



Ensuring safe CO₂ storage

Measurement, Monitoring and Verification

Permanent carbon dioxide (CO₂) 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 CO₂ storage.

MMV planning prior to CO₂ storage operations

Before CO₂ injection can begin for any carbon capture and storage (CCS) project, a potential storage site must be extensively characterized and tested – not only to meet stringent regulatory requirements but because CO₂ storage requires CCS project planners to verify that the CO₂ will be permanently stored in the chosen rock formation. Companies and government regulators can then verify the precise quantity of CO₂ stored to ensure permanence and safety.

MMV and safe CO₂ storage

As part of Enbridge Gas' 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 Gas' MMV plans are being developed and reviewed by world-leading CO₂ 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 CO₂ possible). Cores are also tested to ensure CO₂ 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 CO₂.
- **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 CO₂ 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.

MMV design

The CO₂ 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 CO₂ injection begins, baseline measurements related to the MMV design items above will be collected for comparison against measurements taken throughout operations.

A word about CO₂ incident prevention

Emergency response is an important facet of Enbridge Gas' 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 Gas 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 CO₂ leak, Enbridge Gas 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.
- 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 provincial agencies, Enbridge Gas would then restore the affected areas to avoid long-term impact to landowners, residents and the environment.

MMV during CO₂ storage operations

Site-specific MMV activities are required by regulators throughout the life of a CO₂ 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 CO₂ 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 CO₂ over time are examined.
- **Periodic seismic shoots.** As CO₂ 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 with CO₂ 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 CO₂ 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 CO₂ release is remote.

Enbridge Gas is advancing CCS projects in Ontario as a key enabler to reaching provincial, national and international emissions reductions goals. This is one of a series of Enbridge Gas fact sheets intended to provide an overview of the many facets of CCS.