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What Have We Learned about Monitoring from Large Scale CO_2 Storage Projects?

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Introduction

The IEA Greenhouse Gas R&D Programme (IEA GHG) is currently undertaking an assessment of the learning that is being provided by the current operational large-scale pilot, demonstration and commercial Carbon Capture and Storage (CCS) projects around the world. By compiling and assessing this information we hope to increase awareness of developments, and what is being learnt that will assist wider CCS development and deployment. We also hope to use the information to identify gaps within the global CCS portfolio to help direct future funding, research and ultimately further projects toward filling these gaps.

For CO_2 storage, the following criteria have been chosen to define operational, large scale projects:

- Operational by the end of 2008, and either:
- Injecting over 10,000 tCO_2 per year with the purpose of geological storage with monitoring;
- Or, operating as a commercial CO2-EOR project with an associated storage monitoring programme.

Whilst acknowledging that significant learning has been gained from smaller projects and research, this study focuses only on these larger projects.

We initially identified 15 storage projects which meet the above criteria (Table 1); each of these projects has been contacted individually. Compiling a database from these projects is regarded as an iterative process; an initial questionnaire has been circulated to elicit key details from each project. The questionnaire is in five parts: parts 1-4 request basic information, with part 5 focusing on key learning aspects.

The information provided has allowed an initial assessment, which will be reported to IEA GHG members and sponsors prior to issue as a published report, made available on our website. We see the updating of this information as an ongoing activity every 2-4 years, and in conjunction to our other activities, leading to a global network of learning from large scale CCS projects.

Table 1. Large Scale Storage Projects

Project	Type	Net storage rate (tCO_2/year)	Depth (m)	Questionnaire Response*
In Salah, Algeria	Saline Formation	800,000	1,900	Yes
K12-B, Holland	Depleted gas field	20,000	3,800	
Ketzin, Germany	Saline Formation	10,000	650	
MRCSP – Michigan Basin, USA	Saline Formation	10,000	972	Yes
Nagaoka, Japan	Saline Formation	10,000	1,000	
Otway Basin, Australia	Depleted gas field	50,000	2,050	Yes
Pembina Cardium, Canada	CO2-EOR	18,000	1,600	Yes
Rangely CO2 Project, USA	CO2-EOR	750,000	1,950	Yes
SECARB – Cranfield II, USA	CO2-EOR	500,000		Yes
Sleipner, Norway	Saline Formation	1,000,000	1,000	
Snohvit, Norway	Saline Formation	800,000	2,600	
SRCSP – Aneth Paradox Basin, USA	CO2-EOR	200,000	1,700	Yes
SRCSP – San Juan Basin, USA	ECBM	10,000	960	Yes
Weyburn-Midale, Canada	CO2-EOR	1,600,000	1,675	Yes
Zama, Canada	CO2-EOR	67,000	1,470	

** Responses as of March 2009*

Monitoring Techniques

Questionnaire returns so far indicate a wide range of monitoring techniques in use. The extent of seismic surveying varies, 3D being common and 4D surveys utilised in some projects. Several projects have used vertical seismic and cross-well seismic techniques, and a few are starting to use electrical conductivity methods. A number of projects have employed tracers but downhole fluid sampling is not so common. Several projects have attempted to measure microseimic and passive seismic events. A number of projects use soil gas samples for monitoring at the surface but detector arrays and eddy covariance methods have also been employed. Satellite imaging and tiltmeters to detect ground movement have also been tested.

Seismic is an effective technique for monitoring the CO_2 plume in some, but not all storage scenarios. Learning so far indicates that seismic is not quantitative beyond a certain resolution and is relatively expensive, so the merits of seismic surveying should be assessed for each site. Electrical conductivity measurements are seen as promising additions to the monitoring suite although their value beyond experimental projects has yet to be demonstrated. Interest in monitoring microseismic events appears to be waning due to an emerging belief that this technique may have little to offer. Monitoring of layers above the target reservoir is mentioned in a couple of projects as being potentially a more convincing way of showing seal integrity to non-specialists. Better and more extensive sampling of downhole fluids under reservoir conditions is considered worthwhile but does not seem to be practiced by many projects.

Choosing an optimum suite of monitoring techniques, and identifying the best methods of proving storage integrity to authorities and public, are potential areas of future research collaboration. Enough information is now available about how all the techniques work, to enable the 'slimming down' of requirements for commercial projects. The construction of a monitoring programme will always have to be a site-specific process given the variation in site characteristics and the different capabilities of monitoring techniques.

IEA GHG will continue to encourage the sharing of knowledge on monitoring techniques through continued updating of the large-scale projects questionnaire-based database, and through the international research network on monitoring, details available on our website at http://www.co2captureandstorage.info/networks/networks.htm.