STORAGE
CCS EXPLAINED SERIES

GLOBAL CCS INSTITUTE

Carbon Capture and Storage (CCS) refers to a suite of technologies that capture and store the greenhouse gas carbon dioxide (CO_2), so that it does not reach the atmosphere and contribute to climate change.

CO_2 STORAGE

The final stage in the CCS process involves the storage of CO_2 at a suitable storage site. During this stage, captured CO_2 is injected into carefully selected porous rock formations (known as **storage formations**). Storage formations can be depleted oil and gas reservoirs, or porous rock filled with unusable, saline water. They are always underground, and typically at depths 2-3 kilometres below the earth's surface.

STORAGE FORMATION CHARACTERISICS

A formation is assessed as suitable for CO_2 injection and storage based on the following characteristics:

Porosity

Millimetre-sized pore spaces in the formation provide the capacity to store the CO_2.

Permeability

The pores in the formation rock are sufficiently connected to allow the CO_2 to move throughout the formation and be injected at the required rate.

Permanence

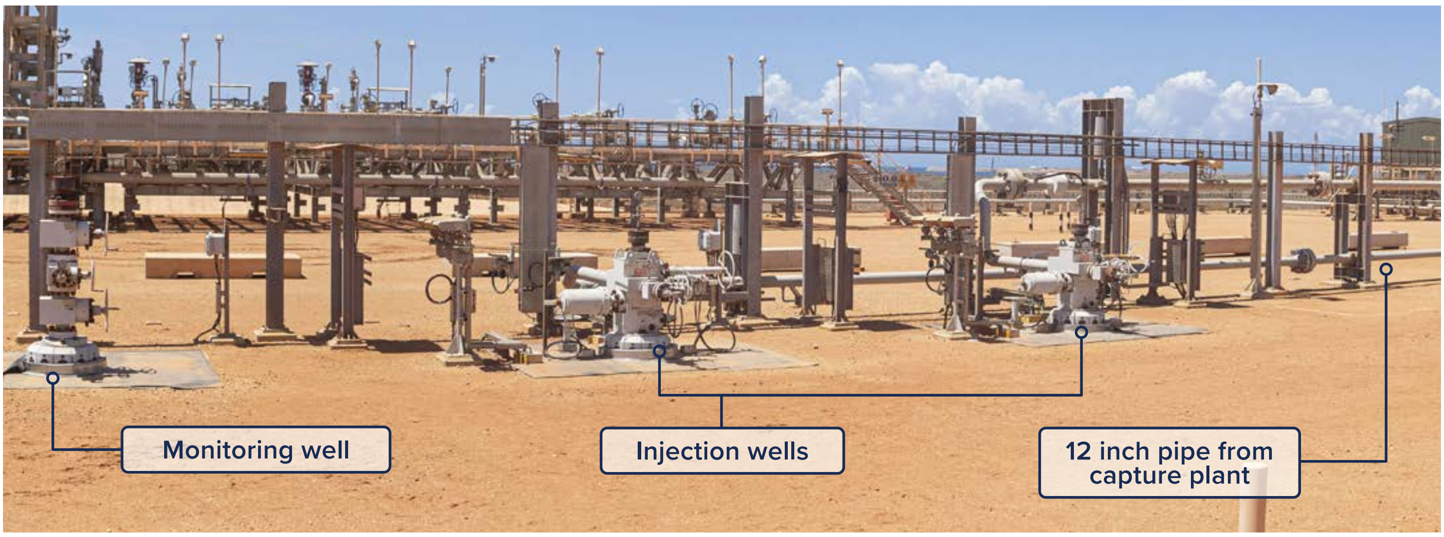
An overlying cap rock seal exists **above** the formation to ensure the CO_2 is contained permanently.

CO2/H2S Injection well in Hellisheidi, Iceland. Image courtesy of Carbfix.

CO_2 INJECTION

During injection, CO_2 is pumped down a wellbore and injected into a formation through perforations or screens cemented into a storage formation. The CO_2 then moves through and fills the microscopic pore space in the storage formation.

CO_2 is not injected into underground caverns.



Gorgon LNG facility incorporating CCS system, Western Australia. Image courtesy of Chevron.

TRAPPING MECHANISMS

Injected CO_2 is permanently trapped in a storage formation by naturally occurring trapping mechanisms that happen over time.

STRUCTURAL	RESIDUAL	DISSOLUTION	MINERAL
The first stage of permanent storage occurs when injected CO_2, which is slightly more buoyant than the saline water of the storage formation, migrates to the top of the formation and becomes structurally trapped underneath the impermeable cap rock, which acts as a seal. This is how hydrocarbons have been naturally trapped underground for tens of millions of years.	Injected CO_2 enters the microscopic pore spaces of a storage formation, where it is permanently trapped by capillary forces that prevent it from exiting.	Injected CO_2 dissolves in a storage formation's saline water, becoming permanently trapped.	Injected CO_2 chemically reacts with the minerals in a storage formation to form a new, stable mineral product – locking it in a solid state permanently.

When injection begins, all of these mechanisms start occurring simultaneously, but they don't occur at the same rate.

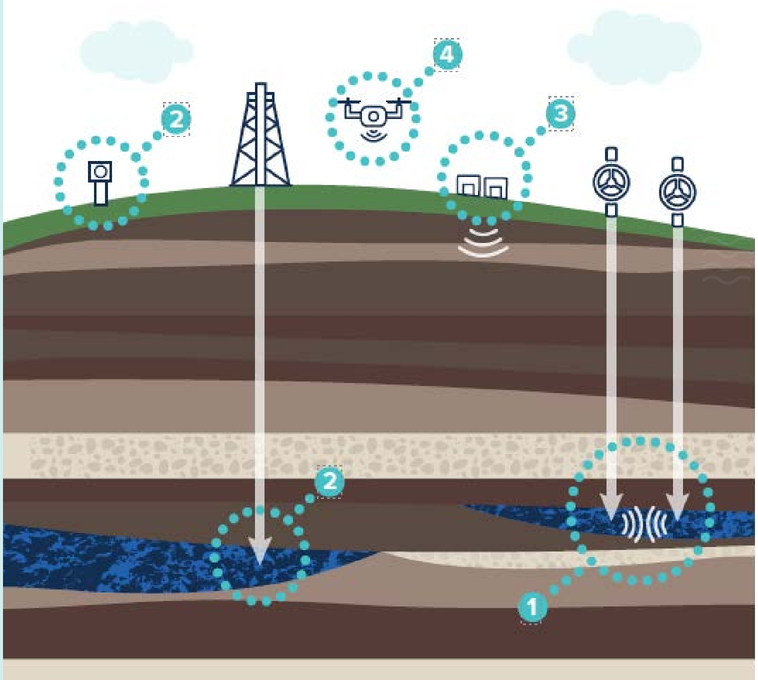
Migration into a structural trap will be the most rapid trapping mechanism, but as time progresses and the CO_2 plume moves through the storage formation, residual trapping, dissolution, and mineral trapping all begin to occur, generally in that order.

CO_2 STORAGE IS STRICTLY CONTROLLED AND MONITORED

CO_2 storage is conducted under robust national and international regulatory frameworks. These apply across all stages of operations from authorising storage through to pre-injection, operation and post-injection.

Once stored underground, operators need to measure, monitor and verify that the CO_2 is behaving as expected. This is done through a variety of monitoring techniques, the most common of which are:

1. **Seismic Monitoring**
   Uses acoustic (sound) waves to image the subsurface to detect CO_2 plume movement.
2. **Surface and Subsurface Monitoring**
   Uses sensors at various depths to monitor CO_2 concentrations, formation pressure and temperature, as well as other parameters.
3. **Soil Gas Monitoring**
   Measures CO_2 concentrations in the soil above onshore storage sites.
4. **Aerial and Satellite Monitoring**
   Uses remote sensing technologies to monitor large areas for CO_2 emissions.



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