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# Knowledge Sharing in MVA / MMV in CCS Demonstration Projects and Large scale $CO_2$ Injection Tests

Workshop summary

**A report for the European CCS Demonstration Project Network**

Mobile, Alabama May 2012

## Summary

This report provides an update on the event held in Alabama focusing on $CO_2$ monitoring techniques. Overall there was a very large variety of projects presented, covering a variety of techniques from the US, Canada and Europe. These ranged in scale (from pilot to the commercial large scale injection of $CO_2$), location (comparing onshore and offshore challenges), process (EOR monitoring as opposed to CCS), project maturity (from planning to ongoing injection), risks and opportunities (hundreds of wells to a small number), and focus (research as opposed to commercial).

The differences between research and commercial actions were clearly articulated. Researchers' activities focus on the benefits, costs, performance and sensitivity of tools, and ultimately act to inform commercial MMV plans. In contrast commercial MMV plans are to prove that predictions of containment are correct (are reasonably close to the models), provide the confidence to inject (that there are no adverse consequences), but are primarily used for risk management – and are an important tool in proving secure $CO_2$ storage.

Despite this variety – a number of shared learnings were made.

- Some techniques are becoming 'standard', particularly downhole P&T sensors. Others, such as 3D seismic, are proving themselves to be powerful tools, if it can be appropriately used.
- Clear and agreed definitions for monitoring objectives are needed.
- Characterisation of the local rock/fluid/stress system is important.
- Reservoirs will always cause surprises.
- Appropriate baseline measurements are critical.
- Public engagement is key, especially at an early stage.

Going forwards more work is required on monitoring technologies and techniques. In particular further work is required on costs; needs; interpretation of the data; and triggers - especially for communications with regulators.

All of those consulted felt that this was a very positive and useful event. As Victor Der of the Global CCS Institute stated "MMV is part of getting CCS 'right'". In the case of MVA, the continued sharing of such knowledge, learnings and data will aid and stimulate monitoring developments - paving the way to less contingency, less cost and the provision of greater guarantees.

Regular events providing updates on projects progression - combined with a focus on specific issues - was seen as a useful, stimulating and valuable activity for all concerned. Specifically it allowed the CCS community to pool their learnings about the costs and benefits of various techniques, aiding the accelerated development of CCS as a key technology. It is anticipated that such events can continue to be held on this and other topics, as expertise is developing globally and it is vital that these key experiences are shared.

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## Introduction

This report provides an update on the event held in Alabama focusing on $CO_2$ monitoring techniques, organised by The Southeast Regional Carbon Sequestration Partnership (SECARB), the Southern States Energy Board, the Global CCS Institute, Natural Resources Canada, the European CCS Demonstration Project Network and the U.S. Department of Energy.

Introductions opening the session were given by Marc D'Iorio (Natural Resources Canada), Bob Wright (U.S. DOE), Vic Der (Global CCS Institute) and Simon Bennett (European CCS Demonstration Project Network, EC) whose presentation can be found here. Simon commented that this event provided a great opportunity for deepening the connections between EU, US and Canadian large-scale CCS and injection projects – and developing global knowledge on CCS project deployment.

This was followed by Richard Esposito's updated of Southern Company's CCS related activities – including Plant Ratcliffe IGCC storing $CO_2$ at a rate of 3.4 Mtpa; the National Carbon Capture Centre; and Plant Barry CCS demo. Further details can be found here.

Some of the more important findings or lessons learnt are listed below, though more information is provided per project presentation – which can be found by following the links provided.

## US projects

### Illinois Basin – Decator Project

Rob Finley first gave details from the Illinois Basin – Decator Project, which is planning to store 1Mt of $CO_2$ at a depth of over 2000m by 2014. Injection, currently totalling nearly 150kt has been running since 2011. Primarily focusing on the R&D aspects of monitoring, some key learnings include Bromine (Br) being a useful indicator in the brine geochemistry, with the $CO_2$ arriving sooner than modelled. Microseismic activity, 3000ft away from the injection site, was also noted.

The presentation and details can be found here.

### Bell Creek

Charles Gorecki provided details of the EOR and $CO_2$ storage project, sourced from Lost Cabin gas-processing plant. With injection planning to commence in Q1 2013, the MMV plan that has been developed for this 1Mtpa of $CO_2$ injection is part of an integrated approach: guided by site characterisation, modelling, simulation, and risk assessment.

The collection of surface and near-surface baseline data is seen as key, and baseline data will be taken throughout the field (to cover natural, agricultural and seasonal variations) over a 1-year

period, to obtain a complete log of seasonal $CO_2$ variations for comparison. Regarding the reservoir itself, continuous monitoring will take place regarding wellhead pressures and via permanent downhole monitoring (PDM) equipment. Periodic monitoring will be via seismic; well logs, pressure surveys and possibly tracers.

Monitoring is particularly problematic as this is part of an active EOR operation, resulting in limited access to wells, and a reservoir in constant flux (water injection prior to $CO_2$ and simulations projection and injection). In terms of some lessons learnt using LIDAR to locate P&A wells was seen as particularly useful. The presentation and details can be found here.

## Cranfield Large Scale $CO_2$ Injection

Susan Hovorka provided details of the research project, monitoring the $CO_2$ taken from Jackson Dome for use in EOR operations at Cranfield. One of the key objectives of this research lead activity is to demonstrate that it is probable that 99% of $CO_2$ is retained. As a result there has been continuous in zone and above zone monitoring interval (AZMI) monitoring for the past 3.7 years, concluding that pressure alone cannot guarantee permanent storage. There has also been extensive geochemical modelling of the sensitivity of groundwater chemistry to $CO_2$ leakage, and process accounting. Regarding leakage detection, some important findings have been made as it appears as though concentration of $CO_2$ vary considerably at different depths.

The main lessons were that in-zone monitoring alone cannot be used to determine non-leakage; that continuous AZMI pressure monitoring for permanence (particularly cross wells) is important (as pressure alone cannot guarantee storage), and that near surface leakage monitoring strategy needs to be based on modelling (not just based on results). Specifically there is a need to understand geomechanics and the impact of fluid and pressure. The presentation and details can be found here.

## SECARB – Plant Barry

On the following day, an overview was given of the capture, transport and storage facilities at Plant Barry. The presentation of the 25MW capture facility that started up in June 2011 can be found here. They are primarily focusing on emissions testing, compressor performance, and flexible load following operations. The presentation for the transport element followed. A 12mile, 10cm pipeline has been constructed, with some of Denbury's purity requirements being > 97% dry CO2 at (46ºC) and < 20 ppm H2S. Details can be found here. The presentation and details of the storage site, which will operate for 2 to 3 years and will be followed by 3 years of monitoring, can be found here.

## EPRI – Experimental technologies

Robert Trautz gave an overview of the activities that EPRI are pursuing in relation to monitoring technologies, focusing on groundwater sampling methods, an integrated modular downhold monitoring system, and using fibre optics for VSP. The presentation and details can be found here.

## Canadian projects

### Shell Quest

Mauri Smith presented Shell's JV with Chevron and Marathon. The project is progressing well, with an FID being expected by Q2 2012, with commissioning planned for 2015. Between 3 and 8 wells will be used to inject 1.2Mtpa of $CO_2$ over 10 years.

MMV is central to Shell's risk management framework. The MMV plan is explicitly designed to cover the area of potential brine displacement. Some of the key lessons learnt are that there is a need for early and clear definitions of the MMV goals to be created and agreed upon. In Shell's case 'conformance' will validate predictions and long term security, while 'containment' will demonstrate safety and current security. The MMV plan was then developed as part of the risk analysis, evaluation of tools (including cost/benefit analysis), and then used to create a diversified monitoring program that is not based on a single technology. The presentation and details can be found here.

### Fort Nelson

Mark Jenkins provided an overview of Spectra Energy's plans for Fort Nelson, which will plan to inject around 2.2 Mtpa of $CO_2$. Following the development of a risk assessment methodology with Oxand and EERC, Bayesian Analysis Techniques will be applied to select appropriate MVA technologies. The storage site has some limiting factors, due to the climate, and 3D seismic surveys can only take place in winter. It is anticipated that the results of this survey will be important for informing the MVA plan. A FID is expected in 2013, with injection to commence in Q3 2016. The presentation and details, particularly of the Bayesian analysis, can be found here.

### Weyburn-Midale and Aquistore

Neil Wildgust gave the presentation for the two projects, indicating that in September 2012 a 'Best Practice Manual from Weyburn data' will be published. Over 20Mt of $CO_2$has been stored since 2000 at Weyburn, where 3D time-lapse seismic has proven to be very useful, though data repeatability is critical. A short update was also given regarding the Aquistore project, which aims to inject $CO_2$ by December 2012.

In terms of overall lessons learnt, characterisation of the local rock/fluid/stress system is essential to the design of the monitoring plan. The measurement of baseline conditions has proven to be very useful. The presentation and details can be found here.

## European Network projects

### Porto Tolle

Silvana Iacobellis illustrated the steps being taken by Enel in its approach to Porto Tolle. Within Europe monitoring is a key activity to ensure permanent storage of $CO_2$ under both the CCS Directive and the ETS. Again, the issue of baselines was addressed. Both onshore monitoring (soil gas and

diffusive degassing; shallow aquifer and dissolved gas; microseismicity) and offshore monitoring (physical and chemical characterisation of the column and dissolved gases; characterization of sediment interface and water/sediment; benthic communities; oceanographic measurements; chemical-physical parameter continuous monitoring) is taking place to obtain a comprehensive baseline

Regarding the offshore monitoring, the baseline study covers a 400 km2 area in water depths ranging from 13 to 40 m. Given the off shore location, low-cost $CO_2$ monitoring sensors could be deployed at a larger number of points throughout the area, and will be used in combination with one continuous monitoring station. The presentation and details can be found here.

## Sleipner

Sveinung Hagen gave an update on the activities taking place at Sleipner. In Statoil's experiences with Sleipner, Snøhvit, and In Salah, there are relatively few monitoring wells. While a separate monitoring well was considered for Sleipner, it was decided that only the injection well would be drilled due to safety, operational and cost considerations. Monitoring technology has changed, and downhole monitoring in particular wasn't available at the time of the well completion – and instead Statoil were initially mainly relying on well head pressure and flow rates. Since 1996 there have now been seven time-lapse (4D) seismic surveys, two repeat gravimetric surveys, an electromagnetic survey, and two seabed surveys.

In terms of key lessons, sharing data has significantly improved the overall knowledge of the fluid dynamic processes in particular – and has been very beneficial. It was also felt that detailed geological features are difficult to predict in advance. Geophysical, non-invasive monitoring has been extremely valuable and has been used to address most of the operational questions. The presentation and details can be found here.

## Compostilla

Andrés Pérez-Estaún presented the Compostilla's current plans for the Hontomín site, where drilling will commence in December 2012 to a depth of 1600m with injection expected in early 2013. A significant number of monitoring techniques are being investigated, with the key questions being addressed through testing are costs; detection limits; resolution; autonomy; versatility; and durability.

Some of the technologies include the PISCO2 impacts on bio organisms, ground based SAR, passive subsurface monitoring etc. with three wells including ERT electrodes, P&T sensors, pore pressure, geophones, multilevel geochemical sampling etc. The presentation and details can be found here.

## Table indicating only discussed (simplified) techniques per project during the conference. (Will not reflect all of the tools that a project is currently using / will use)

| Type of tool | Illinois Basin - Decator Project | Bell Creek | Cranfield | Shell Quest | Fort Nelson | Weyburn | Aquistore | Porto Tolle | Hontomin | Sleipner | Secarb (Plant Barry) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atmospheric / Eddy covariance | Y | | | Y | | | | | Y | | |
| Soil flux monitors | 110 | Y | Y | Y | | Y | Y | Y | Y | | Y |
| InSar | Y | | | Y | | N | Y | | Y | | |
| Multibeam / sonar | | | | | | | | Y | | Y | |
| Sediment | | | | | | | | Y | | | |
| Benthos | | | | | | | | Y | | | |
| Oceanographic | | | | | | | | Y | | Y | |
| Ground water | 17 | Y | | 3 | Y | Y | Y | Y | Y | | Y |
| Lidar | | Y | | | | | | | Y | | |
| 3D s | Y | Y | Y | Y | | Y | Y | | Y | Y | |
| Gravity | | | | | | N | Y | | Y | Y | |
| Wells | 3 | 147 | ~55 | 12 | 4 | 500+ | 2 | | 3 | 1 | 10 |
| P&A | | 44 | | ~5 | | | 1 | | | | |
| Injection | 1 | 93 | ~46 | ~5 | | | | | 1 | 1 | 2 |
| Observation / monitoring wells | 2 | 10 | ~9 | 7 | Y | | 1 | | 2 | | 8 |
| VSP | Y | Y | Y | Y | | | Y | | Y | | Y |
| Microseismic | Y | | Y | Y | | Y | | Y | Y | | |
| ERT | | | Y | | | | Y | | Y | Y | |
| Reservoir Saturation Tool / pulsed neutron | Y | Y | | | | | | | | | Y |
| Tracers | | | Y | Y | | | | | Y | | Y |
| High res noise interferometry | | | | | | | | | Y | | |

Excel table with further details and comments attached below:

MVA event.xlsx

## Table of projects at the event

| Project | Country | Scale | Status | Type | R&D / Commercial | Link to presentation | Link to website |
|---|---|---|---|---|---|---|---|
| **Illinois Basin - Decator Project** | US | 0.1Mtpa | Operating (2011) | Onshore | R&D | here | www.sequestration.org |
| **Bell Creek** | US | 1.0Mtpa | Planned (2013) | Onshore EOR | Commercial | here | www.undeerc.org |
| **Cranfield** | US | 1.0Mtpa | Operating | Onshore EOR | R&D | here | |
| **Shell Quest** | Canada | 1.2Mtpa | Planned (2015) | Onshore | Commercial | here | www.shell.ca/quest/ |
| **Fort Nelson** | Canada | 2.2Mtpa | Planned | Onshore | Commercial | here | |
| **Weyburn** | Canada | 3.0Mtpa | Operating (2000) | Onshore EOR | R&D | here | http://www.ptrc.ca/weyburn_overview.php |
| **Aquistore** | Canada | | Planned (2012) | Onshore | R&D | here | http://www.ptrc.ca/aquistore_overview.php |
| **Porto Tolle** | Europe | 1.0Mtpa | Planned (2016) | Offshore | Commercial | here | www.portotolleproject.com/ |
| **Hontomin** | Europe | 0.1Mt | Planned (2013) | Onshore | R&D | here | www.compostillaproject.eu |
| **Sleipner** | Europe | 0.9Mtpa | Operating (1996) | Offshore | Commercial | here | www.statoil.com |
| **Secarb (Plant Barry)** | US | 0.1Mtpa | Planned (2012) | Onshore | R&D | here | http://www.secarbon.org/ |

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