Approach to Building Confidence Concerning Geological CO₂ Storage: Risk Assessment Perspective

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Outline of Presentation

• Introduction / Background
  – Drivers / issues concerning geological CO₂ storage
• Relevant feedback from regulators on role of RA in geological CO₂ storage projects
  – Summary of key findings from IEA GHG project
• Feedback from other stakeholders
• Public outreach - specific examples
  – Weyburn Public Education and Outreach
  – DOE CO₂ Sequestration Regional Partnership Program
• OSPAR Technical Workshop (2006)
• Summary observations
CCS Projects: Importance of Confidence Building - Role of RA

- **Stakeholder / Public Acceptance**
  - Stakeholder acceptance, in particular public acceptance, is considered essential to developing CCS projects in a timely manner.
  - Risk/Safety Assessment (RA/SA), as the quantitative method of demonstrating safety, is likely to be a key component of the regulatory approval process and, hence, public acceptance.....BUT.....*not the only component*
  - *RA/SA is unlikely to be the only means of assuring safety and building confidence in CCS projects*
Confidence Building Aimed at Two Key Drivers for CCS

- Greenhouse gas (GHG) mitigation
  - CO$_2$ remains underground - requires *effective reservoir storage*
  - Need to be able to account for any CO$_2$ released back to the atmosphere

- Health, safety and environmental (HSE) impacts
  - Need to be assured that CO$_2$ is not released back to the surface / near-surface environment causing harm
  - Also requires *effective reservoir storage*

- *Timescales of two drivers are potentially different*
- *Different stakeholder attitude to GHG / HSE*
RA for CCS Projects: Timeframes

- Two timeframes are relevant to CCS depending on the needs of the regulator, whether for \textit{GHG reduction inventory control}, or for HS&E impacts
  - Overall timeframe for RA of several thousand years......BUT
  - Natural processes exist that can act to reduce the potential hazard over time
Geological CO₂ Storage - Trapping Mechanisms

- Physical trapping *cf.* hydrocarbons
- Residual trapping (pore trapping)
- Solubility trapping (CO₂ dissolution)
- Mineral trapping (CO₂ reactions with rock-water system)

IPCC [2005]
Geological CO₂ Storage: Issues?

Discuss in the context of GHG and HSE drivers and timeframes ……[previous IEA GHG project]
Key Issues: Main Conclusions

- Regarding assurance of safety and confidence, no hurdles specific to geologic CO$_2$ storage that have not been addressed in other types of projects, with the exception of CO$_2$ migration and how this affects GHG mitigation / accreditation accountability
  - *Only the relevant timeframes are different*
- With regard to regulatory oversight, *flexible system* is preferable in order to be able to adapt to, and take advantage of, the benefits of increased knowledge from collective understanding and experience of CCS projects
### Role of RA at Different Stages of Project

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<tr>
<th>Stage of Project Development</th>
<th>RA Role</th>
<th>Input Data</th>
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<tr>
<td>Preliminary site characterization - site selection</td>
<td>Screening</td>
<td>Generic data</td>
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<tr>
<td>Detailed characterization</td>
<td>Guidance</td>
<td>SC data primarily; generic data to fill gaps</td>
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<td>Licensing / Permitting phase</td>
<td>Major</td>
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<td>Injection phase</td>
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<td>Post-injection phase</td>
<td>Major</td>
<td>SC and monitoring data</td>
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RA = risk assessment;  SC = site characterization
RA - Iterative Process

Iterative nature of RA leads to increased confidence

Site characterization
Risk assessment / assessment modeling

INPUTS
- Site-specific information/data
- Baseline information/data
- Site-specific information/data

FEEDBACK
- Data gaps
- Key data
- Types of data
- Spatial domain
2006 IEA GHG Study: Role of RA in Regulatory Framework: Objectives

• To establish whether there are existing (regulatory) provisions for authorizing CO₂ storage projects and whether these are sufficient / adequate for future implementation of large-scale geologic CO₂ storage projects
  – Are there any ‘disconnects’ between regulator and implementer in terms of timeline?

• To identify key gaps associated with RA and its role in regulatory oversight and confidence building
  – ===> RA needs
Project Feedback Questionnaire

- Regulators from 9 countries participated in project by responding to questionnaire on variety of topics associated with RA and CCS
  - Australia, Canada, France, Germany, Japan, The Netherlands, Norway, U.K., U.S.A.
- Responses of regulators supplemented with those of implementers involved in major CO$_2$ storage projects
- Substantial comments provided supporting “Yes/No” answers
Regulator Feedback - General

• Regulators (and implementers) view the assurance of long-term safety to be essential to the successful progress of CCS projects. One way of building confidence is to have a rigorous methodology
  – Flexibility in methodology and modeling approach

• Link between RA results and monitoring
  – Confirmation of predictions
  – As means of ensuring safety (HSE impacts)

• Integrated (‘end-to-end’) assessment framework preferred, where
  – Predictions of releases linked directly to potential HSE impacts
Regulator Feedback: Specific Comments

• Risk communication - Regulator:
  – “should be involved in public communication and safety, by providing as much fact-based information as possible for the public to be aware, and make a determination, of all potential risks”
  – should “ensure that project operator……provides adequate information”
  – should “NOT be a proponent of individual projects”
  – can participate in “project-specific interaction with the public….conveying information on a qualitative basis, involving identification of risks and strategies for mitigation”

• Comprehensive risk modeling approach may not be appropriate when interacting with the public
RA Needs - Regulator Feedback

• Perceived gaps / issues and building confidence:
  – Nature of long-term risks and associated institutional management
    • Better understanding of timeframe in the context of potential hazards - if/how this changes with time
  – Wellbore and caprock integrity, especially with regard to long-term storage performance
  – Monitoring, in the context of quantifying CO₂ leakage/migration
  – Improved knowledge of specific environmental impacts, in particular groundwater different ecosystems, and offshore environmental impacts

• Many of the above concerns are linked to uncertainties in the long-term predictions and how these uncertainties are communicated to the various stakeholders
RA, Confidence Building and Role of Natural Analogues

- Natural Analogues (NA) serve a number of purposes linked to RA and the most quantitative purpose being the validation of predictive modeling results. In the absence of quantitative information, NA examples can be used to support risk communication with stakeholders, by identifying geological environments that are suitable for long-term CO_2 storage, and, on the other hand, by explaining why bad sites leak.

- Stakeholder / Public Acceptance
  - All indications suggest that science-based information is not sufficient to satisfy public concerns, and other avenues of communication, e.g., natural and industrial analogues, are needed to support the science-based approach, particularly when RA techniques are not easy to communicate.
Risk Assessment / Knowledge Gaps - Implementer Perspective

- Experience with different types of storage site, in particular deep aquifers
- Wellbore seal longevity
- Quantitative information from natural analogues
- Fundamental data
  - Thermodynamic behavior of CO$_2$ - effect of impurities
  - Thermodynamic, kinetic data (mineral reactions)
- Coupling between geochemical and geomechanical processes - include in modeling
- Benchmarking of RA modeling approaches
Geological CO$_2$ Storage: Public Awareness Study [1]

- 2004 UK study [Shackley et al.] found public awareness and understanding to be low; in absence of information, people tend not to have an opinion or, if they do, slightly negative.
- Provision of some, even limited information on the topic moves public opinion to a more positive stance.
- Public support tends to depend on concern over climate change and global warming, with CCS being viewed as one positive strategy.
- Uncertainties about the potential risks of CCS, in particular the risks of accident and leakage, need to be addressed and reduced.
Geological CO$_2$ Storage: Public Awareness Study [2]

- Battelle study on public attitudes linked to Mountaineer Project (Ohio, USA) had similar findings:
  - Discussion of CCS issues tended to be at national and conceptual level, with little comment at local public level
  - Local concern expressed over leakage and potential for environmental and health effects
    - “What could be done to minimize their potential / or detect and mitigate their effects if leakage occurs?”
Public Outreach

• Engaging the public in dialogue and an exchange of information - with a view to increasing public awareness and general confidence
IEA Weyburn CO$_2$ Monitoring and Storage Project: Public Outreach

- Key activity for Phase 2 (commenced 2005) is development and implementation of public communication strategy
- 2006 Workshop on Public Education and Outreach (PEO) - Natural Resources Canada - key findings:
  - Framework for PEO should be broader than just Weyburn; focus on longer term large-scale CCS deployment
  - General education materials on CCS technology should be open, transparent and unbiased - NOT marketing!
  - Commitment to ongoing communication and feedback mechanism for answering questions and addressing concerns
  - Share information with community before project starts
IEA Weyburn CO$_2$ Monitoring and Storage Project: PEO

- **Communication strategies:**
  - **Website** with opportunities for questions and feedback from ‘experts’
  - **Mailouts** to local community and local bulletin boards
  - Provide **media articles** - preferably using well-known and trusted reporters

- **How to monitor effectiveness of communication?**
  - Number of hits on websites
  - Periodic surveys
  - Media monitoring

- **Sensitive to balance between providing balanced information on potential risks and benefits, and raising concerns unnecessarily**
DOE Regional Carbon Sequestration Partnership Program

• One of the key goals is public outreach and education, each Partnership developing a range of materials for this purpose:
  – Fact sheets
  – Interactive websites
  – Videos
  – Town hall meetings
  – Focus groups
  – National Environmental Policy Act (NEPA) allows for public involvement

• Programs themselves are phased, one stage allowing for validation through field tests
OSPAR Convention; Technical Workshop on RA Framework

- London Convention/Protocol (LC/LP) and OSPAR Convention are focused on protecting marine environment
  - Influential treaties that will shape national guidelines/regulations
- Risk assessment framework was developed and adopted by LC/LP
- Technical framework discussed at OSPAR Workshop October 2006
  - RA considered within broader risk management framework
  - Acknowledgement that RA is not sufficient for assuring safety / building confidence
Framework For Risk Assessment and Management (FRAM)

- Framework directly applicable to storage of CO₂ under seabed, but generally applicable to other environments
- Integration of RA and risk management
  - Some emphasis given to monitoring, mitigation, remediation plans

Diagram courtesy of TNO, The Netherlands
Components of FRAM

- Framework aimed at assuring safety and increasing confidence
- Acknowledgement that assessment is not sufficient

Diagram courtesy of TNO, The Netherlands
Summary Observations

• Phased approach to storage projects is beneficial to stakeholder acceptance
• Improved understanding of the processes associated with geological CO₂ storage continues to benefit from the experience gained in pilot-scale and full-scale CCS projects, building on the experience gained from projects such as Sleipner and Weyburn
• Sharing of project results extremely useful
• RA and its results are not sufficient
  – Inclusion of monitoring and remediation plan in CCS projects is beneficial to overall acceptance
Ways of Building Confidence

- **Technical standard / protocol** - basic *framework* (flexible)
  - Build on existing documents, e.g. Best Practice Manual, SACS Project, national standards for risk analysis

- **Benchmarking studies** to enhance confidence in different modeling approaches
  - Need to be carefully planned

- **Monitoring**: provide quantitative resolution capability to match needs:
  - Confirmation of RA predictions
  - Quantification of migration of CO₂ for GHG inventory purposes
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