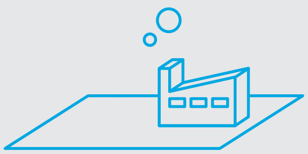
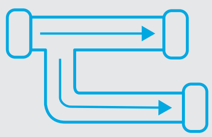
Carbon Capture 101

Carbon capture refers to a group of technologies that prevent industrial and electric power facility carbon emissions from reaching the atmosphere or remove carbon dioxide (CO_2) from the atmosphere.

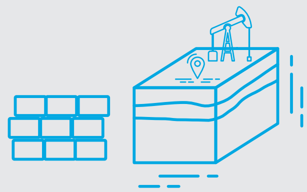
Carbon capture projects generally include the following steps depending on the project type (e.g., many projects include beneficial use as part of the carbon storage process):



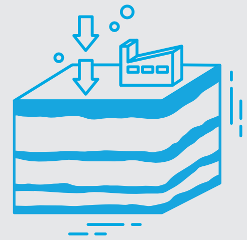
Capture technology removes emissions from a range of facilities (e.g., power plants, refineries, ethanol and fertilizer plants, and steel mills) or directly from the atmosphere. Capture equipment can be retrofitted to existing facilities or built into new facilities.



Captured CO_2 is **transported** via pipeline from the emissions source to geologic formations. There are currently about 5,100 miles of CO_2 pipelines in the United States. Trucks occasionally transport CO_2 for short distances.



Beneficial use of captured carbon occurs when CO_2 or carbon monoxide (CO) becomes a feedstock to produce lower carbon intensity fuels, chemicals, materials and products (e.g., concrete). The largest commercial use is the injection of CO_2 for enhanced oil recovery (CO_2-EOR).



Geologic storage of captured CO_2 occurs in oil and gas fields through the process of CO_2-EOR, or through injection into other deep geologic reservoirs, principally saline formations.

Why is carbon capture important?

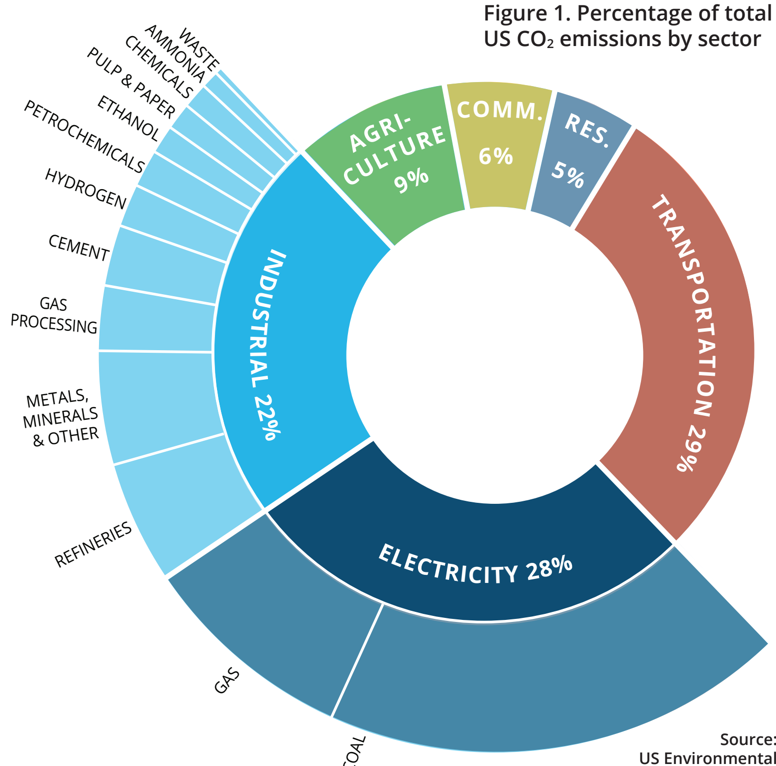
Authoritative analysis by the International Energy Agency and Intergovernmental Panel on Climate Change (IPCC) shows the critical role carbon capture must play in achieving US and global carbon reduction targets by 2050. Carbon capture enables many industries to reduce or eliminate their carbon emissions while protecting and creating high-wage jobs.

Moreover, for key carbon-intensive industries such as steel and cement, significant CO_2 and CO emissions result from the chemistry of the production process itself, regardless of energy inputs.

Thus, carbon capture is an essential emissions reduction tool for major industrial sectors that are otherwise difficult to decarbonize.

Figure 1 illustrates that emissions from the US industrial sector are as significant as the electric or transportation sectors.

Figure 1. Percentage of total US CO_2 emissions by sector



Source: US Environmental Protection Agency (EPA), 2018

Carbon Capture 101

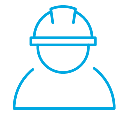
Cost of capture

While carbon capture is cost-effective today on a per-ton basis as part of a portfolio of other low- and zero-emissions reductions, more project deployment will lower costs further. Costs currently range from an estimated $10–$20 per ton in industrial sectors with highly concentrated CO_2 emissions, $40–$60 per ton for industrial facilities with mid-tier CO_2 concentrations, and $55–$75 per ton for fossil fuel-based electric power plants.

Table 1. Factors that influence cost of capture

Factor	Description
CO_2 purity	Highly concentrated CO_2 sources (e.g., ethanol) require less energy to capture and are thus less costly to process before transport.
Facility operation	Facilities that maximize utilization rates of carbon capture equipment reduce effective capital costs relative to tons of CO_2 captured.
Policy environment	Policies like the recently reformed federal 45Q tax credit, tax incentives, low-cost financing, and state low carbon fuels policies help reduce costs of capture and increase investment in carbon capture projects. Additional federal and state incentives and other policies are under consideration.
Regional carbon pipeline infrastructure	Transporting CO_2 long distances increases the cost of carbon capture. Scale-efficient, high-volume CO_2 trunk lines create economies of scale and can lower the cost per ton of CO_2 transport. Regional project coordination may enable higher volume pipeline construction and lower project costs, as would low-cost federal financing of CO_2 transport infrastructure.
Market for CO_2	When current and emerging markets increase demand for CO_2, it increases the market feasibility for carbon capture projects.
Equipment & installation	There is relatively minimal variation by industry in the cost of capture equipment itself. However, facility-specific assessments and installation, as well as variation in financing rates set by investors and lenders, lead to differing project costs within industry sectors.

Carbon capture benefits the economy & environment



Enables production of low- and zero-carbon fuels, electricity, chemicals, materials, and products that transform captured carbon into economic value, **sustaining and creating industries and high-paying jobs.**

Increases the competitiveness of industries by helping them meet growing societal and market expectations for emissions reductions and cleaner, lower-carbon products.

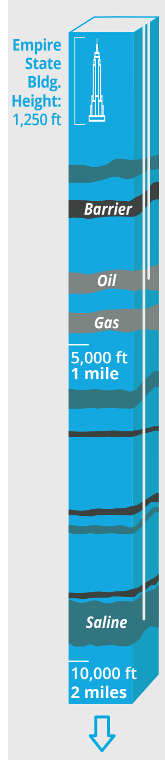
Lowers the cost of reaching a zero-carbon energy system. The IPCC estimates a nearly 140 percent increase in the cost of meeting midcentury emissions reduction goals if carbon capture is not deployed economywide.

Carbon capture is proven

The US has **nearly a half-century's commercial experience** safely capturing, transporting, using, and storing CO_2 at large-scale, with no loss of life or significant environmental incident since projects began in the 1970s. Globally, there are 60 large-scale projects in operation (21 of which are in the US), 12 under construction, and 121 projects in various stages of development.

Geologic storage projects operate under existing state and federal regulations. **CO_2, which is nonflammable and nontoxic, can be stored securely** in suitable geologic formations by physical and chemical trapping mechanisms. Storage sites are monitored to ensure that the CO_2 stays underground and out of the atmosphere and that water resources are protected.

Figure 2. CO_2 injection and storage



CO_2 can be injected into oil and gas reservoirs for use and geologic storage through EOR or can be **injected for storage** in deep geologic reservoirs, principally saline formations. Stored CO_2 is secured by **layers of impermeable cap rock barriers** and other natural trapping mechanisms.

North American CO_2 storage potential may be as high as an estimated 22 trillion metric tons, which could **store nearly 3,500 years of US CO_2 emissions** (US Dept. of Energy Carbon Storage Atlas, 2015; US EPA, 2017).

According to the IPCC, well-selected and managed geologic sites are likely to retain over 99% of injected CO_2 over 1,000 years.

Note: CO_2 can be stored in a variety of geologic formations at multiple depths. This diagram depicts examples of some typical injection and storage depths.

Authors:
Jennifer Christensen, Dane McFarlane, & Elizabeth Abramson

GREAT PLAINS INSTITUTE | Better Energy. Better World.

For more information, contact:
Patrice Lahlum, Program Consultant, Carbon Management
plahlum@gpisd.net | (701) 429-1861

Last updated on January 4, 2022