

Summary of DOE's Monitoring, Mitigation, and Verification Program and Modeling Program



*Monitoring, Mitigation, and
Verification*

Modeling

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Office of Fossil Energy



Monitoring, Mitigation & Verification (MM&V)

- **Monitoring and Verification**
 - Ability to measure the amount of CO₂ stored at a particular site
 - Monitor the site for leaks
 - Track the location of underground CO₂ plume
 - Verify that the CO₂ is stored in a way that is permanent and not harmful to the host ecosystem
- **Mitigation**
 - Near-term ability to respond to risks such as CO₂ leakage or ecological damage in the unlikely event that it should occur

Modeling

- **Modeling**
 - Simulating the underground conditions that influence the behavior of CO₂ injected into geologic formations
 - Characterizing any resulting geomechanical changes to the reservoir

Critical in ensuring the long-term viability of carbon capture and storage (CCS) systems

Satisfying both technical and regulatory requirements



Monitoring Mitigation & Verification

CRITICAL CHALLENGES

- ▶ Robust, flexible accounting protocols
- ▶ Scale and timeframe
- ▶ Cost-effective long-term monitoring
- ▶ Natural CO₂ flux

RESEARCH PATHWAYS

CROSS CUT PATHWAYS

Geologic Formations

CO₂ fate and transport models

Plume tracking

CO₂ leak detection

Mitigation

Terrestrial Ecosystems

Plant matter measurement

Soil carbon measurement

Ecosystem response models

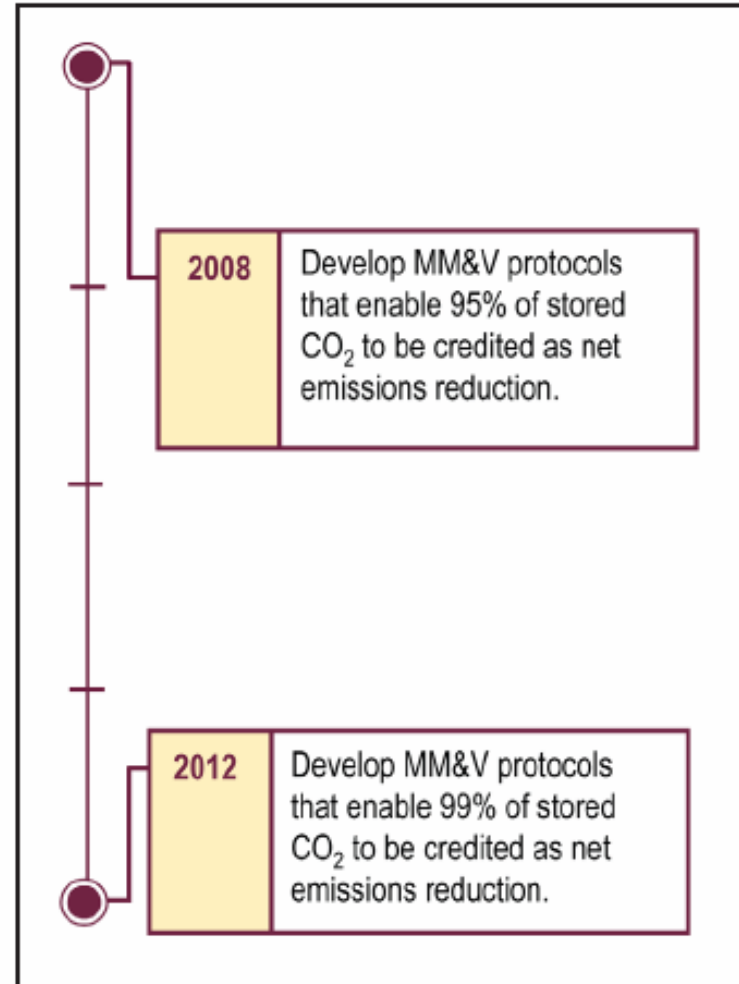
Risk analysis protocols

Accounting protocols

Monitoring network design

Goals

MM&V goals focus on ensuring permanence, which support the overarching Program goal of achieving 90% carbon capture with 99% storage permanence



Monitoring, Mitigation, and Verification

Geologic Formations

- **CO₂ fate and transport models – simulating underground conditions that influence behavior of CO₂**
- **Plume tracking – map injected CO₂ and track its movement**
- **CO₂ leak detection – critical measurements of whether CO₂ is escaping from storage reservoir**
- **Mitigation- steps to be taken to arrest the flow of CO₂ and mitigate the impacts**

Terrestrial Ecosystems

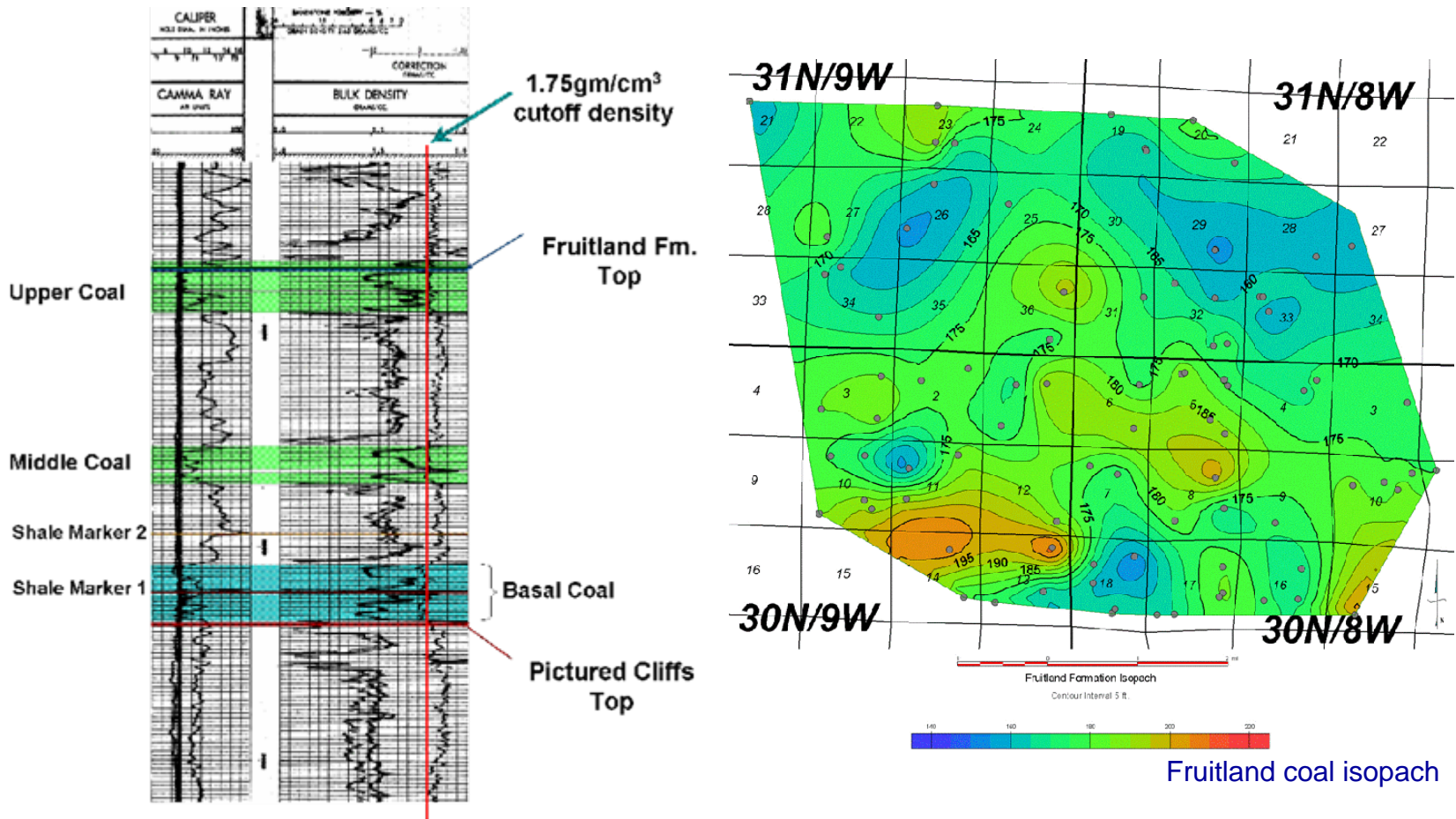
- **Organic matter measurement – reducing cost for measuring carbon in terrestrial ecosystems and analyzing soil samples**
- **Soil carbon measurement – automated technologies for measuring soil carbon**
- **Modeling – extrapolating results of carbon uptake activities from random samples to entire plots for estimating net increase in carbon**



Modeling

- Enables researchers to predict how CO₂ plumes will flow and become hydrodynamically trapped in the short term and to understand the effects of chemical reactions (and other mechanisms) that will immobilize CO₂ over the longer term
- Helps operators reduce the risks associated with inducing fractures in caprock and reactivating faults during injection
- Engenders confidence that injected CO₂ will remain securely stored *before* injection commences
- Examines potential pathways that fugitive CO₂ may follow

Geologic Model of Coal Seam Developed by NETL



- Taken from several area well logs near Farmington, NM
- Southwest Partnership-San Juan Basin Site



Plume Tracking

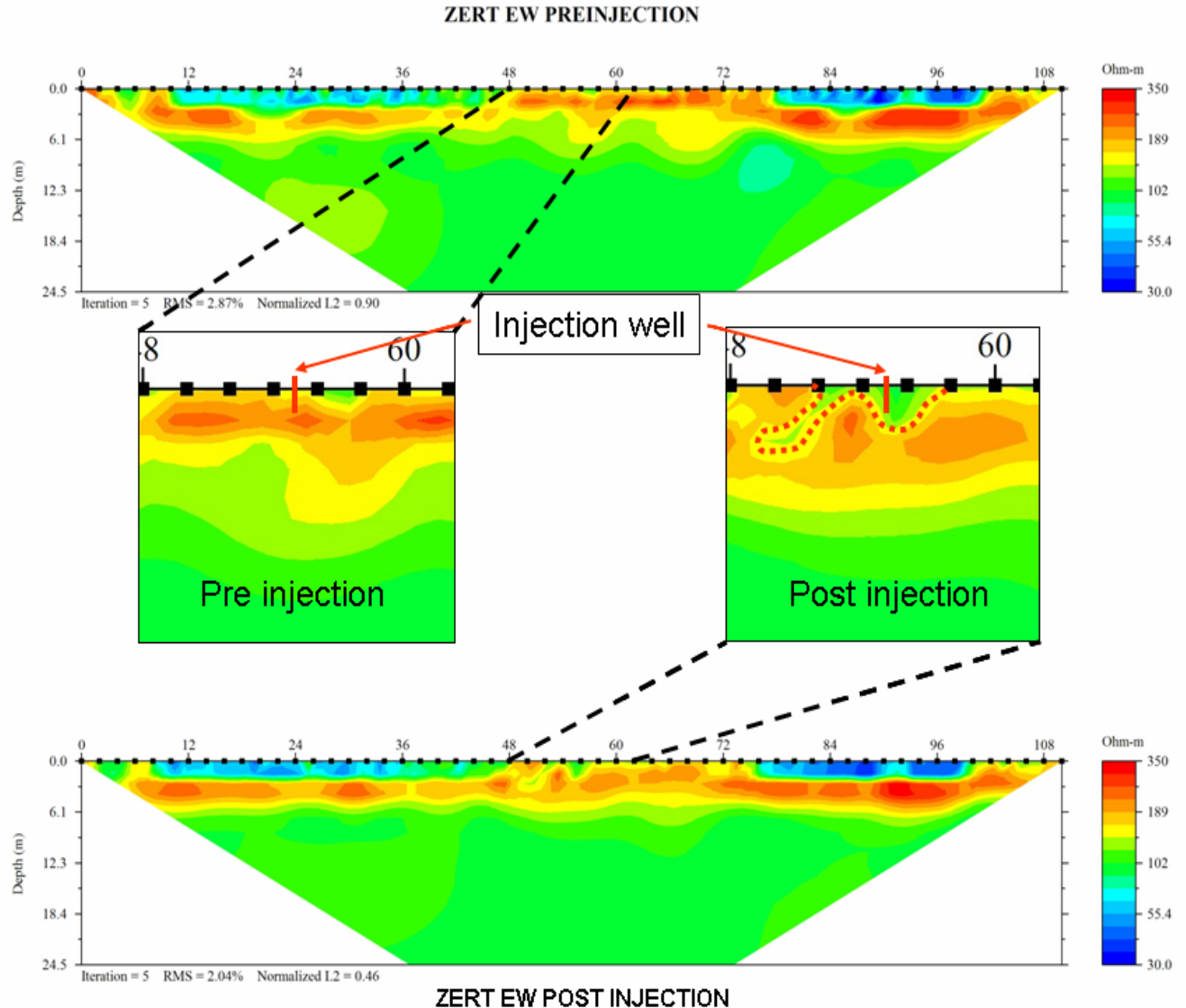
- Ability to “map” the injected CO₂ and track its movement and fate through a reservoir
- Assures storage permanence

- Key technologies for plume tracking:
 - Seismic surveys (e.g., 4-D seismic, time-lapse vertical seismic profiling)
 - Sampling from wells (borehole logging)



Plume Detection at Vertical Injection Site

- Resistivity surveys
- East/West surveys (performed for 2 hours)
- Montana State University, Bozeman, MT – ZERT Project Site



Leak Detection

- Backstop for modeling and plume tracking
- Provides critical measures of whether CO₂ is escaping from the storage reservoir

- Challenge - the need to cover large areas cost-effectively at the required resolution

CO₂ plume from an injection of one million tons of CO₂ per year in a deep saline formation for 20 years could be spread over a horizontal area of 15 square miles or more



Soil Carbon Measurement Sampling



- Depth profile of soil-gas down to 1 meter
- CO₂ and light hydrocarbon concentrations
- CO₂ stable isotope ratio ($\delta^{13}\text{C}$)



Mitigation

- **In the unlikely event that CO₂ leakage occurs, steps can be taken to arrest the flow of CO₂ and mitigate the impacts:**
 - lowering the pressure within the CO₂ storage reservoir by stopping injection
 - forming a “pressure barrier” by increasing the pressure in the reservoir into which CO₂ is leaking or by intercepting the CO₂ leakage paths
 - plugging the region where leakage is occurring with low permeability materials

Terrestrial MMV

- **Organic matter measurement:** automated technologies that provide detailed information at a sequestration site
- **Soil carbon measurement:** automated technologies for measuring soil carbon
- **Modeling:** detailed models are used to extrapolate the results of carbon uptake activities from random samples to an entire plot and to estimate the net increase in carbon storage relative to a case without enhanced carbon uptake.
- **Economic Models:** show accumulations of emissions credits and revenues versus an initial investment



Summary

- **MM&V research is aimed at providing an accurate accounting of stored CO₂ and a high level of confidence that the CO₂ will remain sequestered permanently**
- **Successful efforts will allow project developers to obtain permits for sequestration projects while ensuring human health and safety and preventing potential damage to the host ecosystem.**
- **Sets the stage for emissions reduction credits that approach 100% of inject CO₂**
- **Provides improved information and feedback to sequestration practitioners, thus accelerating technology progress**



Additional Information

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Home > Technologies > Carbon Sequestration > Monitoring, Mitigation, Verification

Carbon Sequestration Monitoring, Mitigation, Verification

The area of monitoring, mitigation, and verification (MM&V) is aimed at providing an accurate accounting of stored CO₂ and a high level of confidence that the CO₂ will remain sequestered permanently. MM&V research seeks to obtain:

- Instruments that can detect carbon in a storage reservoir and/or measure its movement and its physical and chemical state with useful precision.
- The capability to interpret and analyze the results from such instruments.
- The ability to predict how movement and/or chemical reactions of carbon in the reservoir will affect (1) the permanence of storage, (2) the environmental impacts within the reservoir, and (3) any impacts on human health.
- Best practices and procedures that can be used to respond to any detected detrimental changes in the condition of the stored carbon and thus mitigate losses of carbon and/or negative impacts on the environment and human health.

A successful effort will enable sequestration project developers to ensure human health and safety and prevent damage to the host ecosystem. The end result is that developers will be able to obtain permits for sequestration projects. MM&V also seeks to enable emissions reduction credits that approach 100% of injected CO₂, contributing to the economic viability of sequestration projects. Finally, MM&V will provide improved information and feedback to sequestration practitioners, thus accelerating technology progress.

MM&V efforts are divided into three sub-areas:

- **Geologic formations.** MM&V systems focused on below-ground CO₂ draw upon a significant capability developed for fossil resource exploration and production. Work is focused on (1) refining existing CO₂ detection technologies and developing new ones and (2) developing models of subsurface systems that enable processing and analysis of information from detection devices. Measurement technologies being investigated include surface-to-borehole seismic, micro-seismic, cross-well electromagnetic, and electrical resistance tomography. This area is less mature and is focused on detecting leaks or deterioration in reservoirs and assessing ecological impacts of geologic carbon storage.
- **Terrestrial ecosystems.** Traditional methods for measuring carbon in terrestrial ecosystems (e.g.,

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3D Seismic conducted at the Sleipner Field show a bright CO₂ signature and no leakage above the Utsira formation.

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http://www.netl.doe.gov/technologies/carbon_seq/index.html

Questions ?

