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Monitoring and Verification of CO_2 Geological Storage sites

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Outline

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- Introduction
- Monitoring Objectives
- Integrated monitoring plan
- Two examples
  - The Decatur project – Illinois
  - CO2FieldLab – Norway / EU

Background

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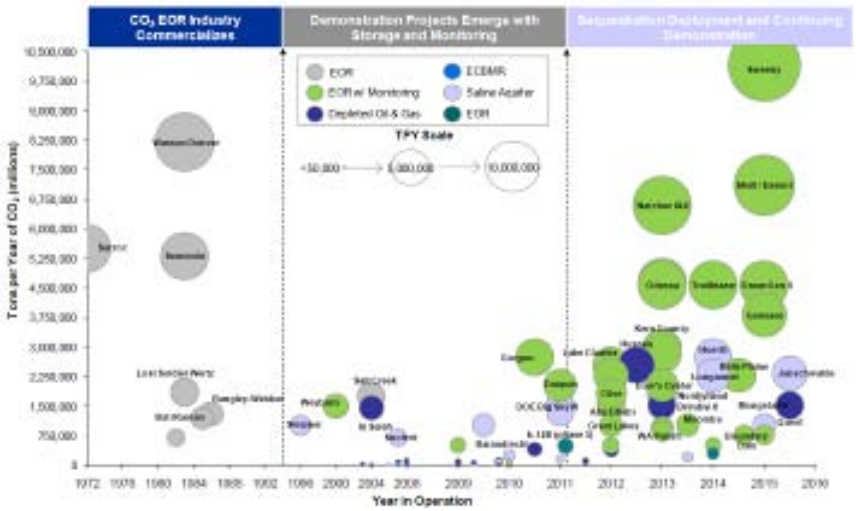
- **From demonstration projects to industrial deployment:**
  Storage considered as an acceptable option for mitigation of climate change.



- **Regulatory framework**:
  EU legislation (CCS directive) passed December 2008, to be derived state by state
  Monitoring, Reporting and Accounting protocols are under development.

A well-chosen and well-engineered site is not expected to leak.

However, the **issue of leakage** must be well addressed :

- Safety: Minimize the Health, Safety & Environmental risk
- Mitigation and early remediation
- Public acceptance: credibility of geological storage challenged
- Accounting: if leakage occurs, emission credits must be surrendered and the site stabilized (EU)

SCS CO_2 storage project workflow

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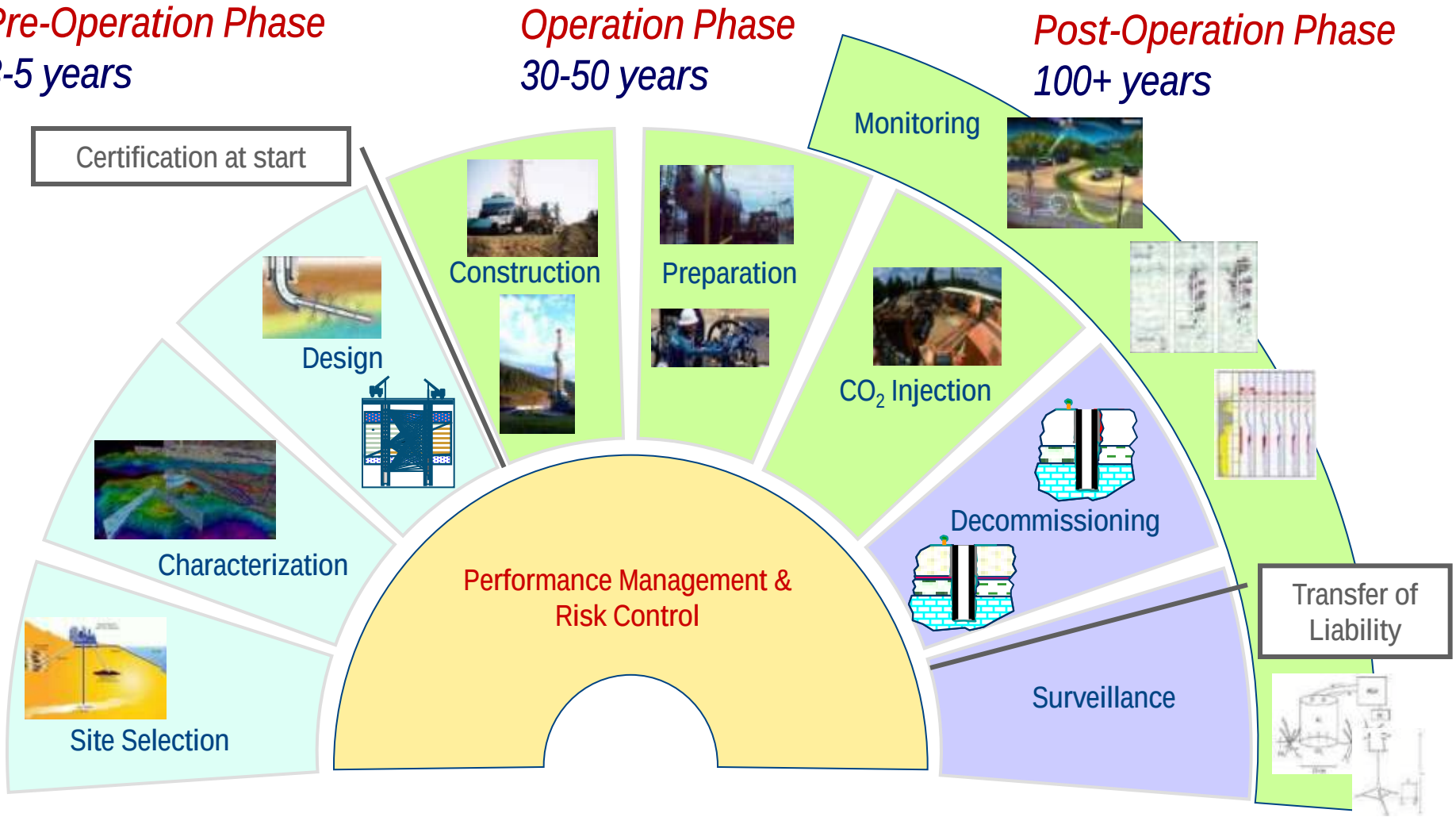

General objectives for the monitoring plan

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Optimization of the storage performance and control of risks

Three main objectives:

- Control of the injection operation
- Control of the fate the CO2 plume and control of injection-induced effects
  - Displacement of the plume, trapping efficiency
  - Pressure effects, brine displacement
  - Calibration of predictive models
- Control of the containment
  - Barriers integrity
  - Leakage and associated impact

Monitoring objectives and measurements

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Operational Monitoring

Injection operation control

- Wellhead pressure
- Bottom hole Pressure
- and Temperature
- Injection rate
- Microseismicity

Quantification of injected CO_2

- Mass flow
- Gas stream composition
- and phase

Verification Monitoring

Well Integrity

- Annulus pressure
- Corrosion
- Cement
- Soil gas measurements

Cap Rock / Fault Integrity

- Microseismicity
- Pressure interference

CO_2 displacement & fate

- Geophysics techniques
- Pressure, Temperature
- Well logs (CO2 Saturation)
- Sampling
- Geodetic methods

Assurance Monitoring

Impact: HSE monitoring

- Potable water quality
- Soils acidity
- Atmospheric concentration
- Surface deformation

Detection of leaks/migration

- Sampling & chemical analysis
- Geophysics techniques
- Pressure interference
- Soil gas measurements
- Vegetation stress
- Eddy correlation tower

Quantification of leaks

- Soil gas measurements
- Surface gas measurements
- ...

Decatur : CO_2 storage in the Illinois Basin

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- **Archer Daniel Midland** :

Bioethanol plant ~ pure CO_2 stream

- Reservoir : Mt Simon sandstone (saline aquifer)

(6500-7200ft) @ 1000t/d (1Mt for 3 years)

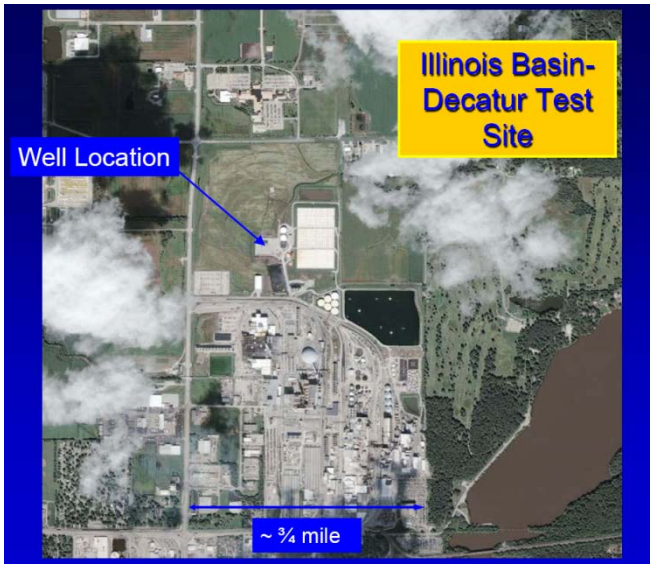
- **Financing: ADM & DOE**
- **Illinois State Geological Survey** is

managing the project (Rob Finley)

- **SCS** is managing operations (Scott Marsteller)

- Injection well drilled in May 2009

  Injection to start in Feb 2011



Decatur - Project Timeline

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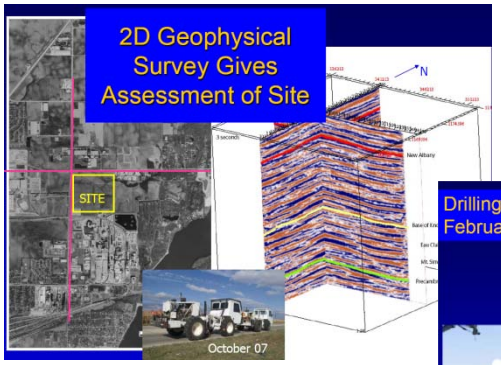
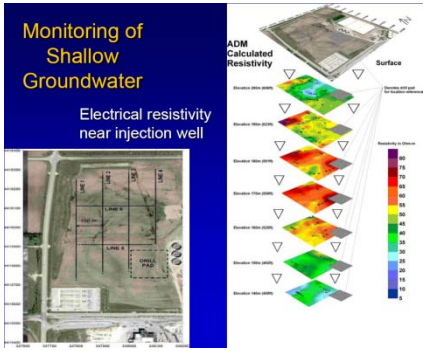
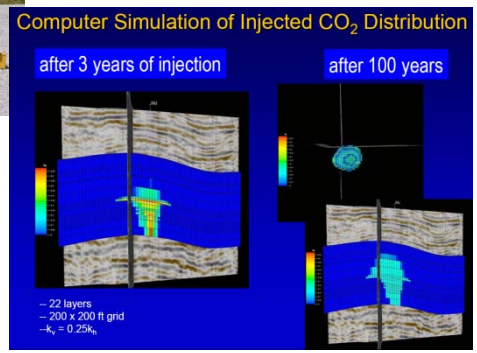
- Project funded December 2007
- Baseline environmental activities began late spring 08
- Preliminary UIC permit hearing October 08
- Permit finalized January 27, 2009
- Injection well drilling: February 14, 2009 start; 68+ days to drill
- CO_2 injection period: February 2010-February 2013
- Environmental monitoring through January 2015







Architecture of the system - Decatur

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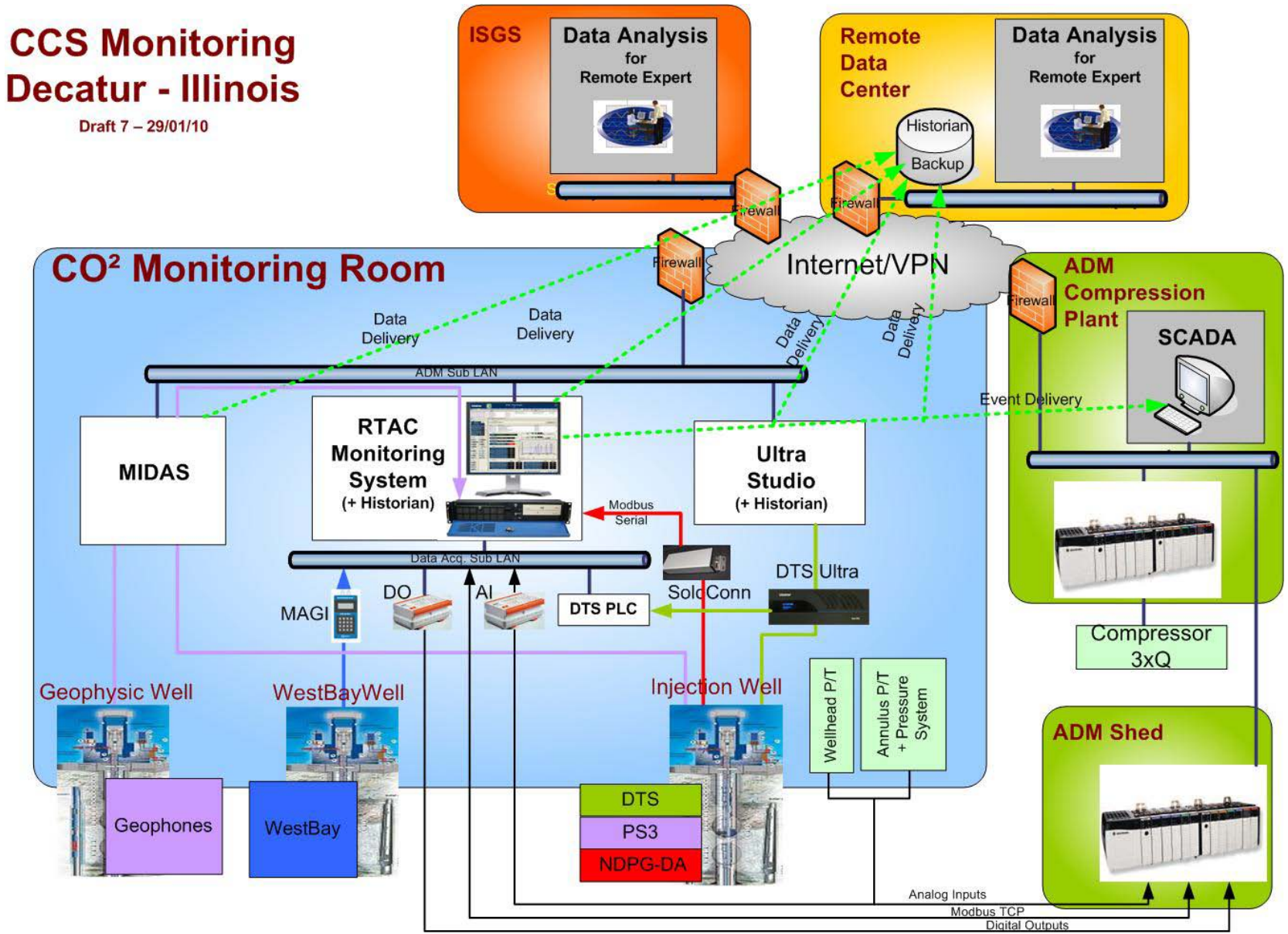

Assurance Monitoring

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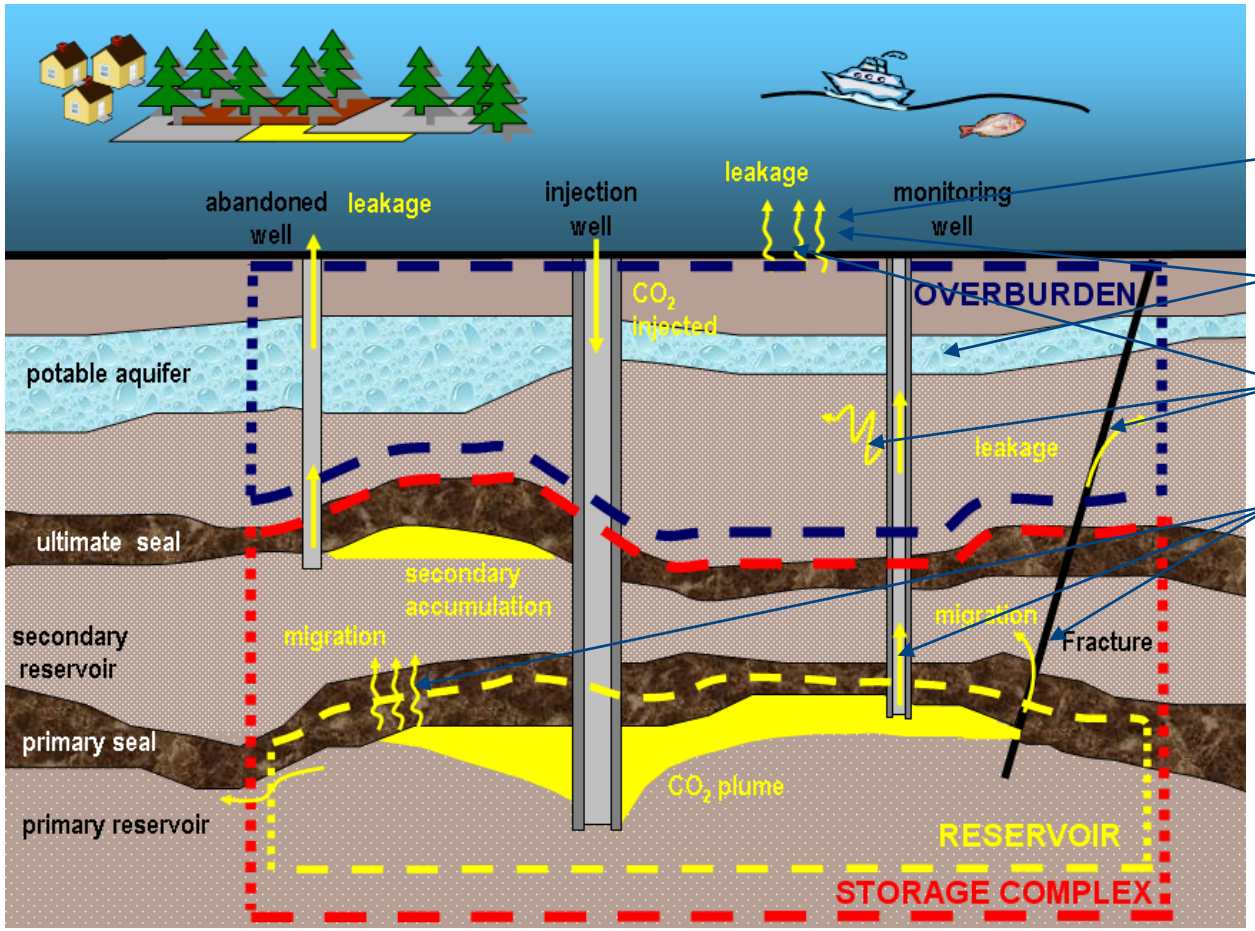
Four monitoring activities targeted at controlling containment



4-Leakage quantification

3-Impact detection and evaluation

2-Leakage detection

1-Control of barriers' integrity

CO2 FieldLab project

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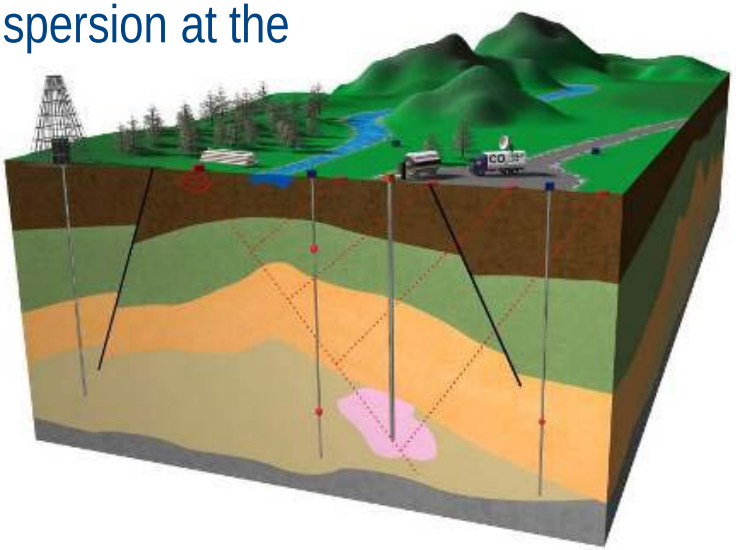
The CO2FieldLab project comprises a shallow injection of CO2 and the monitoring of its migration up to the surface and the dispersion at the surface.



This type of controlled release experiment is unique and will fulfill 4 objectives:

- determine the sensitivity of monitoring systems to detect shallow CO2 migration and surface leakage,
- upscale these results to assess monitoring systems and requirements that will ensure safe CO2 storage,
- test and calibrate migration models in well controlled conditions,
- inform the public about the safety of CO2 storage by showing the performance of monitoring systems.

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Main interests in an Operator's perspective

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- Investigate the feasibility of monitoring tasks 2,3,4 which are out of the traditional expertise of the Oil & Gas industry
  - Leakage detection & Impact evaluation (required by CCS directive)
  - Leakage quantification (required by ETS directive)

- Close technology gaps through focused research objectives
  - Characterization (modeling and monitoring) of CO2 leakage and trapping potential in the overburden
  - Evaluation of various monitoring techniques (shallow depth, surface, atmosphere)
  - Definition of an integrated monitoring protocol
  - Elaboration of methodologies / standards for certification

- Contribute to the definition of the communication strategy towards local communities and general public

- Contribution to the general debate on CO2 storage safety by showing the possibility to control (detect and evaluate) leakage

Conclusion – A monitoring plan for CO2 storage

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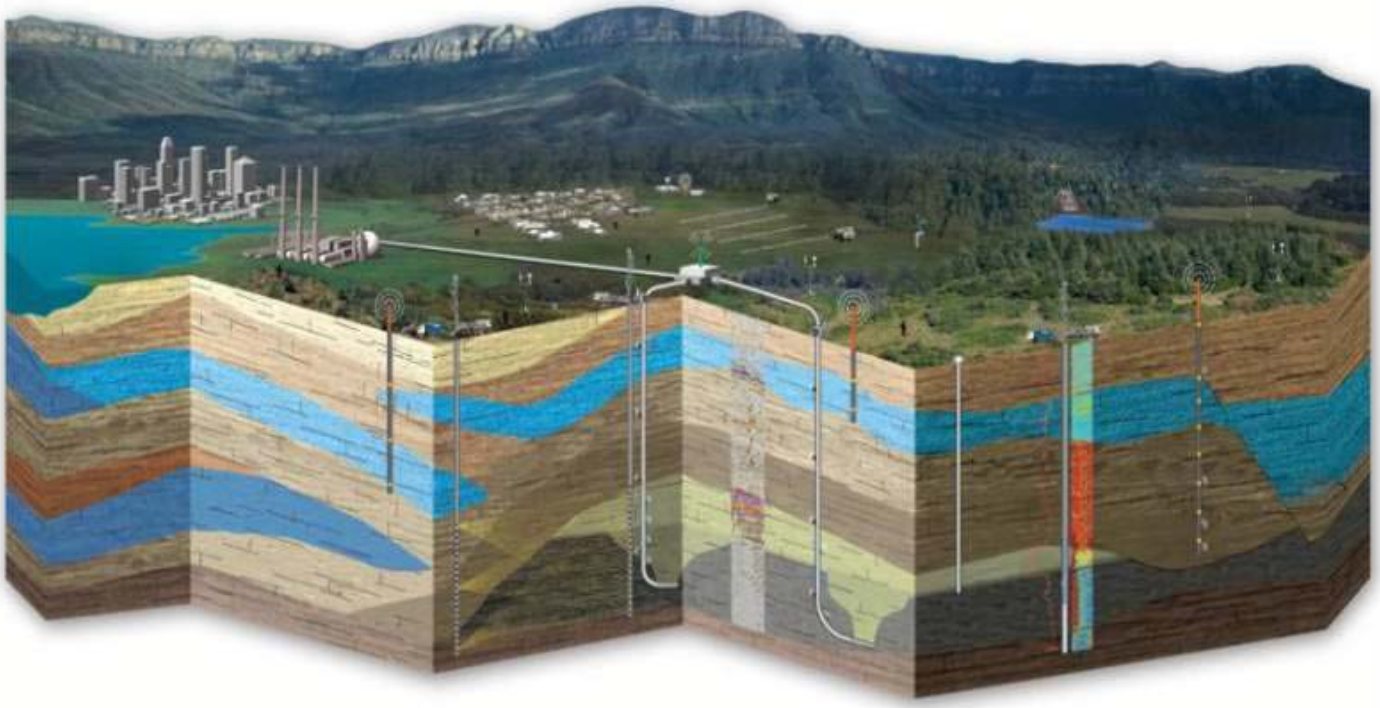

Challenges and research needs

- **Holistic** approach – Sensor placement, feasibility of measurements to fulfill monitoring objectives
- **Integration** of **complementary** measurements, based on various physical principles, of different spatial resolution, in the framework of a **unique interpretation model**
- **Detection and quantification of leaks, to control storage safety and to account for CO2 stored**
- Real-time control of operations for performance management