WHAT IS CARBON CAPTURE AND STORAGE (CCS)?

Carbon Capture and Storage (CCS) is an emission reduction process designed to prevent large amounts of carbon dioxide (CO_2) from being released into the atmosphere. The technology involves capturing CO_2, compressing it for transportation and then injecting it deep into a rock formation at a carefully selected site, where it is permanently stored.

WHAT IS CCUS?

CCS also enables the "utilization" of the CO_2 – often referred to as CCUS; however, CCS\CCUS are often used interchangeably. Increasingly there are several emerging forms of CO_2 utilization – for example as an additive to improve the integrity of products, such as cement. The volumes required for these by-products, however is small and hence negligible toward the goal to mitigate climate change. Alternatively, large volume CO_2 utilization occur when it is used for EOR and has the added benefit of then being permanently stored underground.

ABOUT THE INTERNATIONAL CCS KNOWLEDGE CENTRE

The International CCS Knowledge Centre (Knowledge Centre) is a non-profit organization that utilizes lessons learned, and the knowledge gained from the successful retrofit of BD3 - the world's first coal-fired power station with a carbon capture and storage facility.

Motivated to see sizeable impacts on CO_2 reductions to support global climate change goals, the Knowledge Centre was established - as a non-profit by BHP and SaskPower - the Knowledge Centre provides the know-how to implement large-scale CCS projects as well as CCS optimization through the base learnings from both the fully-integrated BD3 and the comprehensive second-generation CCS study, known as the Shand CCS Feasibility Study.

Contact the International CCS Knowledge Centre at:

198-10 Research Drive,
Regina, SK, Canada, S4S 7J7

E: info@ccsknowledge.com
P: 1-306-565-KNOW (5669)

INTERNATIONAL CCS KNOWLEDGE CENTRE

ccsknowledge.com

INTERNATIONAL
CCS KNOWLEDGE
CENTRE

CARBON CAPTURE & STORAGE
LARGE SCALE CO_2 UTILIZATION & STORAGE

THE PROCESS OF LARGE-SCALE CCS/CCUS involves three major steps and different types of technologies:

CAPTURE

The separation of CO_2 from other gases produced at facilities such as coal and natural gas power plants, oil and gas refineries, steel mills and cement plants.

TRANSPORT

Once captured and separated, the CO_2 is compressed to a "dense phase" or liquid-like state to make it easier to transport and store (liquid takes up much less space than a gas). The CO_2 is usually transported to a suitable site for geological storage using pipelines, although some countries use ships and – for smaller amounts of CO_2 – trucks and trains can also be used.

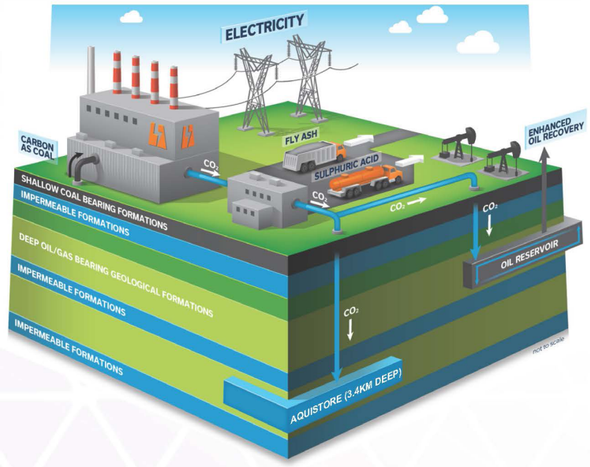
INJECTION FOR STORAGE

1. Permanent Storage. The captured CO_2 is transported to a geological storage site and then injected deep underground where it is stored/remains indefinitely.

2. Utilization to Storage via Enhanced Oil Recovery (EOR). The captured CO_2 is transported to an oil field and is used to stimulate more oil production, with the CO_2 then being stored in the oil-depleted reservoir.

BOUNDARY DAM 3'S FULL-CHAIN ADVANTAGE

SaskPower's Boundary Dam 3 CCS Facility (BD3) is part of a full-chain system – from its coal plant, capture facility, transportation infrastructure via pipelines, access to both EOR fields and permanent storage capabilities. This is an ideal model for CCS. The CO_2 purchased for EOR creates revenue and royalties and, in the event, that the off-taker(s) of CO_2 have no demand, the CO_2 is then redirected to the permanent storage site, Aquistore.



ENHANCED OIL RECOVERY (EOR)

CO_2 FOR ENHANCED OIL RECOVERY

When an oil field has begun to slow its performance, CO_2 can be used to "enhance" production and increase the amount of oil captured, by coaxing more out of the ground than is possible through traditional means.

HOW DOES EOR WORK?

EOR involves the injection of compressed CO_2 into an oil reservoir. The CO_2 acts like a solvent, causing the oil to expand and flow more easily to production wells. As the oil is pumped to the surface, the pressure and temperature begin to decrease and the contained CO_2 begins to get released from the oil.

This freed-up CO_2 (about 60% of the original injection) is collected at the surface, compressed, and re-injected. The remaining 40% of the injected CO_2 stays permanently in the oil-depleted reservoir and never comes back to the surface.

WHAT VALUE DOES CO_2 INJECTION BRING TO THE OIL INDUSTRY

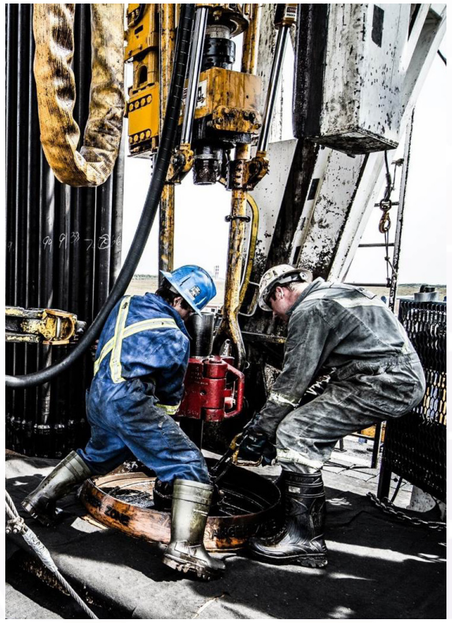
CO_2 is valued as a commodity that helps maximize the production of oil from any given oil field. For example within five years of injecting CO_2 at the Weyburn oilfield in Saskatchewan, Canada, production went from 8,000 barrels to nearly 30,000 barrels of oil per day.

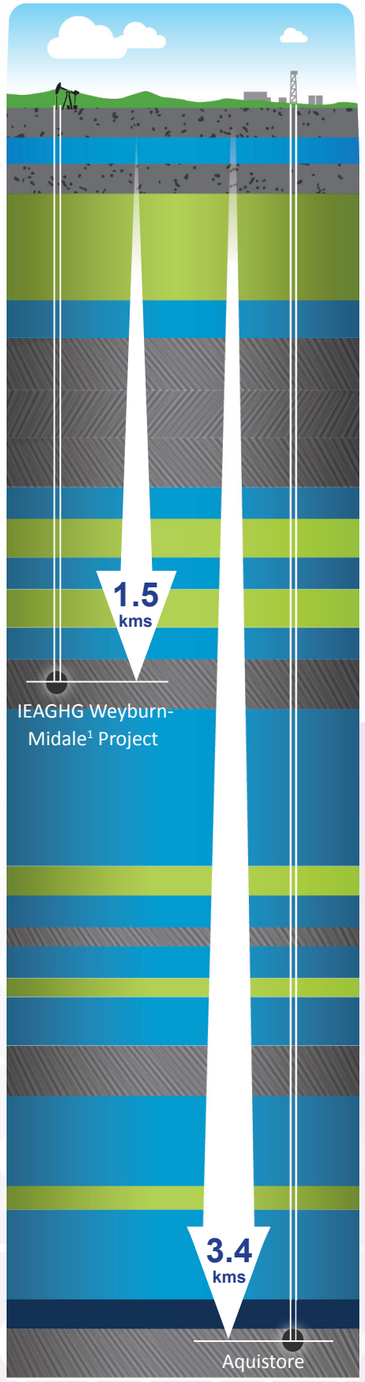
Selling captured CO_2 for utilization and eventual storage, in EOR, not only prevents greenhouse gases entering the atmosphere, it also provides revenue to counterbalance the costs of CCS. Specifically, the capital and operating expenditures for the capture facilities, the pipeline to move the oil, and the infrastructure to inject the oil are offset by the profits made from the sale of the CO_2.

WHAT ASSURANCE IS THERE THAT CO_2 STORED IN EOR FIELDS REMAINS UNDERGROUND?

There are four elements that must meet specific criteria in determining the possibility of a storage site. These are: depth, location, containment, and capacity. Geological storage sites for CCS are chosen, characterised and designed based on zero leakage - so that all of the injected CO_2 will be permanently stored.

This has been well demonstrated. Over the decade of research, at IEAGHG Weyburn-Midale[1] Project, scientists monitored changes in the composition of reservoir fluids due to CO_2 injection (at a depth of 1.5 kilometres), by sampling well production fluids. These changes have not caused any negative effects in the reservoir or surrounding rocks. EOR operation is still active in this oil-field and the CO_2 continues to be safely stored. Scientists and engineers use the collected data to model and verify safe storage in other geological regions around the world.





DEPTH OF CO_2 STORAGE

PERMANENT STORAGE

PERMANENT STORAGE OF CO_2

As one of the first studies in the world to examine injections of CO_2 into geological layers, the Weyburn-Midale Project provided a new level of understanding of what happens to CO_2 once it is injected into the ground. It was the launchpad for the renowned Aquistore Project. With research led by the same scientific and engineering team as the Weyburn-Midale Poject, Aquistore has become is the most comprehensive full-scale geological field laboratory for CO_2 storage in the world.

Located 2 kilometres from BD3, its captured CO_2 (when not needed by off-takers for EOR) is sent by pipeline to the Aquistore injection well where it is injected 3.4 kilometres deep into brine-filled sandstone. This 'buffer storage' ensures that none of BD3's captured CO_2 is released into the atmosphere. By taking industrial CO_2 at variable and intermittent rates, Aquistore is a full-scale project tied to real injection considerations – the learnings of which provide a fundamental understanding of the reality for commercial operations.

HOW DOES PERMANENT STORAGE WORK?

When CO_2 is directed to sites for permanent storage, it is then injected into deep, underground rock formations, at a depth of at least a kilometre below the ground surface or below ocean bottom, in the cases of off-shore CO_2 storage.

These porous rock formations are referred to as deep saline formations or saline reservoirs and they are almost always sedimentary rocks like sandstones or limestones. The tiny pores have stored vast amounts of liquids and gases safely for many millions of years and offer a secure space to permanently store CO_2. Injecting into geological storage sites has been done in the oil and gas sector for over half a century and thus the technology is completed understood, test and proven to be safe.

The Aquistore Project has an impressive Monitoring Measurement and Verification Program. With over 30 technologies installed in the subsurface and above ground, Aquistore consists of heavily instrumented injection and observation wells that continuously monitor the impact and migration of injected CO_2.

HOW MUCH GEOLOGICAL SPACE IS THERE FOR CO_2 STORAGE?

Estimates from the United Nations Intergovernmental Panel of Climate Change (IPCC) state that there is potentially enough storage space in deep saline formations to store all the manmade CO_2 from large, fixed sources for approximately 600 years.

WHY IS IT IMPORTANT TO CAPTURE CO_2?

CO_2 is captured to prevent large amounts of it from entering the atmosphere. CO_2 is the greatest contributor to global warming. Large-scale CCS is the only technology that prevents significant amounts of CO_2 from entering the atmosphere to meet the 2°C climate goals set out in the Paris Agreement. Several global organizations including the International Energy Agency, and the IPCC recognize that much of the world cannot meet their emission reduction targets without large-scale CCS. Research affirms that without CCS, the median increase in mitigation cost is 138%.

[1] International Energy Agency Greenhouse Gas (IEAGHG) Weyburn-Midale Project conducted a long-term study (2000-2012) to validate the safety of CO_2 injection as well as the value of enhanced oil recovery.

Source: *What Happens When CO_2 is Stored Underground?*, Petroleum Technology Research Centre, GCCSI, 2014.