Ensuring safe CO_2 storage

Measurement, monitoring and verification

Permanent carbon dioxide (CO_2) storage in deep geological formations (saline reservoirs) has been done safely for decades in North America and around the world. Measurement, Monitoring and Verification (MMV) plans and processes are a key component of safe CO_2 storage.

MMV planning prior to CO_2 storage operations

Before CO_2 injection can begin for any CCS project, a potential storage site must be extensively characterized and tested – not only to meet stringent regulatory requirements but because CO_2 storage requires CCS project planners to verify that the CO_2 will be permanently stored in the chosen rock formation. Companies and government regulators can then verify the precise quantity of CO_2 stored to ensure permanence and safety.

MMV and safe CO_2 storage

As part of Enbridge's commitment to safety, and as required by law, we will develop and execute site-specific MMV plans for the life of our CCS projects. Enbridge's MMV plans are being developed and reviewed by world-leading CO_2 storage experts. These MMV plans will be continuously enhanced with updated information.

Once a possible storage location has been identified, and with the appropriate approvals, a number of pre-injection measurement activities take place, including:

- **Core samples.** Rock cores are collected and examined to determine the storage location's porosity and permeability (the features that make accepting injected CO_2 possible). Cores are also tested to ensure CO_2 injection pressure never approaches the maximum during operation.
- **Caprock testing.** The thickness and extent of the impermeable rock layers directly above the storage location are tested for their pressure limits and ability to contain the stored CO_2.
- **Seismic imaging.** Images created by seismic shoots show where caprocks or porous rocks are located, along with identifying possible storage risks that might exist.
- **Geological characterization and computer modeling.** Computer models – that create an image of how injected CO_2 in the reservoir will move – are used before and after injection begins, to compare actual measurements with expected results. Once this data and other information has been approved by regulators, injection and storage may begin.

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MMV design

The CO_2 reservoir model is used to determine site specific MMV plans, which include careful consideration of items such as subsurface, groundwater, surface water, soil, vegetation and air.

Baseline data collection

Before CO_2 injection begins, baseline measurements related to the MMV design items above will be collected for comparison against measurements taken throughout operations.

A word about CO_2 incident prevention

Emergency response is an important facet of Enbridge's multi-layered approach to pipeline and facility safety, which also includes rigorous design and construction standards, regular pipeline maintenance, 24/7 system monitoring, inline inspections, leak detection and site-specific MMV planning and processes. Enbridge invests extensively each year in the tools, technologies, and strategies to ensure our infrastructure is operated safely, reliably, and in an environmentally responsible manner.

In the unlikely event of a CO_2 leak, Enbridge has the emergency response equipment, training, and expertise to respond quickly and effectively. If an incident were to occur:

- We would close remotely controlled sectionalizing valves immediately upon detection of a problem, with full closure occurring within three minutes of activation to isolate the affected section.
- We would rapidly dispatch a trained response team, including environmental crews who have a strong understanding of the products we transport.
- Under the oversight of federal and/or state/provincial agencies, Enbridge would then restore the affected areas to avoid long-term impact to landowners, residents and the environment.

MMV during CO_2 storage operations

Site-specific MMV activities are required by regulators throughout the life of a CO_2 storage project, and typically include:

- **Injection and observation well sensors.** Pressure and temperature gauges, along with fibre-optic sensors (distributed acoustic sensing) continuously monitor the wells as CO_2 injection occurs, ensuring safe operating procedures. An emergency shutdown valve is in place should irregular readings occur.
- **Deep subsurface fluid monitoring.** These samples ensure that chemical changes caused by the CO_2 over time are examined.
- **Periodic seismic shoots.** As CO_2 totals increase in the reservoir, new seismic images are used to compare with the computer models and ensure storage remains safe.
- **Continuous passive seismic monitoring.** Geophones and seismographs monitor for any microseismic events and earth movements, with CO_2 injection adjusted if and as risks are identified.
- **Groundwater and soil monitoring.** Samples are collected from the same locations at regular intervals during operations to confirm groundwater, surface, soil and air measurements remain within expected ranges. Changes in these values will be investigated.

Given the extensive MMV tools in use before and during CO_2 injection/storage operations – including downhole monitoring in the wells, seismic imaging, ongoing data from deep and shallow underground, and monitoring of the atmosphere, hydrosphere, and biosphere – the potential risk of CO_2 release is remote.

Enbridge is advancing CCS projects across North America as a key enabler to reaching national and international emissions reduction goals. This is one of a series of Enbridge fact sheets intended to provide an overview of the many facets of CCS.