An Introduction to the IEA GHG International Research Network on Risk Assessment

Brendan Beck* Toby Aiken

IA Greenhouse Gas R&D Programme, The Orchard Business Centre, Stoke Orchard, Cheltenham, GL52 7RZ, UK

Abstract

Regulators, industry and other stakeholders will need to have confidence in the predictions made by risk assessment studies for CO₂ capture and storage (CCS) activities. To gain such confidence it will be necessary to understand the different approaches available for risk assessments and the underlying assumptions. This led to the establishment of the IEA GHG Risk Assessment network in 2005.

The purpose of the network is to bring together the key groups working on risk assessment for CO₂ storage from around the world and to address what the regulators are expecting in regard to CCS assurance and whether risk assessment can provide the answers they require. At the launch meeting, it was agreed that the network should aim to address the expectations of regulators, and determine whether risk assessment can satisfy these expectations. The scope of the network was divided into separate areas of interest; data management and risk analysis, regulatory engagement, and environmental impacts. Corresponding working groups focus on these issues, running alongside the research network, and report back to the whole group at the network meetings.

Network activities include overviews of other related international research activities that may impact on the risk assessment network, such as the IEA GHG wellbore integrity network, provision of feedback to the working groups, reviewing risk assessment status using case studies, assessing the role of risk assessment in a risk management framework and determining communication strategies for results of risk assessment studies. Site characterisation was identified as an element of CCS that was heavily reliant on risk assessment, and risk assessment plays an important role in all stages of site characterisation and selection from the initial pre-screening to permitting and implementation. Natural analogues have been identified as a means of instilling confidence in CCS by generating a better understanding of leakage and trapping mechanisms, providing verification of numerical models, and helping to communicate the safety of CO₂ storage.

The network has also raised the questions of the role of risk assessment guidelines in CCS, the confidence that can be felt in numerical modelling results, the length of time monitoring programmes are required for after injection has stopped, and what value does the accident/worst case scenario hold for risk assessment.

*Tel.: +44 1242 680753; fax: +44 1242 680758; E-mail address: brendan.beck@ieaghg.org

doi:10.1016/j.egypro.2009.02.023
The future work for the network will be maintaining the individual working groups, and continuing to monitor demonstration projects as these will provide valuable information to support numerical models and verify the worthiness of studies on analogues.

© 2008 Elsevier Ltd. All rights reserved

Key Words: Risk assessment, IEA GHG international research network, joint network meeting

1. Introduction

The Risk Assessment network is one of several international research networks operated by the IEA Greenhouse Gas R&D Programme (IEA GHG). The launch meeting of this network was hosted by TNO-NITG in Utrecht, Netherlands, in August 2005. Subsequent meetings were held hosted by the Lawrence Berkeley National Laboratory in California during October 2006, and by Imperial College, London during August 2007.

Early studies by IEA GHG and others concluded that to gain public acceptance of CO₂ capture and storage (CCS), two key areas need to be demonstrated: that the technology is safe, and that its environmental impact is limited. Risk assessment provides a structured framework through which potential problems of safety and environmental impact can be evaluated. These considerations led to the formation of the network in 2005.

2. Aims & Objectives

The overall aim of the network is to bring together the key groups working on risk assessment for CO₂ storage from around the world to share knowledge and experiences. There is an emphasis on potential regulatory requirements with regard to CCS safety and impact assessment.

At the launch meeting in 2005, specific aims and objectives were set for the network:

- Develop an open and transparent process to allow different risk assessment approaches and associated results to be understood;
- Provide a forum where different approaches to risk assessment can be compared;
- Provide an ‘umbrella group’ for international collaboration;
- Identify knowledge gaps and determine actions required to close these gaps;
- Act as an informed body on risk assessment and to maintain dialogue with regulators and NGO’s

3. Key Developments

At the launch meeting in 2005, the network was divided into smaller and more specific subject areas: data management and risk analysis; regulatory engagement; and environmental impacts. Working groups were created that focused on these more specific areas and run alongside the operation of the network. The working groups directed their own work, reporting back to the network at the annual meeting. The working groups are diverse in topic but allow participants in the network with special interest to focus on specific areas.

The second network meeting in 2006 addressed a number of CCS risk topics including wider risk management frameworks, site characterisation, natural analogues, risk assessment communication and case studies.

A definition of risk assessment in the context of CCS was defined as the means of identifying, estimating or calculating and evaluating potential risks of storage to human health and safety, the environment and assets. Risk assessment, which is ‘problem orientated’, was identified as part of a larger risk management framework, which focuses more on monitoring and remediation and is ‘solution orientated’. Consensus was reached that for CCS risk assessment and communication of results, emphasis should be placed on ‘solutions’ ahead of ‘problems’.
The meeting agreed that site characterization would need to be a ‘step wise’ process, with initial pre-screening of poor prospects allowing efforts to be concentrated on those sites with the best potential. Risk assessment was identified as one tool that can be used in the early screening of storage sites. Discussions highlighted that risk assessment and site characterization both work in an iterative manner, and are involved over different project stages from preliminary screening to permitting and implementation. It was also noted that data requirements increase at each progressive stage.

Natural storage analogues were discussed and identified as a means to build confidence in CCS:

- Helping geologists to understand leakage and trapping mechanisms,
- Verification of numerical models and risk assessment procedures,
- Interpretation and risk management,
- Helping to communicate the safety of CO\(_2\) storage sites.

By compiling a database of events from natural and industrial analogues comparable to those that could occur from CO\(_2\) storage, a matrix could be constructed to allow comparison and communication of CCS risks in a readily understandable manner.

Risk assessment studies were seen as providing guidance on likely seepage rates from storage sites, but not determining potential impacts of leakage. Environmental Impact Assessments (EIA) can provide the framework for assessment of long term impacts. However, the meeting noted there was little research underway to assess the potential effects of CO\(_2\) leaks that could allow an EIA to be compiled and agreement was reached to address this knowledge gap.

There was consensus that risk assessment is only part of the risk management framework that needs to be given to regulators; remediation is another important issue. Delegates felt strongly that regulators need to be reassured that storage is a proven technology.

A major component of the second network meeting was the review of four case studies, comprising three on aquifers and one on an oilfield. Several of these case studies were not completed risk assessments, but rather scoping studies. The results of such studies should therefore be treated with some care when communicated outside of the technical community.

The aquifer based assessments generally suffered from a lack of data, which resulted in a lot of assumptions needing to be made. The oilfield case was much better characterized, thus allowing a more detailed risk assessment. All the assessments were informed by expert panels and involved a degree of subjective analysis. Expert panels ideally need to be drawn from a wide group of individuals, whereas those involved in these assessments tended to be drawn from within the research organizations involved. The oilfield study gave confidence that CO\(_2\) could be retained in the storage formation for 1000’s of years; however the same degree of confidence could not be drawn from the aquifer studies. The studies did, however, contribute significantly to the learning process and will be of future benefit to allow better definition of data requirements for robust risk assessment. The meeting agreed that more studies were needed to help develop confidence in the techniques and models used.

The network had also identified a need for dialogue with the regulatory bodies, concerning their needs and expectations of risk assessment within regulatory processes. This led to a study carried out by Monitor Scientific Inc, USA, which aimed to initiate dialogue with regulators. The study was completed in early 2007.

The study firstly involved development of a briefing document and questionnaire on risk assessment for CO\(_2\) geological storage projects. The briefing document reviewed the status of risk assessment for CCS and served as a future reference document. The questionnaires were used as a means of determining the ability of existing or planned legislation in different countries, to authorise CCS projects.
Both documents were sent to regulators and operators of CCS projects in ten countries, to form the basis of dialogue concerning their roles in CCS projects: Australia, Canada, France, Germany, Japan, Netherlands, New Zealand, Norway, U.K., and U.S.A. The countries selected were considered those most likely to implement CCS.

This dialogue process proved useful as a two-way exchange of ideas and information. As a result of the dialogue, regulators in particular were better informed on the current status of risk assessment when applied to CCS projects. While risk assessment is not a new tool, its application to CCS is new and requires considerable development before confidence can be built in the methodology and results derived.

The study also highlighted a number of key areas to be addressed including; the estimation of possible fluxes to the surface and their impact on the environment. In regard to fluxes, monitoring data can be correlated with geological/geochemical/hydrogeological modelling, to gain confidence that predicted fluxes from risk assessment analyses can be justified scientifically. On the issue of surface impacts IEA GHG has recently undertaken and completed a review study of current knowledge on the impacts of CO₂ leakage onshore; this should help to clarify issues related to surface impacts.

The third network meeting took place in the UK in 2007. Key topics up for discussion included: the relative merits of quantitative, qualitative, or simple analytical methods to analyze CCS risk; risk assessment terminology; site characterization; and the feature, event, process (FEP) risk assessment method. The meeting was attended by representatives of the Wellbore Integrity Network, who provided an overview of the lessons learned in that network and how they may be applied to the risk assessment process.

There was much debate concerning the alternative use of quantitative, qualitative, or simple analytical methods to analyze CCS risk. The meeting concluded that whilst quantitative risk assessment is preferable, present knowledge could restrict methods to semi-quantitative or predominantly qualitative approaches. This led to a discussion on the use of expert panels in risk assessment, which was seen as a process needing formalization.

A key discussion concerned the process of site characterisation. This is a common theme running throughout the networks and was explored in detail at the meeting, although no clear conclusion was identified. A particular issue that remained unresolved was determination of the level of characterization required to satisfy all stakeholders in CCS projects.

A meeting session was devoted to the FEP risk assessment process; there was general agreement that this process is one many available tools and may be better suited as an auditing tool, rather than a primary tool for risk assessment.

4. Joint Network Meeting

When the Risk Assessment Network discussed their past progress at the Joint Network Meeting in New York, June 2008, they determined that overall, they had identified knowledge gaps and helped to direct research efforts, but at the same time had not achieved enough progress towards establishing risk management and mitigation strategies. This will form a central part of the future programme of work for the network, and at the same time, there were several specific issues picked up that need to be addressed. Prime among these is the fact that the vast majority of focus is centred around the risks associated with CO₂ leakage, and it is often overlooked that this is not the only risk posed by CCS activities. Further analysis should be dedicated to the risks associated with brine displacement, co-contaminants, mobilisation of heavy metals and the risk of earthquake inducement. Secondly, the network will aim to focus on risk assessment rather than risk management, and look at variances in regional approaches to risk assessment and management. Finally, the network must cover some specific topics such as the ruling by OSPAR restricting the injectate stream in terms of additional substances, the timescales involved with risks, site specific components of risks, the criteria of risk and vulnerability, and the ongoing debate of risk versus uncertainty.

The next stage of the Joint Network meeting addressed the technical gaps that the network highlighted, these were:

- Risk quantification,
• Modelling.
• Communication,
• Case studies.

The discussion also yielded 2 risks that require much consideration in the future, and these are the risks associated with leakage into shallow marine environments and potable aquifers, and the risks associated with co-contaminants. When these are addressed, the group should also focus on the associated impacts and attempt to quantify these. Quantification of risks and impacts was identified at this stage as an area in need of further review.

As with the other networks, the subject of modelling was discussed in depth, and it was decided that the discussions at future meetings should include risk assessment modelling, and the application of process models to risk assessment scenarios. While these areas are being discussed, it is considered to be beneficial to look at the different models and modelling techniques that are available for risk assessment and the associated processes.

As with the wellbore integrity network, the risk assessment network identified that more could be learned from reviews of existing projects, and the risks assessments that were carried out before and since commencement of practical operations. It was highlighted that the limited number of projects will lead to a need to extract as much information as is possible from those projects that are accessible.

In the future, all these points will prove invaluable in the communication aspects necessary in a CCS project, demonstrating clarity of processes, involvement and engagement of regulators, insurers, NGO’s and the general public. In order to go some way to achieving this goal, the gaps identified in this meeting must be ranked according to urgency as the list of risks and gaps are currently unranked, and a ranking process will allow the most urgent and important to be addressed first.

It was felt that links with the other networks could be forged in the areas of better integration with the monitoring network and vice versa, as monitoring will play a vital role in the ongoing risk assessment process. The wellbore integrity network and the risk assessment network need to focus on the clarification, statistics and causes of leakages through wellbores and the influences this has on the risk assessment process. It was recognised that currently there is a lack of communication between networks, and suggestions to overcome this lack include cross-network meetings or workgroups, newsletters and possible webcasts. While communication was being discussed, it was also noted that communication with experts not involved with the networks was a weakness and effort should be diverted into broader engagement and involvement with a wider range of regulators and experts. There was much interest in the engagement of the risk assessment network with the newly formed IEA Regulators Network, and it was hoped that this would assist in overcoming some of the technical gaps and issues identified.

5. Conclusions

Risk assessment studies, based on ‘state of the art’ modelling simulations, can predict the long term fate of injected CO₂ and assess potential for, and impact of, leakage in both the short and long-term. Risk studies can also assist the development of monitoring programmes for injection sites. To gain stakeholder acceptance of CCS, regulators and the wider public will need to have confidence in the predictions made by the risk assessment studies. To gain such confidence it will be necessary to understand the different approaches being used and underlying assumptions; results should be produced in an open and transparent manner, so that implications for ecosystems and human health can be fully appreciated.

6. Focus for the Future

In the concluding session of the third meeting, a number of issues were identified that will steer the agenda for the next (fourth) gathering. With regard to risk assessment terminology, Imperial College are performing a study to identify and define key terms that are integral to CCS risk assessment communication. The terms identified are drawn from CCS literature and associated industries. The next step in this work will be to circulate a questionnaire to people within the industry, in order to build consensus on the terms to use and their definition. One suggestion was to set up a Wikipedia style website to act as a forum to build an agreed pool of terms.
There were also a number of additional issues/questions raised over the course of the network that need to be addressed. These include:

• Risk assessment guidelines; are they required and if so, what is the best way of formulating them?
• What level of confidence can be placed in modelling results generated for CCS projects?
• How long do we need to monitor for after the cessation of CO₂ injection?
• What use is the accident/worst case scenario risk assessment approach to the overall risk assessment process?

For the future development of risk assessment methodology, demonstration projects will undoubtedly be a significant source of information that can be drawn upon to help develop confidence. It should be noted however that when developing demonstration projects, developmental needs for risk assessment should be considered, to ensure that knowledge gaps do not undermine the confidence of the scientific community and the general public in predictive risk assessment. Demonstration projects will naturally take time to produce the required results; in the interim, natural and industrial analogues may be used as sources of information and to generate confidence in geological storage of CO₂ as a safe and environmentally acceptable global warming mitigation option.

7. Acknowledgements

Funding for the work described in this paper was provided by the IEA Greenhouse Gas R&D Programme. The views expressed are those of the authors and do not represent those of the IEA, the IEA Greenhouse Gas R&D Programme or its members.