



STATE OF NEW YORK

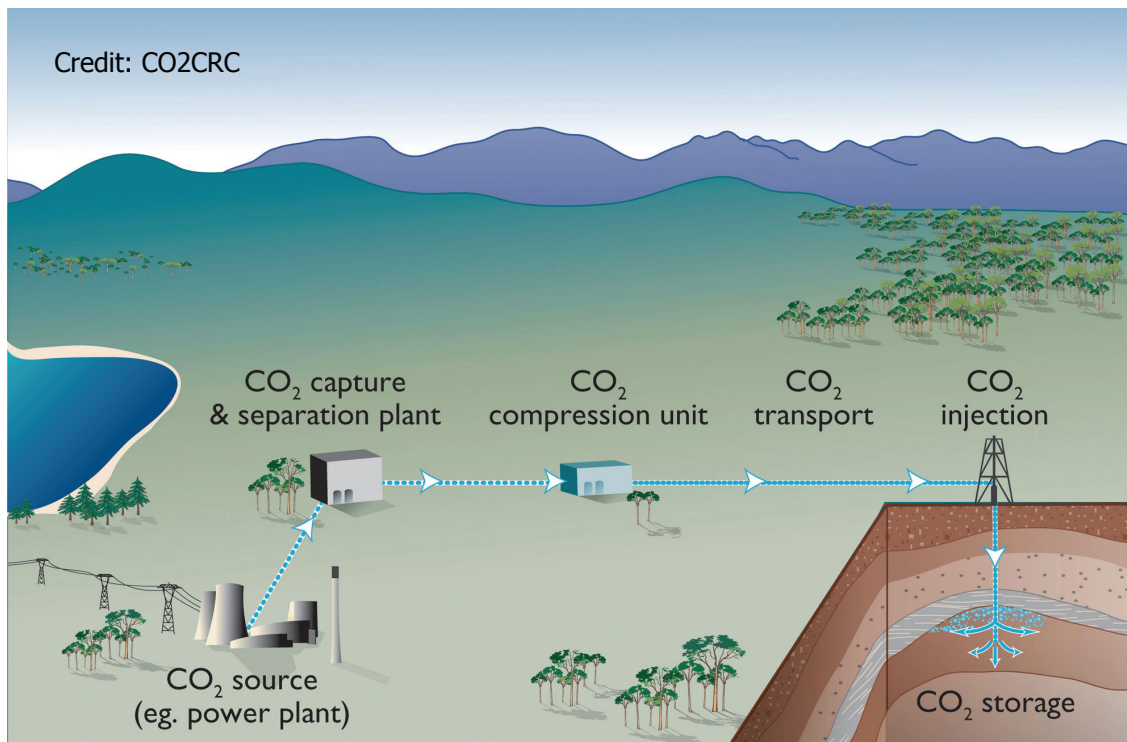
What is Carbon Capture and Sequestration?

The vast majority of scientists agree that global climate change is occurring and that to prevent its most serious effects we must begin immediately to significantly reduce our greenhouse gas (GHG) emissions. One major contributor to climate change is the release of the greenhouse gas carbon dioxide (CO_2).

Many experts believe that the consequences of climate change are so dire that we must explore all potential means to reduce GHG emissions. Carbon capture and sequestration (CCS) may be an effective way to reduce CO_2 emissions from power plants and other industrial processes. Its viability is being actively explored throughout the world, including in New York State.

CCS is a strategy that can help reduce CO_2 emissions into the atmosphere, while helping to meet present and future energy demands. CCS involves the following steps:

1. Capturing CO_2 from a source such as a power plant or industrial facility
2. Transporting the compressed CO_2 to the injection site
3. Injecting compressed CO_2 into a deep subsurface rock formation for permanent geological sequestration
4. Monitoring sequestered CO_2 while it undergoes a series of natural processes to become permanently integrated into the geologic environment.



How is CO₂ captured?

There are various ways in which CO₂ can be captured. Capture can occur before, during, or after fuel is combusted. With pre-combustion technologies, CO₂ is removed from the fossil fuel prior to combustion. With post-combustion technology, a chemical reaction is used to capture CO₂ from flue gas after the fuel is burned.

Although CO₂ can be captured from any combustion plant, some combustion technologies can make capture easier. These include two techniques involving gasification, the conversion of coal into gas.

Oxy-fuel combustion is another technology that is gaining attention. This process entails injecting pure oxygen (rather than air) into the chamber in which coal is being burned. The oxy-fuel process produces an exhaust stream of nearly pure CO₂, making separation from other combustion by-products unnecessary.

After the CO₂ has been captured and, if necessary, separated from other components of the flue gas, it is compressed to a *supercritical* state. In this state, CO₂—which most people know as a gas—has the density of a liquid but flows as a gas. The CO₂ remains in the supercritical state during transport and injection to subsurface geologic formations. Natural subsurface temperature and pressure at injection depths are great enough to maintain the supercritical state. Because supercritical CO₂ is so dense, more of it can be sequestered than if it remained a gas.

How is the CO₂ transported?

Captured CO₂ can be transported by pipeline, ship, rail, or truck. At present, the most efficient mode of transporting large quantities of CO₂ is pipeline. The U.S. has extensive experience in handling and transporting supercritical CO₂; approximately 3,800 miles

of pipeline are currently dedicated to transferring CO₂ in the U.S., mainly for enhanced oil and gas recovery activities. While construction of additional pipelines will be necessary for broader-scale deployment of CCS, existing CO₂ pipelines could be integrated into expanding CCS infrastructure.

Where can CO₂ be sequestered?

CO₂ can be sequestered in deep underground formations of porous rock at least 2,500 feet below ground surface, but diligent geological site characterization is essential. To be suitable for CCS, porous formations must lie under layers of impermeable rock that will provide a “cap” or seal to prevent upward migration of the CO₂.

The following types of geologic formations are suitable for sequestration:

- Oil and gas reservoirs – Oil and natural gas have been held in numerous natural oil and gas fields in the U.S. and around the world for millions of years. Once empty of the oil and gas, these same rock formations could hold injected CO₂. For decades, the oil and gas industry has been injecting CO₂ into natural gas and oil fields to assist in maximizing production levels. Currently, approximately 32 million tons of CO₂ per year are injected into subsurface reservoirs throughout the U.S. for recovery of additional gas or oil. For economic reasons, the CO₂ is usually recovered and re-injected; however, once all of the gas or oil in a field has been recovered, the CO₂ could be left underground, where the oil and gas had been held for millions of years. Through these operations, state-of-the-art techniques have been advanced to ensure that CO₂ could be sequestered safely and effectively. Advanced technologies and experience gained from these operations

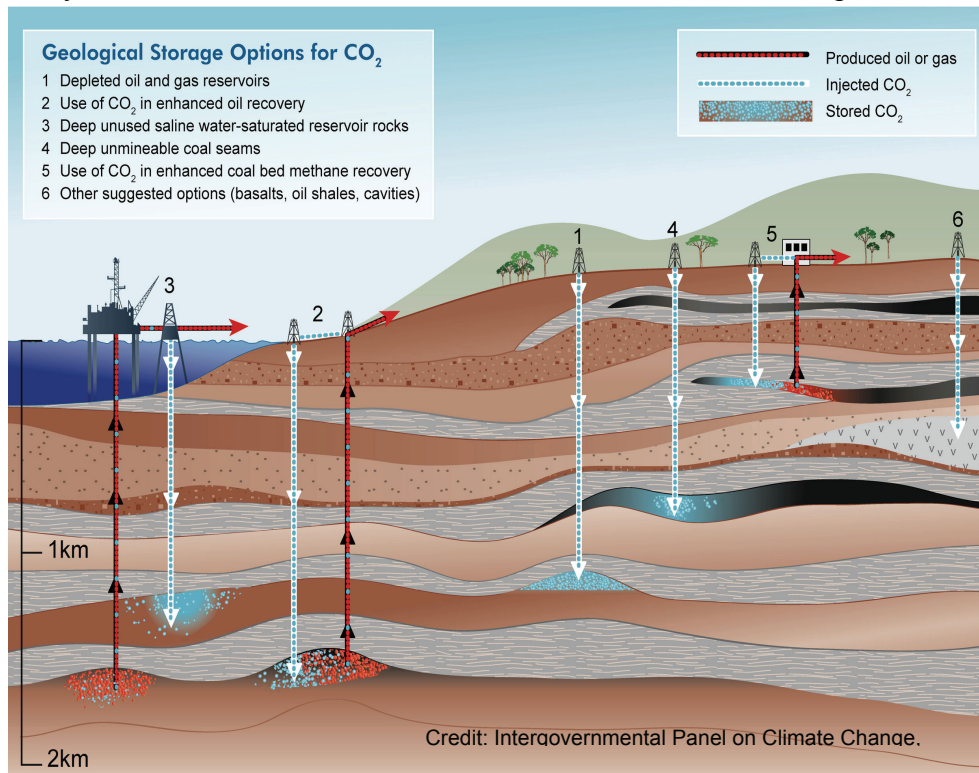
have resulted in a more detailed understanding of the subsurface geologic environment and behavior of injected CO₂.

- Deep or unmineable coal seams – During enhanced coal bed methane recovery operations, CO₂ is injected into these seams. The CO₂ displaces methane from the coal, and the methane can be recovered as an energy source. While coal seams could be effective reservoirs to sequester small volumes of CO₂, other formations would be needed to sequester the amounts of CO₂ being generated today.

formations are porous, saltwater-bearing rock formations that are located thousands of feet below the earth’s surface. Because the water in these formations is very salty, it has no value as drinking water.

- Shale formations – Some shales have the potential to sequester CO₂. Currently, natural gas is produced from a type of rock called “organic shale.” Due to the chemical properties of the shale, natural gas, and CO₂, it is possible that injecting CO₂ could enhance the production of natural gas and sequester CO₂ at the same time. Since New York State includes large areas of shale, this process could be an effective option for managing CO₂ while

facilitating natural gas extraction. This idea is currently being studied in New York and elsewhere.



How does the CO₂ stay underground?

Once CO₂ is sequestered thousands of feet below the ground surface, it is confined in tiny pores within the rock layer.

- Saline formations – In New York State, the most likely rock formations to be targeted for CO₂ sequestration are saline formations. Saline formations are abundant and have the necessary capacity to sequester the large amounts of CO₂ being generated today. Because of this, they are considered one of the best choices for CO₂ sequestration. Saline

Subsurface temperature and pressure keep the sequestered CO₂ in its supercritical state. Impermeable rock units, or cap rocks, serve as barriers against migration of the CO₂ toward the surface. Over time, the CO₂ becomes even more securely trapped, as it dissolves into the salty water of a saline formation or undergoes natural reactions to form a solid mineral. Ongoing geologic research has demonstrated

that the risk of CO₂ finding its way back to the surface is extremely low.

How much capacity is available to sequester CO₂?

Geologic research and advanced modeling are a few of the many techniques used to determine the amount of CO₂ that a specific geologic formation could retain. The U.S. Department of Energy (DOE) estimates that geologic formations in the U.S. could sequester 1-4 trillion tons of CO₂. Annual total U.S. emissions of CO₂ are approximately 5.5 billion tons, so there is likely to be sufficient sequestration capacity for many decades.

The sequestration capacity of geologic formations within New York State is presently being researched. Regional geologic assessments suggest that New York contains a wide array of formations suitable for the successful deployment of CCS.

What is the likelihood of successful long-term CO₂ sequestration?

It is extremely likely. There is international agreement that CCS is a safe and successful strategy to manage large volumes of CO₂ over the long term. In 2005, the Intergovernmental Panel on Climate Change (IPCC) released its *Special Report on Carbon Capture and Storage*. The report predicted that well-selected, designed, and managed geologic sequestration sites would allow CO₂ to remain sequestered in the deep underground for millions of years.

For more information

New York State Energy Research and Development Authority's webpage on carbon capture and sequestration in New York State:

www.nyserda.org/programs/Environment/EM/EP/carbon_capture_and_sequestration.asp

Produced by the members of the New York State Interagency Carbon Capture and Sequestration Working Group:

- Empire State Development Corporation
- New York Power Authority
- New York State Department of Environmental Conservation
- New York State Department of Public Service
- New York State Energy Research and Development Authority
- New York State Museum
- New York State Office of the Attorney General
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This fact sheet is one of a series of four New York State fact sheets on the potential role of carbon capture and sequestration in addressing climate change:

- 1) *Climate Change and the Role of Carbon Capture and Sequestration*
- 2) *What is Carbon Capture and Sequestration?*
- 3) *Carbon Capture and Sequestration Safety*
- 4) *Carbon Capture and Sequestration in New York State*