# ARB CCS Technical Discussion Series: Monitoring

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# Monitoring: General Overview

*Some common questions*

# Context: steps for safe & effective CCS

- Demonstrate that sites are capable of long-term containment of carbon dioxide
- Identify and characterize potential natural and man-made leakage pathways, devise appropriate risk management and corrective actions
- Design, construct and operate within parameters to prevent, mitigate and remediate the creation or activation of leakage pathways, or and the migration of CO2 or fluids into an unauthorized zone
- Minimize fugitive CO2 emissions from project operations

# Context: steps for safe & effective CCS

- Monitor and model to predict and confirm the position and behavior of the CO2 and other fluids in the subsurface during and after injection
- Account and report CO2 quantities sequestered, injected, recycled, leaked, vented, and any other categories as appropriate
- Follow post-injection site closure and financial responsibility requirements that ensure the long-term containment of injected CO2

# The purpose of monitoring

- Validate and improve theory (models) with observation
- Understand the spatial extent and distribution of CO2
- Remain within design/safety parameters, or modify as needed
- Detect activation of leakage pathways
- Trigger additional diligence for other leakage pathways
- Trigger corrective action
- Eyes and ears of project: continuous evaluation

# The best tools for monitoring

- Several available:
  - Direct measurement (e.g. produced fluid analysis)
  - Geophysics, geochemistry
  - Pressure, temperature, resistivity
  - Direct air measurement, and many more
- Highly site/project specific:
  - What works for one site may be of limited use to another
    - 4D seismic / pressure at different depths / produced fluid sampling

# Should monitoring be static?

- No!
  - Update when results and models dictate
  - CO2 near certain potential leakage pathways may necessitate revisions
  - Continuous feedback between results and monitoring regime

# How long to monitor?

- During entire operational life of project
- Duration of post-injection monitoring will depend on geology and site:
  - Uniformly dipping saline formation vs. structural closure in oil field
  - Number of wells/leases adjacent to project lease that could produce injected CO2

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# How quickly/accurately can leakage be estimated?

- Depends on nature of leakage
  - Well leakage vs. geologic leakage
  - Blowout vs. slow release into groundwater and atmosphere
  - Fugitives
- Depends on monitoring scheme
- Can take weeks-years to pinpoint
- In general, devising upper/lower bounds is feasible
- Estimating to the nearest ton is not

# Monitoring Requirements in Practice

*Possible choices*

# Monitoring trade-offs

- Projects will vary in their inherent risk of leakage:
  - Geology, number/age/depth of wells etc
- **Allow all projects or only low-risk projects?**
- Desired/possible level of monitoring may vary by operator and project
- **Cap maximum allowable "credit" based on a tiered risk evaluation and/or robustness of monitoring plan?**

# Site specific nature of monitoring

- No universally useful list of tools or methods
  - Different geologies
  - Pure injection vs. EOR
  - Out-of-state projects and regulators
- **Regulator or operator to suggest approach?**
  - Expediency will range from useful to necessary
- **Designate independent expert review panel?**
  - Recognized subject matter experts to review plan

# Leakage quantification

- In the event that leakage is discovered:
  - **Require effort to mitigate/offset?**
  - **Require effort to quantify?**
- **Use best leakage estimate?**
- **Default (conservative) discount to apply immediately?**
- **Operator to refine estimate in the future?**


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