feedstock in production methods, the chemical reduction of iron oxide, and the sheer volume of iron and steel produced has made the industry among the highest in GHG emissions.

To help achieve net-zero goals, the Iron and Steel sector can:

- Transition to low-and no-carbon fuels and expand industrial electrification
- Pilot demonstrations for transformative technologies such as hydrogen-steel production, electrolysis of iron ore, and carbon capture and utilization storage (CCUS)
- Improve materials efficiency and increase materials circularity

Food and Beverage

The food and beverage industry is a critical component of the U.S. economy, and one of the largest energy consuming and GHG emitting industries in the United States.

To help achieve net-zero goals, the Food and Beverage sector can:

- Improve energy efficiency by advancing the electrification of process heating, evaporation, and pasteurization processes
- Maintain strict product safety and quality control standards to decrease food loss and waste
- Pursue recycling and material efficiency through alternative packaging and package waste reduction

Cement

In the U.S. cement industry, process-related CO_2 emissions from calcination account for about 58% of total CO_2 emissions and energy-related CO_2 emissions accounted for 42% of total emissions. Cement manufacturing requires high levels of heat, with heat from coal and petroleum coke combustion accounting for 88% of total energy consumption within the sector.

To help achieve net-zero goals, the Cement sector can:

- Evolve existing processes to reduce waste, including circular economy approaches for concrete construction
- Improve materials and energy efficiency with deployment of breakthrough technologies and innovative chemistry solutions
- Expand use of CCUS technologies
- Increase use low carbon binding materials and natural supplementary cementitious materials to lower the carbon-intensity of clinker and solid materials used to create cement ■