ccsnetwork.eu

* connect * construct * share

Thematic Report

Characterisation session (Storage) – October 2012

A report from the European CCS Demonstration Project Network

Website version

Proceedings from the Rotterdam knowledge sharing event 24th/25th October 2012

Executive Summary

The European CCS Projects Demonstration Network is a community of leading demonstration projects committed to sharing knowledge and experiences to achieve safe and commercially viable CCS. As Europe's most advanced projects, they are often faced with new issues and challenges, which the projects have had to negotiate.

By sharing these experiences with a wider audience the Network provides other projects with the benefit of their experiences, both successful and unsuccessful, and delivers best practices for how to operate a CCS project thus saving new projects both time and money. Consequently the reports from the Network play a vital role in delivering information and experience to other CCS stakeholders, maximising the efficiency of achieving commercially viable CCS.

This report presents the information, discussions and key learning points from the 2nd knowledge sharing event of 2012 on Storage site Characterisation, held on the 24th and 25th of October. The 1st knowledge sharing event on Storage site Monitoring was held on the 24th and 25th of May.

Besides the very informative sharing of knowledge and discussion of issues and suggestions which are summarised in the key learning points of this document, the event's main outcomes re-emphasised the following needs to accelerate the deployment of CO_2 storage:

1. Address project "stoppers" and "delayers": An update given by each of the projects within the Network showed that storage site characterisation work is ongoing but faces a slow-down in activities due to postponed Financial Investment Decisions (FID) tied to funding prospects and delays in permitting. It is recognised that the "Early movers" projects play an essential role in identifying barriers and establishing a more streamlined process to deploy commercial CCS. However each geological site is unique and must be screened and extensively characterised, taking years before a decision can be made to proceed with a commercial project. **It is therefore crucial that storage faces no further delays and is treated as a priority.**

2. Facilitate further project "enablers": The recent addition of the Sleipner project to the network has brought considerable added value because it is the only project within the network that is currently injecting in the operative phase. Some projects mentioned referring to the US EPA guidance documents for best practices. **There are benefits in including more advanced projects in the Network**.

3. Address project "challenges": The discussions stimulated a debate about baseline surveys acquired during the pre-injection/characterisation phase and monitoring during injection and closure phases; they do not have the same objectives. The baselines need to anticipate future problems which is challenging. As well, projects needs to anticipate the technology that will be available in 10 years from now. Monitoring plans should therefore be designed based on the project's performance management and risk control process. **Distinguish and address adequately baseline surveys and monitoring**.

4. Finally, the event highlighted the importance of investigating **injection back-up options**.

Table of Contents

1 Introduction

This report gives an update on the storage site characterisation work undertaken by the leading European projects since the knowledge sharing event held in May 2012 as well as a summary of the discussions and key learning points that resulted from the thematic event held in Oostvoorne close to Rotterdam and hosted by the ROAD project on the 24 and 25 of October 2012. The workshop was one of three sessions held in parallel during the EC CCS Project Demonstration Network knowledge sharing event. The other thematic groups were public engagement and regulatory development (see separate reports).

Reminder: Mission of the European CCS Demonstration Project Network

The European CCS Demonstration Project Network has been setup to:

- Help fulfil the potential of Carbon Capture and Storage by creating a community of projects united in the goal of achieving commercially viable CCS by 2020.
- Foster knowledge sharing amongst the demonstration projects.
- Facilitate the identification of best practices.
- Accelerate learnings and ensures that we can assist CCS to safely fulfil its potential, both in the EU and in cooperation with global partners.
- Leverage this new body of knowledge to raise public understanding of the potential of CCS.

Storage Knowledge Sharing Themes for 2012

Two topics have been selected by the European CCS Demonstration Project Network Steering Committee to be addressed during the year 2012 concerning storage: best practice in monitoring, and storage characterisation. The monitoring topic was addressed during the first knowledge sharing event held in May 2012 in Germany (see separate report).

Given the projects' state of development, it was considered that storage characterisation for the second knowledge sharing event would benefit the Network projects since previous discussions were based on principles and conceptual or early models. While projects' specific needs will be more clearly defined with data acquisition and analysis - an early and constructive dialogue (particularly with the more 'advanced' projects within the Network) could prove to be very useful. In particular, it was felt that a more thorough investigation into seismic characterisation (jointly with other geophysical methods) could benefit a number of projects at this stage in their development. A teleconference was held on the 6th of September followed by one-on-one mail and phone conversations to refine the knowledge sharing event agenda.

2 Key learning points

1. All projects in the network are demonstration projects at an industrial scale except for the Hontomin site of the Compostilla project, a research pilot devoted to real scale experiments. The

Hontomin project demonstrates the added value of pilot experimentation in developing new technologies in storage engineering such as:

- Cost-effective operations such as slim drilling technologies.
- Testing of various injection strategies.
- Deployment of a large set of monitoring technologies at depth and at the surface.

2. The recent addition of the Sleipner project to the network has brought considerable added value because it is the only project within the network that is currently injecting in the operative phase. The participation of Sleipner greatly facilitates knowledge transfer and is a stimulating positive example to the other participants of the network.

3. The early development of this project demonstrates the importance of tax incentives to reach operational stage in a CCS project. Several projects from the network are facing difficulties to reach Final Investment Decision (FID) due to financial constraints when at the same time the Gudrun field is being added to the Sleipner storage project in a more favourable economic context. The carbon tax on CO_2 associated to hydrocarbon production in Norway has recently increased to NOK410 per ton (56€/t).

4. The portfolio of storage solutions investigated within the network is varied, spreading from migrated assisted storage in saline aquifers (Compostilla) to EOR (Don Valley). Powerful learning can be anticipated from an open exchange of information between these projects.

5. The importance of a solid monitoring baseline is recognised by all partners. It can be seen as an "assurance" policy against potential future claims of negative effects of the storage operations. Baselines need to be broad enough to be able to anticipate unexpected events and new technologies that will be developed in the future. The recent example of media coverage on a "sea bed feature" located in the Sleipner area shows the importance of wide baseline coverage to be able to disprove any relation between such a feature and the Sleipner CO_2 plume.

6. The risk-based monitoring programme should also be established jointly with the regulator to ensure a good balance between risk management and cost effectiveness. The technologies to be applied are very much site-dependent. For example 4D seismic is an essential tool in Sleipner but is not foreseen to be able to detect fluid variations in the case of the Don Valley EOR project. The monitoring plan should not be focusing on tools but rather on site-driven knowledge gaps. What needs to be measured /detected should drive the selection of tools.

It is felt that the development of the different monitoring technologies could also be driven by future regulations. For example if the regulator requires numerous repeat surveys, the installation of permanent installations (such as bottom cables offshore) would be more cost effective than surface data.

7."Early movers" projects can unlock some of the bottlenecks. An example is provided by the detailed reservoir characterisation study performed on the Don Valley EOR reservoir that found no detectable rock fluid interactions on typical North Sea sandstone cores. The results of this study can be applied to future projects that will not necessarily need to conduct such detailed petrophysical analysis on all future reservoirs to be considered.

8. Collaboration between the various CCS projects in Europe is very important to benefit from positive synergies. Clustering and pipeline sharing is essential for example in the development of the Don Valley project. Another example is the development of the storage part of the Air Liquide Green Hydrogen project in the Netherlands that should tie into the ROAD storage site.

9. Member States are responsible for the selection of storage sites in their respective countries and for the application of the European Directive on CCS. As good collaboration between industry experts and regulators will be needed to define the optimum criteria for such selection.

10. Technical progress is not the critical factor limiting progress within the network. Regulatory, financing and contractual issues have a strong influence on project development:

- Porto Tolle is affected by issues related to the power plant permitting.
- Compostilla had to re-apply for the exploration permit under the new storage law adopted following the transposition of the EU CCS directive.
- The Bełchatów project has been delayed following the cancellation of a first tender to select the coordinator of the characterization phase.
- The ROAD project is well advanced technically; FEED studies have been completed successfully. Structural assessments of the existing installations and flow assurance studies have been completed. The project is now waiting on FID that remains uncertain because of budget constraints.

11. The EEPR projects are producing high quality dynamic models to predict the evolution of the plumes.

- A 7km X 3km plume has been modelled in Compostilla over a 10,000 years period. Further studies are ongoing to better take into account reservoir heterogeneities.
- Full field models have been performed on the 2 potential fields of the Don Valley EOR project. 3D compositional (7 components) simulation models (Eclipse 300 with 300,000 cells) derived from a Petrel model of 28 million cells have been built.
- Extensive modelling has been performed on the Sleipner data and a good match with monitoring data (seismic + gravity data) demonstrates the validity of early model predictions. The systematic improvement in prediction performance with the use of the repeat seismic surveys data demonstrates that performance controls are identified and understood.

12. Injectivity is a crucial factor in the successful development of the projects. Experience from Utsira in particular shows that the provision of potential injection backup at the design phase is advisable. The fact that Sleipner has achieved 2 phase flow CO_2 injection with success was highlighted. The topic is a high priority for the members of the network and injection wells design/strategy and further knowledge sharing on this central theme needs to take place.

3 Project Status Update

The projects gave an update on storage progress since the last event in May 2012, in Cottbus, Germany.

The below **project status table** for the projects in the Network (except Sleipner since all boxes would be marked as completed) presents a summary of their current status:

	Belchatow	Compostilla	Hontomin	Don Valley EOR	Don Valley Saline	Porto Tolle	ROAD
Site screen	✓	✓	✓	✓	✓	✓	✓
Site select	✓	☐	✓	✓	✓	✓	✓
Feasibility study	O	☐	☐	☐	☐	✓	✓
Appraisal drill and/or seismic	O	☐	O	n/a	O	O	n/a
Baseline surveys	O	☐	☐	O	☐	☐	n/a
FEED	O	O	✓	O	O	O	O
LT monitor plan	O	O	☐	O	O	O	O
Storage License application	O	O	n/a	O	☐	O	✓
CO_2 Injectors	?	3-5	1	5-6	2-6	1	1
Injection backup?	?	yes	no	yes	yes	no	no

O not started ☐ in progress ✓ complete

3.1 Bełchatów

As a result of the Phase I of the storage component implementation (Site Selection) Wojszyce structure has been selected for Site Characterization – Phase II. Latest activities undertaken within the Phase II:

- A tender release in March 2012 to select a coordinator for the second phase of the storage implementation. The signature of the contract being expected in June.
- On July 10th the tender was cancelled and a new one was launched on July 20th.
- Currently the offer submitted within the second round is being evaluated. Implementation of the second phase of the storage component i.e. site characterization is consequently shifted.

3.2 Compostilla – Hontomin site

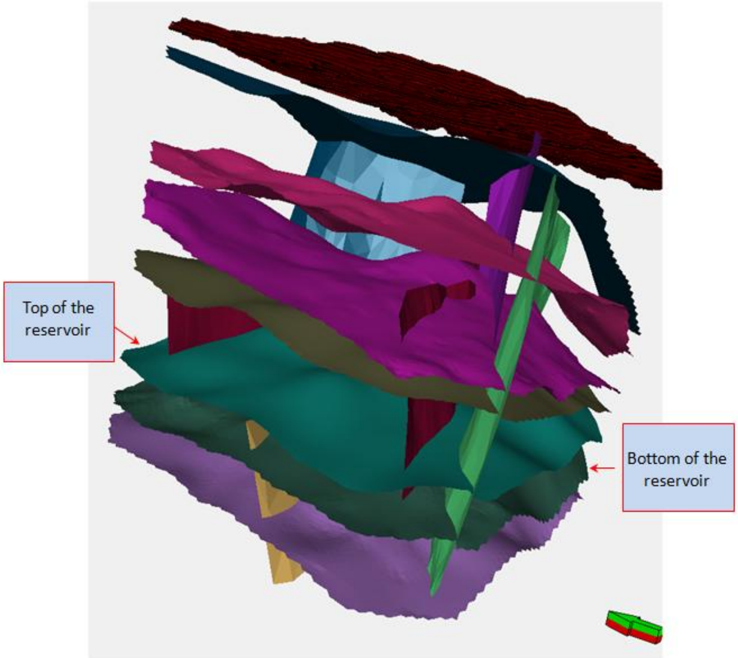
The project is currently building the infrastructures at the Hontomin injection and storage test site which is expected to be operative in Sept/Oct 2013.

The total surface area covered by the project is of 140,000 m^2 and the injection platform covers an area of 25,000 m^2.

This installation will be devoted to real scale experiments in deep porous carbonate rock formations to test and develop new technologies in storage engineering.

The location fulfils the internationally established geological criteria for installations of this kind, such as depth, porosity, thickness of the seal and reservoir formations and water salinity (reference: Table 3.1 Key Geological Indicators for storage site suitability (Based on Chadwick et al. 2007). Page 31 Best Practice for the storage of CO_2 in saline aquifers. Observations & Guidelines from the SACS & CO2STORE Projects).

A 3D model was shown, illustrating the bottom and top of the reservoir as well as the various overlaying geological formations, including the caprock.



3.2.1 Hydrogeological objectives of the project:

- The hydraulic characterization of the Cretaceous formations which are more sensitive in case of eventual CO_2 leakage events.
- To detect the existence of hydraulic connections between the formations located upwards of the seal formation.
- To provide the needed infrastructure to start the tasks related to groundwater monitoring prior and during CO_2 injection & storage phases.

1) Location & Design:

    2 boreholes: Upper Cretaceous & Utrillas Fm. (3 shallow boreholes in Cretaceous)

    Prognosis of injection well (H-I) & observation well (H-A).

2) Drilling & Instrumentation:

    Control of hydrogeological & drilling parameters.

    Development of the lithological column.

    Geophysical Logging.

    Installation of devices & pressure+quality dataloggers.

3) Characterisation and testing:

    Pulse, slug or one borehole tests: Low K intervals.

    Pump tests: permeable intervals.

3.2.2 Site characterisation technology deployed

1 Permanent seismic network
2 Superficial monitoring emission
3 Gravimetry
4 Geophysical logging
5 Piezometric level sensor
6 Shallow hydrogeological well
7 Hydrogeological logger
8 Seismovie
9 SAR Techniques

The techniques in bold are being deployed in shallow wells; the other technologies are methods investigating from the surface.

The Injection plant will feed into an injection well (H-I) and one observation well (H-A) will be drilled at about 80m of the injection well (the initial plan was to have 3 wells instead of 2, but the project's budget was cut).
Both the Injection well and the observation well will be drilled to a depth of 1550 m.
The project will use mining drilling technology to reduce drilling costs (thinner wells drilled faster).

3.2.3 CO_2 injection plant, CO_2 injection strategies and hydrochemical tests

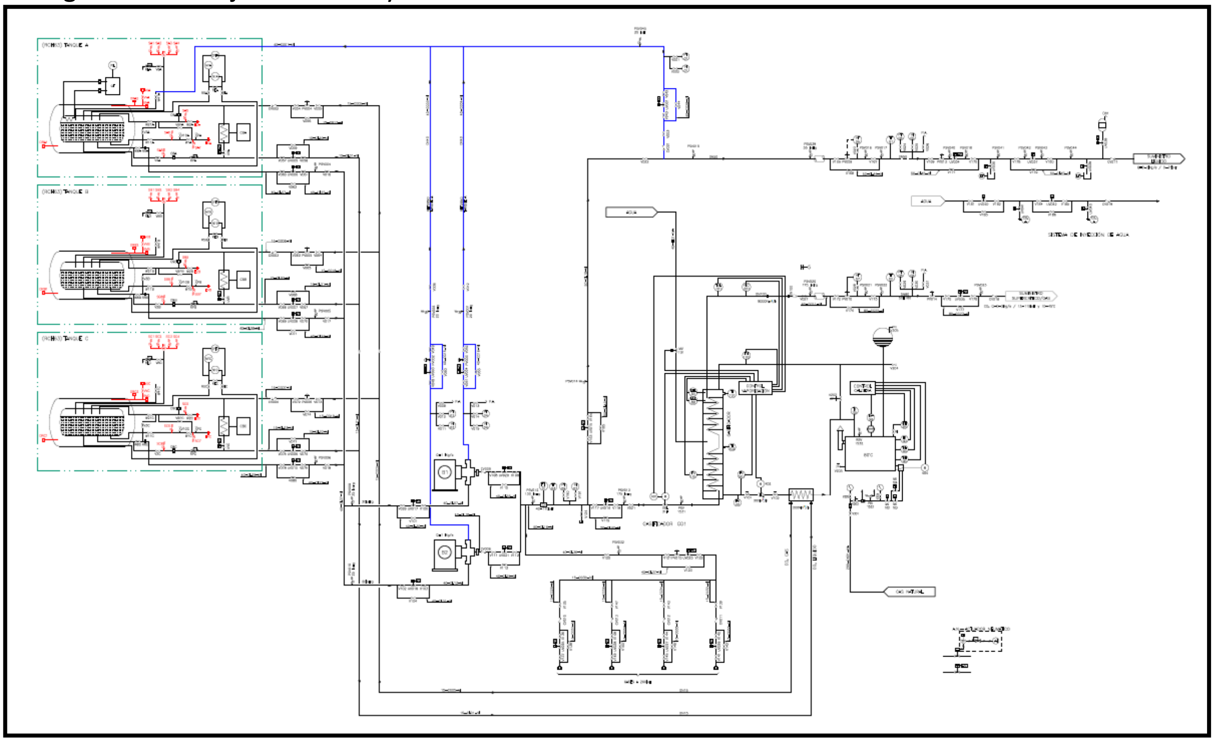
A number of concepts and strategies will be tested for efficient CO_2 injection, including:

- Continuous CO_2 injection (conventional CO_2 injection).
- CO_2 injection at fluctuating flow rates: aiming to increase the CO_2 dissolution rate.
- Liquid CO_2 injection (cold injection): aiming to improve energy efficiency and enhancement of the storage operation.

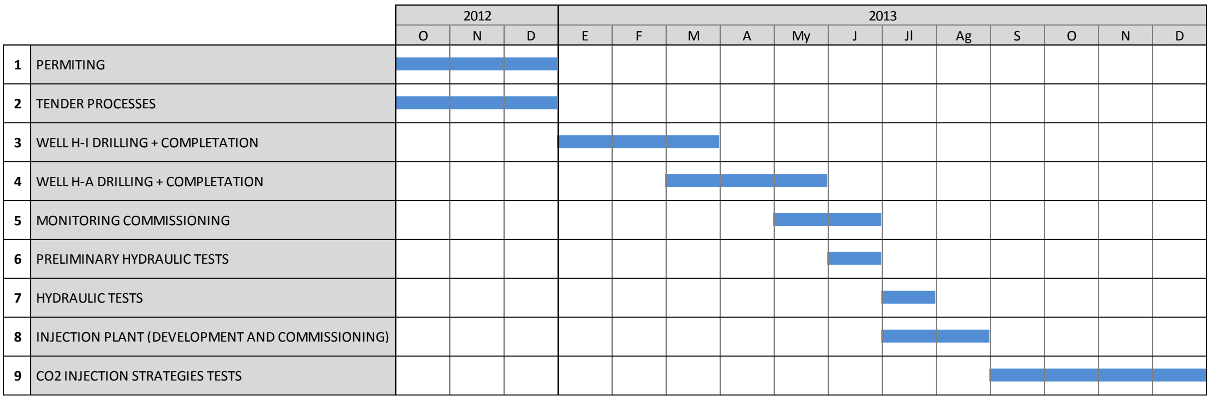
Hydrogeochemical tests will be developed to identify thermo-hydro-chemical-mechanical properties of the reservoir and caprock formations. The characterization tests planned at the Hontomín TDP include:

- Hydraulic (pumping-injection) tests.
- Tracer tests (conservative and reactive tracers) (push-pull).
- Injection-extraction of CO_2 with gaseous tracers (CO_2 push-pull).

A diagram of the injection facility was shown:



Project schedule for the remaining of 2012 and for 2013 was shared with the group:



Note that tendering processes have been launched for the drilling and well services. 3 shallow boreholes were drilled this year for the hydrogeological study and the initial results conform to those obtained from the existing wells in the area. They are 500m depth boreholes in the Cretaceous.

The current plan is to store approximately 20,000 t of CO_2 , since the project needs to stay below 100,000 t (to retain its qualification as a demonstration injection, and above which level the Spanish transposition of the 'CCS Directive', under law 40/2010, would come into effect).

3.3 Compostilla – Duero and Andorra sites

A review of the storage site identification process for the commercial storage sites was given and is as follows:

3.3.1 Site selection

The main ranking and screening criteria applied to the project is as follows:

1. Distance between CO_2 source and storage plant (max 150 km).
2. Previous experience (oilfields and gas fields) and technical information available (bulk volume), hydro-geological, geological, and geochemistry information such (dissolution and mineralisation rates).
3. Geomechanics (permeability, fracture pressure) information available.
4. Reservoir depth of > 800 m or pressure > 72.9 atm/7.39 MPa.
5. Reservoir petrophysical properties: Injectivity > 2.7 Mt CO_2 per year, permeability > 200 mD, low geothermal gradient.
6. Integrity of seal-caprock and structural seals in terms of thickness, faults, impermeability, etc.
7. Low seismicity area.
8. Presence and condition of natural and man-made pathways including wells and boreholes which could provide leakage pathways.
9. Populations and cities in the region overlying the storage site (preferably sparse).
10. Activities around the storage complex and possible interactions with these activities (e.g. exploration, production and storage of hydrocarbons, geothermal use of aquifers and use of underground water reserves).
11. Availability of site.

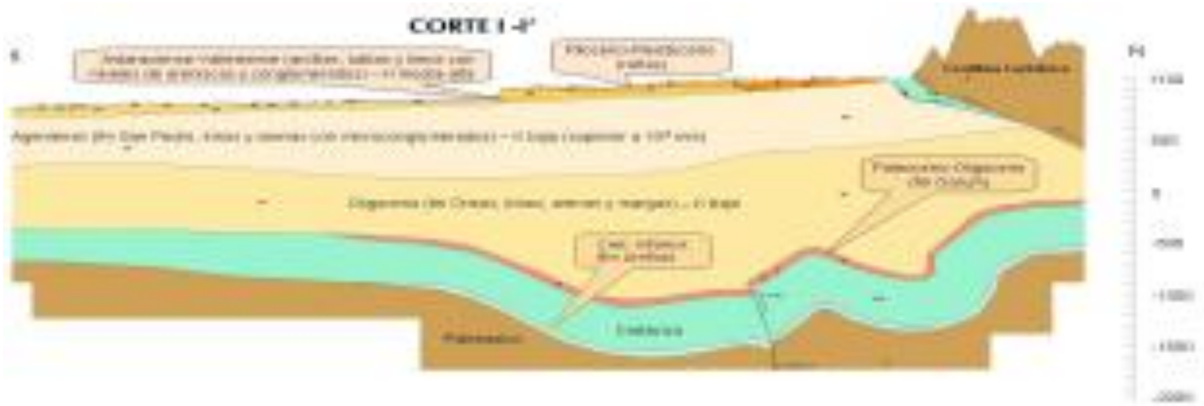
This was illustrated with a geological map of Spain showing the 8 areas of investigation.

Outcome: Two possible saline aquifers have been selected to store the CO_2 from the OXY-CFB-300 plant, the “Duero Site” and the “Andorra-Ebro Site”, in the NW and NE of Spain respectively.
These saline aquifers (>800 meter deep) are located in Mesozoic formations of the geologic periods: Triassic, Jurassic and Cretaceous.

3.3.2 Site characterisation

Permits had to be obtained to explore both sites, followed by extensive surface characterisation.

Cross-section of the project site:



1. 3-D Seismic Interpretation and Inverse model: Completed.
2. New appraisal wells: Caprock and storage formation analysis: Completed.
3. Upgrading & up-dating Structural and Stratigraphic models: On-going.
4. Upgrading & up-dating studies and models: Earth static & dynamic models: defining a set of new scenarios: On-going.
5. Geomechanical models: Ongoing.
6. Reservoir performance: Ongoing.
7. Risk analysis and monitoring assessment: Ongoing.
8. Base line campaigns (INSAR, CO_2 soil fluxes, groundwater and surface water monitoring): Completed.

5 wells were drilled to approximately 2200m depth average, showing a wide average permeability range in the Utrillas formation reservoir (300 to 1000 mD).

The reservoir characterisation studies indicate good reservoir conditions with a 200m thick reservoir (braided system) with high porosities and permeabilities ranging from 0.3 to 1.4 Darcies. Coring is difficult and requires special equipment in these unconsolidated reservoirs. It is not possible to take water samples in such conditions. Inverse faults are present but do not disconnect the reservoir.

Monegrillo site in Aragon: reservoir is over-pressured. Gradient Fracture: 0.12, injection 20% safety range.
The injection is planned into an open system, in the Utrilla formation, on the flank of a dipping monocline. A 7km x 13km plume has been modelled. A regional seal consisting of 300m of unfractured shales is present. Since the injection is taking place in the lower parts of the monocline the CO_2 can dissolve in water before reaching shallower depths. A maximum migration of 13km of the plume in the next 10,000 years has been modelled (reduced to 3 km in homogeneous

conditions). The available space is more than 48 Km. Further studies are ongoing and a new heterogeneous model is being built.

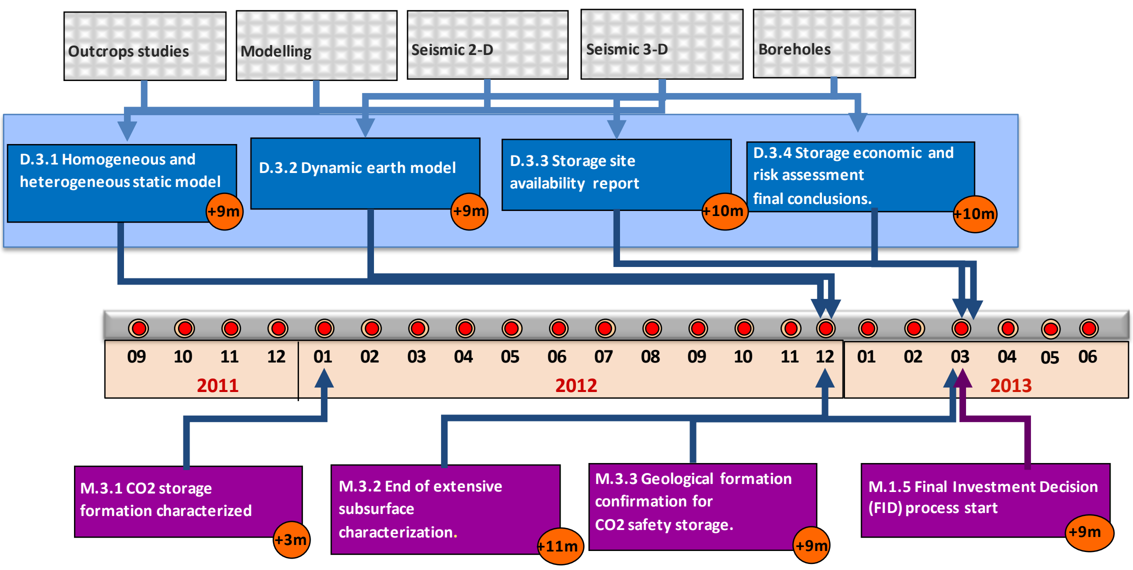
3.3.3 Monitoring risk and management plan

- CO_2 Base-line methodology and procedures have been developed. 28th June 2010 started the first base line campaign for Duero, with the second in May 2012.
- The study area (20 x 30 km) was divided into equal cells in a way that 99 measuring nodes/points were defined and located by UTM coordinates.
- Temperature, relative humidity and CO_2 concentration measurements were taken in both, atmosphere and soil.
    - Weather conditions were also measured (Atmospheric pressure, Temperature, etc.).
    - Gas samples for CO_2 laboratory determination (concentration and isotopes) were taken from the atmosphere and soil in some of the nodes/points .
    - Atmospheric data was taken at 1.5 m height. Soil data comes from 20 cm depth.
- In November 2011 the second base line campaign started for Duero for measuring CO_2 samples in Tertiary reservoir.
- In April 2012 the second base line campaign for Duero started for:
    - Weather conditions (Atmospheric pressure, Temperature, etc.).
    - Besides, gas samples for CO_2 determination (concentration and isotopes) for soil in some of the nodes/points.

Feature Events and Process procedure and models, based on commercial code, is being developed to establish all potential risk for each selected site.

3.3.4 Timeline

A project timeline was illustrated as follows:



- The storage formation was characterised early 2012.
- The extensive subsurface characterisation to be ended in December 2012; this is to be concluded in combination with the updated homogeneous and heterogeneous static and dynamic models.
    - Storage appraisal plan: 5 wells are being planned; 3 petroleum wells and 2 shallow wells (less than 1500m) to be drilled by a local company based in Andalusia using a mining rig. This should reduce drilling costs from 9 to, 3 to 4 million Euros (pay per meter drilled, not on a daily rate).
    - The 3D interpretation and seismic inversion model have been finalised. A first static model has been finalised (model 25 by 28 km area in Petrel). A dynamic model still remains to be built.
    - Baseline campaigns to be completed end of year when reporting to EC is due.
    - InSAR and soil fluxes have already been completed.
    - An injection test at one of the wells was due to start on Friday 26 October for 6 to 7 days. 800m^3/hour injection test. Results, including lab tests, are expected in 1 to 2 months.
- In March 2013 the Final Investment Decision process will be delivered taking into consideration the storage site availability report and the final conclusions of the economic and risk assessment studies. Further to that decision an exploitation/ injection license would be applied for over a smaller area.

It is to be noted that it is the first application for CO_2 storage in Spain, under the new storage law. Following the transposition of the EU CCS Directive into Spanish law (law 40/2010) the existing exploration permit that had been granted under the mining law had to be re-applied for.

3.4 Don Valley

Two update presentations were given by the Don Valley project, one about the EOR site and one about the Deep Saline Aquifer site. The project investigates both a deep saline formation and an EOR site in parallel.

3.4.1 Don Valley project update

3.4.1.1 Project overview

- The planning was awarded in 2009.
- Final Investment Decision to be taken in 2013.
- Construction to be completed mid-2016.
- Commissioning late 2016.
- The Humber Cluster to be put in place in 2020.
- North Sea Oil Reserves extended to 2040.

The CO_2 is to be captured and transported by a collective pipeline 300 Km offshore.

The consortium is made of a number of companies involved respectively in the 3 components.

3.4.1.2 Don Valley alignment with European and UK policy objectives

Infrastructure:

- Pipeline with capacity for multiple projects.
- Potential for trans-shipment of CO_2 from continental Europe.

Energy Security benefits:

- Prolonged access to coal and gas for power generation.
- Increased North Sea oil production.

Climate benefits:

- Access to 650MW (net) of new clean power.
- 5 million tonnes CO_2 stored per annum.

Financial benefits:

- Tax revenue and deferred decommissioning from EOR.
- Thousands of jobs in Yorkshire and Scotland.

3.4.1.3 Don Valley CCS Project Progress

Onshore:

- Section 36 planning permit in place (conditions discharged).
- Environmental permit work underway.
- £25m contract signed for next phase of engineering work to reduce risks and increase bankability.
- £25m contract for site clearance imminent.
- Team to reach 230 later this year.

Offshore:

- Studies indicate technically and economically robust CO_2 EOR project.
- Production of 100mmbbl EOR enables 'no fee' storage.
- Preparing proposals to go out to tender for FEED work.

A slide was shown about Don Valley attracting strong inward investment.

3.4.2 EOR storage site

An update was given about:

- The Extended Feasibility Study to year end, with increased budget for additional reservoir modelling and facilities studies.
- Lab results on pressure, volume, temperature (PVT), formation damage and CO_2 chemistry
- Full field models for two fields with > 95 Mt and >40 Mt storage
- Optimising wells and facilities
- Opened leasing discussions with the Crown Estate.

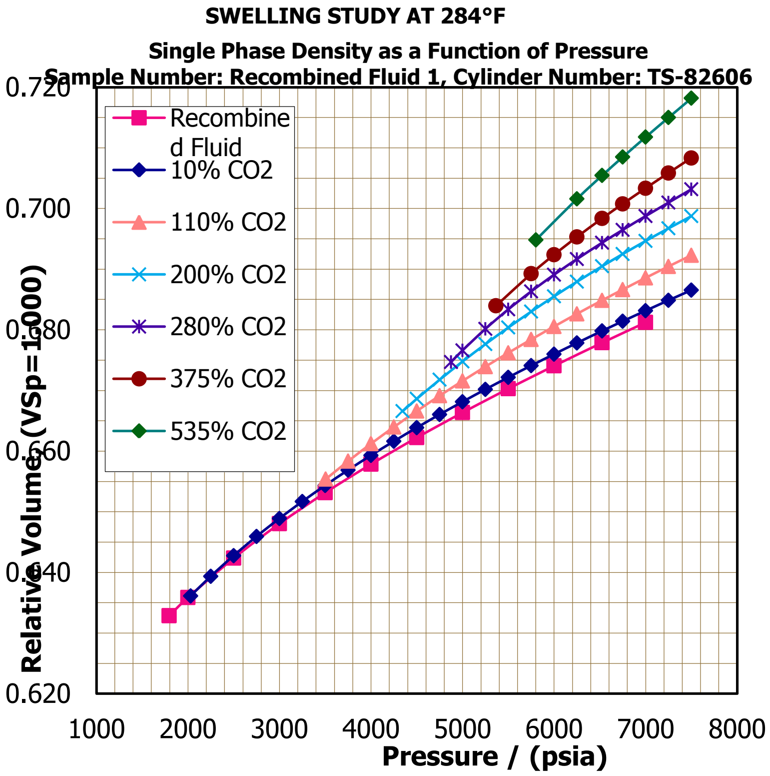
Two central North Sea fields are being considered for this EOR project. The largest one has a 180 Mt capacity, the smaller 40 Mt.
In the large field, the plan is to inject 95 Mt over 20 years and then recycle CO_2 for another 5 years. That would generate a pressure increase of 200psi (around 15 bars), still 70 bars below the fracture gradient. The project plans for continuous injection with producers on the flank and injectors at the top (gravity drainage). No 'water-alternating-gas' (WAG) injection is needed in this case because of "free" availability of CO_2. The structure is a faulted dipclosure with steep flanks. 40 wells have already been drilled in this field (25 years of production history) and 8 new wells are planned during the EOR operation. The top seal is very thick.

3.4.2.1 Laboratory programme

The projects lab programme has included:

- Full suite of PVT experiments with oils from 2 fields and CO_2 (results transferred to reservoir simulation).
- New thermodynamic equation of state from new PVT data for improved EOR forecasting.
- Formation damage tests on cores from 2 fields – **no detectable rock-fluid interaction.**
- CO_2-brine interfacial tension at reservoir temperatures and pressures – **in expected range.**
- CO_2 hydrate stability over expected range of operating P, T – **experiments ongoing.**

An interesting graph of the swelling study at 284°F was presented. It showed single phase density as a function of pressure using various % of CO_2, from 10% to 535%.

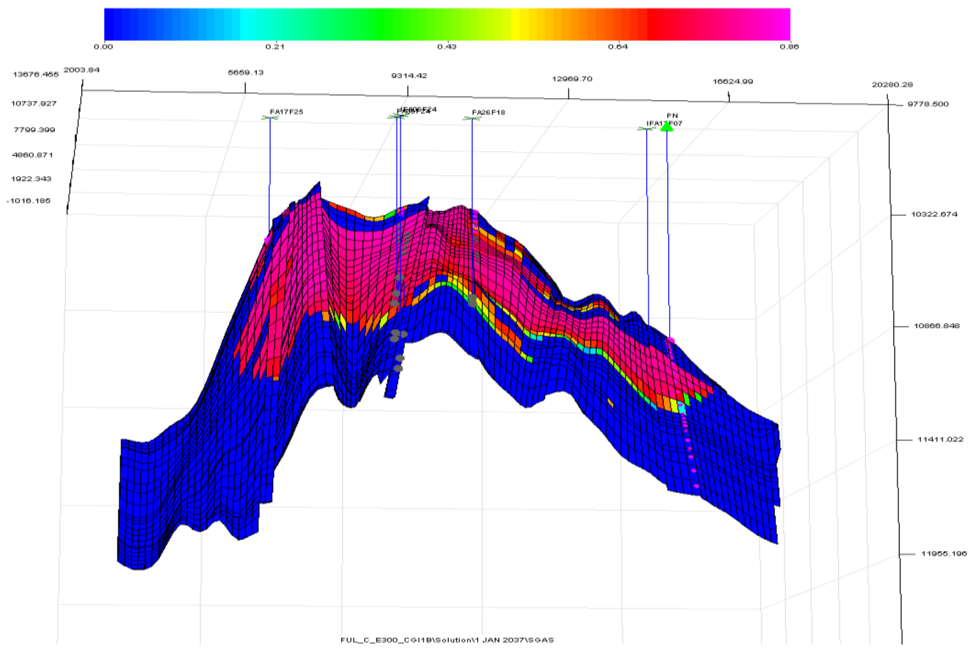


Sample Number: Recombined Fluid 1, Cylinder Number: TS-82606.

3.4.2.2 Full field reservoir simulation models

- 3D compositional (7 components) simulation models (Eclipse 300) adapted from black oil models (designed for water flood).
- 20 years CO_2 import followed by 5 yrs (or more) recycle.
- Optimum 500-600 mmscfd gas recycle.
- 95 Mt stored with attractive recovery and 400 psi pressure increase in larger field; more capacity with extra liquid production.
- Optimisation of storage and EOR recovery ongoing, with focus on larger field.
- More finely gridded (3x) model completed for main field with very similar results.

The 2011 Full Field Mode 3D model was shown with storage reservoir gas saturation after 20 years of CO_2 injection.



A 3D compositional model in Eclipse300 (300,000 cells) and a Petrel Model (28 million cells) were built. Finer gridding in model required a substantial investment into a new model with 3 times more grid cells (Model took 20 hours to run, using 25 years of EOR production and 28 years of flood history). This new model showed similar results to the previous model, but increased the level of confidence of the project in the results.

Typically in terms of performance, the project has to look at how much oil and how much CO_2 it has. The capillary pressure is to be sufficiently high to maintain the column, or translate to a column of CO_2. The project used the density of CO_2 (PT) + interfacial tension between brine and CO_2.

The project looked at CO_2 Hydrates: stability field in expected range of operating P&T.

High injection rates up to 80 mmscfd/well are prognosed in a thick good quality sandstone reservoir. The project would import about 253 mmscfd (4.7 Mtpa) CO_2 from the Don Valley power plant, and recycle up to 600 mmscfd of produced gas (total gas injection up to 850 mmscfd i.e. 24 million cubic meter per day or approximately 8.7 billion cubic meters per annum). In the considered scenario the field should have redundant CO_2 injection capacity.

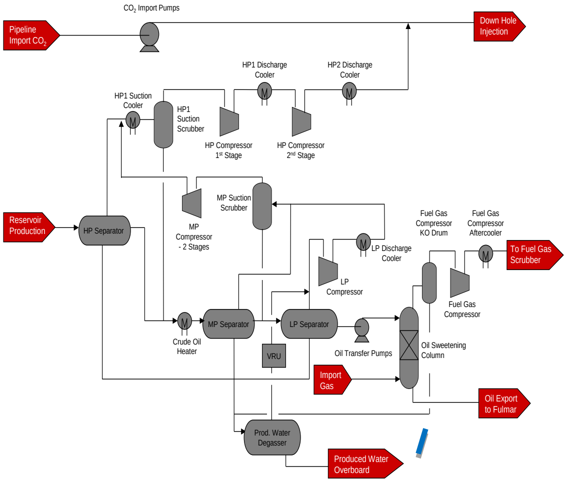
The project can produce oil for 25 years or more, while recycling 600 mmscfd of produced gas, which is almost entirely CO_2 after approximately 5 years. The project would store 95 Mt of imported CO_2 over the first 20 years, with an increase of average reservoir pressure on the order of 200 PSI higher than original. CO_2 storage and oil recovery are expected to be maximised by continuous CO_2 injection, rather than water-alternating-gas (WAG) injection.

3.4.2.3 EOR process and facilities

A diagram of the production process was shown highlighting:

- New bridge-linked platform.
- CO_2 import and pumps.
- New production trains.

- Gas compression and power.
- New wells and extensive workovers.
- Confirm high-pressure (50 bar) separation system.
- 99% availability for CO_2 injection.



The project will build a new production train because of the amount of gas it will be producing, thus needing bigger vessels. However, increasing separation P to 50 bars yields a big saving in capital cost.

The project will have a monitoring programme established jointly with the regulator. Due to the good well control and historical production data, monitoring of key parameters in the wells could be sufficient (data for mass balance, P, T°).

4D seismic monitoring feasibility is an issue considering the depth of the reservoir (10,000 feet, i.e. approx 3000m). The only detectable variations would come from the difference in compressibility between oil and CO2. Gravity would be difficult in this case due to depth and very low density contrast between CO2 and oil. VSPs should also be considered.
The project is planning to install downhole guages.

3.4.2.4 Storage licensing

The reservoir is overlain by a very thick overburden of sealing rocks

- Developed EOR case for storage of 95 Mt CO_2 over 20 years injection
- Identified seismic and well data for delineation of storage complex
- Began assessment of 4D seismic monitoring feasibility
- Opened commercial discussions with the Crown Estate for a CO2 Storage Lease(s)

3.4.3 Deep Saline Aquifer storage site

Update on the deep saline formation site:

3.4.3.1 Licence & Lease

Offshore Carbon Storage Licence application submitted to the UK's Department of Energy and Climate Change (DECC) – facilitates the drilling of up to 2 appraisal wells.

Agreement for Lease negotiations with the Crown Estate are at an advanced stage.
It is expected that both licence and lease are awarded within a month or so of each other.

Appraisal drill consenting process with DECC are continuing.

Contractual terms agreed with a laboratory to undertake Special Core Analysis on 5 of the 42 formation water and core samples.

3.4.3.2 Subsurface Studies

The seabed survey was completed in April 2012. It resulted in better outcrop definition data for modelling and monitoring.
The reservoir consists of sandstones located on a closed structure in the Southern North Sea (Bunter formation that can also be studied on outcrops). The area is well known due to historical data including 3D seismic and core samples. New seismic has been shot. Capacity estimates are ongoing. A twin track storage approach will be followed.

Current studies:

- Formation Damage – evaluate potential impact on injectivity & water productivity, influencing optimum tubing size.
- Sanding – evaluate likelihood of occurrence, influencing injection and water production well designs.
- Chemical Compatibility – evaluate compatibility of injected CO_2 (with impurities) into saline formation water and mineral assemblage.
- Generalised Equation-of-state Modelling (GEM) – model long-term geochemical reactions between CO_2 & formation fluids / rocks.

3.4.3.3 Facilities Conceptual Design

There are four discrete work packages for the design work:

1. Landfall approach & shore crossing (excluding onshore facilities).
2. Flow assurance modelling from landfall to sandface.
3. Offshore subsea facilities, including offshore trunkline, injection facilities & subsea structures, flowlines, cables & umbilicals.
4. Offshore surface facilities, including jackets & topside infrastructure.

Based around four offshore development options; nominal trunkline diameters of 300, 450, 600 & 900mm.

Objective to mature conceptual ideas, definitions, schedules, design basis & costs (Capex & Opex).

Facilitate informed selection of preferred option to progress into FEED.

3.5 Porto Tolle

Update on the Porto Tolle project progress since last May included:

3.5.1 Reminder project characteristics

Capture:

The project is a retrofit of a power plant generating 660 MWe using as primary fuel Bituminous coal and as secondary fuel Biomass.

40% of the flue gas is to be treated (250 MW), representing an energy penalty of 12%.

Post-combustion CO_2 capture with amines at a 90% rate.

Storage:

The project is to store up to 1 Mtpa in a deep saline aquifer offshore, under the north Adriatic Sea.

3.5.2 Permit Status

Since May the project has mainly been working primarily on permitting issues.

For the Power Plant:

- In May 2011, the overall progress of the conversion to coal firing of Porto Tolle power plant has been affected by the Decision of the State Council, that voided the Environmental Authorization (EIA).
- The Environmental Ministry required a new Environmental Impact Assessment to be issued within 2012.
- Due to the issues related to Porto Tolle Power Plant permit, the CCS project is affected by relevant delays and the schedule of the overall project is under assessment.
- Consequently the NER300 requirement to be in operation by 2016 cannot be met.

While the directive has been transposed and the permit for exploration has been submitted, power plant conversion permit has delayed the project with consequences on its eligibility to NER300 funding.

For the CO_2 offshore Storage

- The request for the Exploration permit, including the drilling of an appraisal well that can later be re-used as an injection well, should be submitted in 2012, but the technical decrees of the Storage Regulation are not still implemented.

The new environmental assessment is to be completed end of this year. From a technical point of view the project is ready to submit storage operations permit.

3.6 ROAD

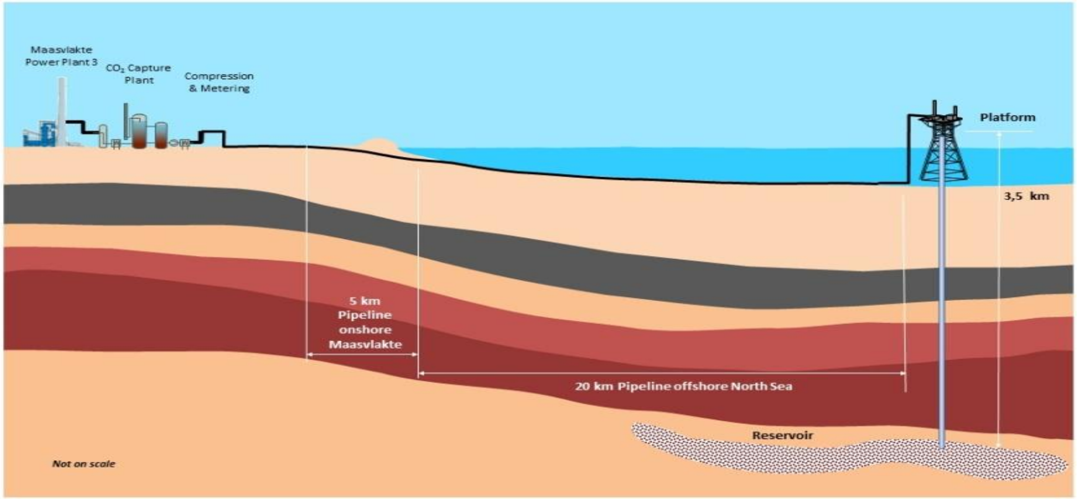
An update on the Front End Engineering Design (FEED) of the P18 Platform in the North Sea in order to transform the depleted gas reservoir into a CO_2 storage site included:

3.6.1 Transport and Storage chain

ROAD applies post combustion technology to capture the CO_2 from the flue gases of a new 1,100 MWe coal-fired power plant in the port of Rotterdam.

The capture unit has a capacity of 250 MWe equivalent and aims to capture approximately 1.1 million tonnes of CO_2 per year.

From the capture unit the CO_2 will be compressed and transported through a pipeline: 5 kilometres over land and about 20 kilometres across the seabed to the P18 platform in the North Sea. It is designed for a pressure of 140 bar and a maximum temperature of approximately 80 °C.



During the trajectory two railroads, a road and pipelines are crossed. Afterwards, the Yangtze Harbor and the Maasmond are crossed by means of a HDD.

The P18 field consists of three reservoir blocks, the P18-2, P18-4 and P18-6 blocks. The reservoirs are situated in the Main Buntsandstein Subgroup and are primarily capped by the Solling and Röt Claystone Members.

ROAD plans to store the captured CO_2 in a depleted gas reservoir under the North Sea. This gas reservoir is located in block P18-4 of the Dutch continental shelf, approximately 20 kilometres off the coast. The gas reservoirs are at a depth of around 3,500 meters.

The P18-4 reservoir block contains only one well, the P18-4/A2 well.

3.6.2 Existing installation

The P18-A platform is located in the Dutch part of the Continental shelf in a water depth of 25m. It was installed in 1993 for Amoco and is now operated by TAQA.

It is an unmanned, remotely operated well platform. It produces gas, which is sent un-treated to the P15-C production platform.

The platform houses 6 well slots. The orientation of platform north is 60° west of true North.

The jacket has four legs braced by horizontal framings at elevation +6m and +25m.

Structural assessment:

The additional loadings, estimated at 150 t, on the structure do not result in overstressing in the jacket members or piles.

The fatigue analysis revealed a minimum life of 480 years.

The ship impact analysis shows that the platform can withstand a 3000 t ship impact at the speed of 1 m/s. The post impact dent and missing brace analysis did not show any overstressing.

There is no overstressing of the topside.

Main platform modifications:

- A new CO_2 riser;
- Addition of a back pressure control valve to control pipeline flow regime and limit slugging impact;
- Provision for a temporary intelligent pig receiver;
- New injection header for up to 4 to 5 wells ;
- Installation of one injection flow line to P18-4A2 wellhead;
- Addition of a CO_2 vent system;
- Allow for methanol and chemical injection;
- Allow for well monitoring and well maintenance (wire-line, coil tubing, clean-up and testing activities...);
- Related modifications on: structures, instrumentation and control, utilities etc...
- After modifications, the platform will remain unmanned and remotely operated.

Gas production and CO_2 injection will occur simultaneously for an expected period of two years.

There is no provision for any start-up heater, although one was considered in the early phase of the design development. Similarly, the fiscal metering and the filtration system were deleted from the design of the platform.

The main venting system is located downstream of the isolation valve at the top of the riser, and upstream of the pigging facilities and the CO_2 injection manifold. The venting system may be used for full platform inventory venting, for depressurisation following an ESD or for platform maintenance.

On line chromatography is placed in the onshore part. But sampling (and subsequent moisture measurements) can be done on the CO_2 manifold.

Fiscal Metering is foreseen at the onshore capture plant only.

When several wells will inject CO_2, flow rate allocation to the different wells will be required. This could be achieved by having a flow meter on each flow line. Other means of allocation could be proposed.

Low temperature alarms and protection shall be installed upstream of the X'mas tree choke valve in order to maintain a minimum temperature of 15°C to avoid hydrates formation down hole, and a minimum temperature of -10°C to protect the casing.

In case of hydrate risk, injection of methanol in the wellhead is possible, using the existing platform methanol system.

3.6.3 Timeline

The final bid list for the Platform FEED after pre qualification is confirmed as follows:

- Evaluation of the offers is ongoing.
- Award contract: November 2012.
- Execution FEED: Q1 and Q2 2013.

Remarks: Flow assurance: There is concern about injecting supercritical CO_2 in a low Pressure reservoir (P= 6 to 7 bar). Cooling with transition to gaseous phase could occur, generating geomechanical effects. There is no space on the platform for a heater. The solution will be to inject at lower rates and design a larger pipeline.

Meters will be installed onshore at the plant. No metering will be installed offshore since the pipeline is only 20km long. Losses of pipeline will be negligible over such a short distance. A venting system will be installed offshore.
The project will only start to inject CO_2 in additional reservoir compartments once the gas exploitation is terminated.
The permit application has not started since licensing needs to progress first (has been granted).

3.7 Sleipner

The group was given an update on the Sleipner project:

3.7.1 Reminder

The Project operator is Statoil with partners ExxonMobil and Total.

Capture: from gas processing facilities is in operation since October 1996 using conventional amine capture.

Transport: 1km delivery pipe.

Storage: into a deep saline aquifer offshore where on average 0.9 Mtpa of CO_2 are stored. Over 13 Mt CO_2 injected to date.

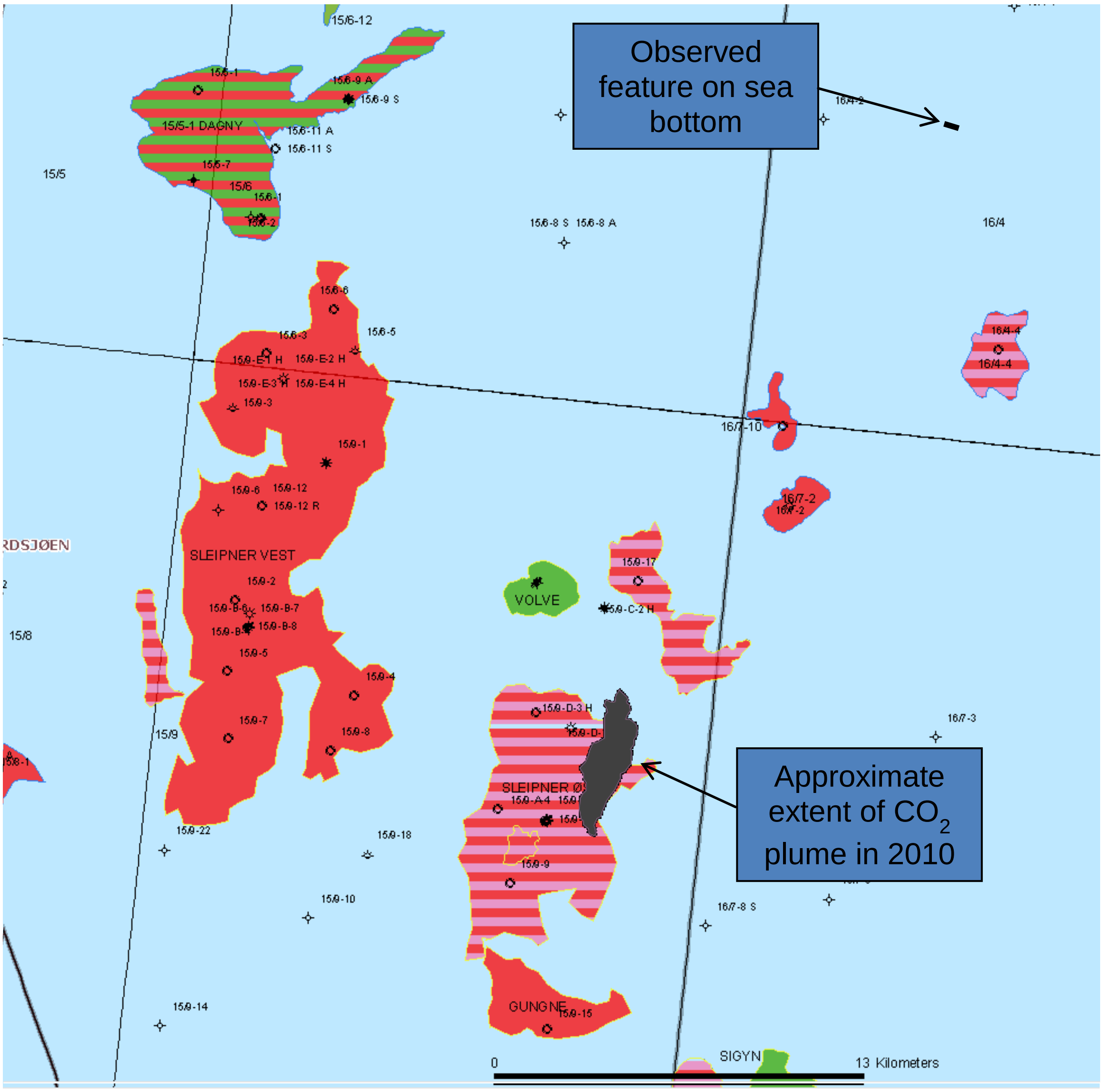
3.7.2 Update

- From 2014, facilities at Sleipner T will separate and inject an additional 100-200 ktpa of CO_2 from the gas produced by the Gudrun field, currently under development. This represents 20 more years of injection into Sleipner.
- The carbon tax in Norway will increase to approximately NOK410 per tonne (€56 per tonne).
- 3D seismic monitoring of the CO_2 injection into the Utsira Formation continues:
    - Large survey acquired in 2010
    - Shows no migration of the CO_2 out of the Storage complex (Utsira).

The water front in gas reservoir and in CO_2 storage can be seen with gravity surveys. So far the injection has generated less than 1 bar of pressure increase because of the high permeability and large extension of the aquifer. At start-up back production of sand was experienced due to the unconsolidated nature of the reservoir. The injection well was recompleted and re-screened in 1996. No further problems have been encountered.

- The ECO2 research project (funded under the European Commission's Framework Seven Programme) performed a seabed monitoring survey (2011) that revealed some interesting features 25km north of Sleipner which:
    - Caused considerable public interest
    - Unrelated to CO_2 injection at Sleipner

A map of the approximate extent of the CO_2 plume in 2010 and the location of the feature observed by the ECO2 project at the bottom of the sea using echo sounder and sonar data of 2011 was shown:



Approximately 25 Km separate the Sleipner East field and the injected CO_2 plume from the Observed feature.
A seafloor feature can be seen in shallow seismic data from 1996. Semblance maps of 1996 do not indicate a discontinuity at deeper levels (approximately 500m below surface).

There is no demonstrated relation between the sea bed feature identified by the ECO2 project and the CO_2 injection. The feature observed on the 1996 shallow seismic data existed prior to the injection.

The use of such "sensational" information in the media raises the issue of crisis management and the highlights the value of establishing a solid baseline. Baseline and monitoring do not have the same objectives. The baseline needs to anticipate all future problems and can be seen as an "assurance policy". One needs to anticipate the technology that will be available in 10 years from now. For monitoring, spatial coverage, timing and number of repeats, and the relevant technologies to be applied have to be balanced against costs.

4 Storage Characterisation – Discussions

During the second part of the day each Project shared a storage characterisation topic with the rest of the group triggering interest and a discussion benefiting CO_2 storage characterisation progress.

4.1 Don Valley – 4D Seismic Technology Options

Don Valley gave an update on the process the project had to go through to evaluate offshore seismic data acquisition options:

The key challenge to address was negating 4D 'noise' to ensure valid response, which required looking into:

- Seismic source & receiver positioning (X,Y,Z) variability
- Seismic source characteristic variability
- Seismic survey geometry variability
- Recording equipment characteristics variability
- Ambient noise variability
- Environmental changes
- Processing parameters & software / algorithm variability
- Tidal and temperature variations

Note that the site is at 90 km from a wind farm.

The technology portfolio evaluated is as follows:

1-Surface Towed Streamer Acquisition:

3 major seismic survey technology service companies offer this technology. Proposals included a scenario Baseline survey and 2 monitoring surveys, high and low acquisition.

Advantages:

- Cost range (8 – 25M USD)
- Proven & reliable technology
- Time efficient
- Numerous service providers

Disadvantages:

- Repeatability
- Acquisition logistics

2-Re-deployable Ocean Bottom Cable Acquisition:

2 technology service companies offer this technology.

Advantages:

- Repeatability
- Surface Infrastructure
- Data quality

Disadvantages:

- Cost (one quote 122M USD baseline!!!!)
- Acquisition & processing time
- Seabed conditions

3-Ocean Bottom Node Acquisition:

3 technology service companies offer this technology.

Advantages:

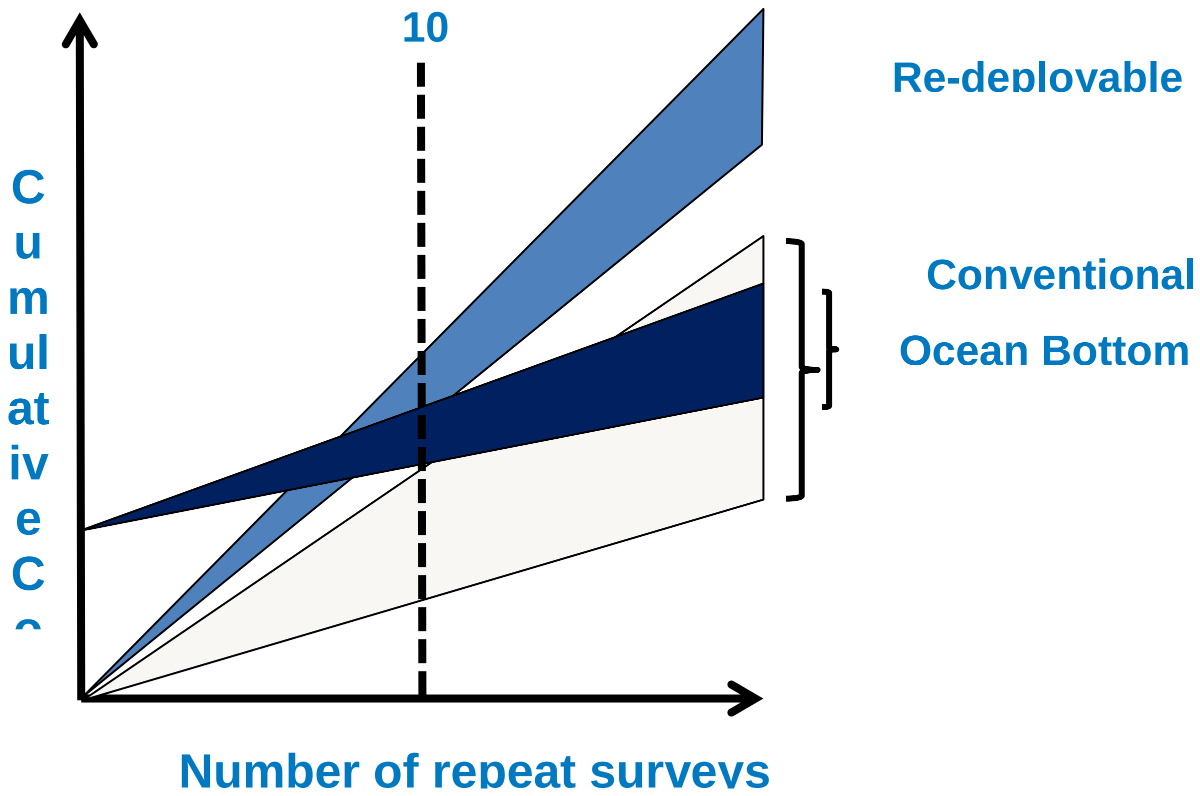
- Repeatability
- Surface infrastructure
- Data quality

Disadvantages:

- Cost range (18 – 73M USD)
- Acquisition & processing time (migrating sandwaves)
- Seabed Conditions

300m depth via remote vehicle.

A comparative cost analysis graph of 4D Seismic Technology Options showing the number of repeat surveys vs. cumulative cost:



Conclusion is that variability in costs is a function of lack of detail in acquisition specifications.

- Monitoring objectives need definition
- Passive plume observation
- Reservoir management tool
- Rock physics work to be undertaken
- What can quantitatively be extracted from the data
- Survey Evaluation & Design Study needs to be undertaken
- What are the minimum acquisition specifications (spatial sampling criteria) that can still meet monitoring objectives and thus minimise costs.

A permanent array of OBC could be an option to investigate if a lot of repeat surveys are considered: high capex, but low opex. This could also provide continuous passive seismic monitoring at very low additional cost.
Passive techniques including Microseismic could be useful.
Gravity could be an option in certain cases but isn't commercial at present.
The development of the different technologies could be driven also by future regulations.

4.2 Don Valley – Core analysis – Formation Damage test

The work done by the project on core analysis was discussed. The objective of the analysis was to verify whether the CO_2 would interact with the rock. As they had no cores in initial state, they used clean cores restored to initial state. 2 samples (fine-medium arkosic sandstones) were believed sufficient as the reservoir had only 1 rock type. Only a few potential reactive minerals (e.g., K-feldspar) could react with CO_2.

The core analysis process was as follows: each core was first saturated with brine, then flooded with oil (oil pumped through the rock until cannot displace any more water). The core was then flooded with sea water (to simulate the historical water flood) and later with CO_2. Differential pressure was measured and fluid chloride, carbonate, sulphate (K+, Ca2+, Na+, Br...) were analysed. Thin sections, scanning electron microscopy and X-ray diffraction were used to identify changes in minerals and textures. Porosity and permeability were measured before and after on core samples.

The cost was of 15000 EUR/sample. No detectable petrographic/mineralogy changes were identified, no significant change in effluents, no change in porosity nor air permeability. A decrease in differential pressure and an increase in water relative permeability were noted. Increased water relative permeability was attributed to reduction of oil saturation due to oil mobilisation by CO_2. As expected, the CO_2 removed the oil from the rock.

Such Formation Damage tests are important for the first CO_2 projects since they demonstrate the impact of the CO_2 on the rocks and can thus be sued to increase stakeholder confidence but should not be necessary for all projects. A similar exercise was not envisaged for the caprock. The structure is known to be able to hold a large hydrocartbon column in an EOR operation and the seal to possess a good physical integrity. Also diffusion through the caprock is slow. Analogue studies in the Miller Field (Central North Sea) by Edinburgh University indicates that diffusion from the reservoir into the caprock would reach 12 m over 100 million years.

4.3 Compostilla – Core analysis, results from lab analysis

The geochemical analysis and core analysis work undertaken at the Duero and Andorra-Ebro storage sites was discussed -

During drilling operations, several fluid and core samples were taken in order to measure directly reservoir, caprock and fluid formation properties.

Currently, some laboratory tests are ongoing (basically SCAL) as well as some fluid samples are pending to take.

Scheduled Laboratory tests (undertaken in Norway, UK, USA, Dubai and Spain):

- Petrophysical core analysis (CCA).
- Special core analysis (SCAL).
- Mechanical core testing.
- Geochemistry analysis.
- PVT analysis.

A total of 16 cores and 8 fluid samples were taken from the 5 boreholes at the Duero site. 2 cores and 2 fluid samples were taken from the 1 borehole at the Andorra-Ebro site. Cores were taken in basement, reservoir and in cap-rock formations. This was illustrated with a table.

DUERO site:

Well	Cenozoic	Garumn (Caprock)	Boñar (Cap-Rock)	Utrillas (Reservoir)	Palaeozoic (Basement)
SD-1	-	1 core (9.35 m)	1 core (9.35 m) 2 fluid samples	2 cores (11.40 m) 2 fluid samples	-
SD-2	-	1 core (9.35 m)	-	1 core (9.35 m) *	-
SD-3	1 core (4.81 m)	1 core (9.88 m)	1 core (6.00 m)	1 fluid sample	1 core (5.50 m)
SD-4	1 core (8.50 m)	1 core (7.50 m)	1 core (9.00 m)	1 core (10.85 m) 3 fluid samples	-
SDE-3	-	-	1 core (3.00 m)	1 core (4.50 m) 1 fluid sample	-

*Fluid samples will be taken (well is on well test phase).

Andorra-EBRO site:

Well	Keuper (Caprock)	Buntsandstein (Reservoir)
SM-4	1 core (12.00 m)	1 core (11.34 m) 1 fluid sample

4.3.1 Geochemistry analysis:

The geochemical analysis included:

- Ion water analysis.
- Isotope analysis in gas and water samples.

The PVT analysis included:

- Density and Viscosity measurements in reservoir conditions.
- Measurement of opening pressure, volume of monophasic sample at ambient temperature.
- Determination of any flash or liberated gas sample composition.
- Dry Gas: Constant Composition Expansion (CCE) at reservoir temperature including Saturation pressure determination PV relationship, relative volume and compressibility, Z factor.
- CO_2 solubility as function of pressure and temperature.

Challenges:

Fluid samples have been taken from two different ways:

1. Normal conditions: these samples were collected in depth through sample catcher, wire-line tools such as RES and MDT. In surface, fluid samples were taken during production test (pumping test).
2. Reservoir conditions (PVT): these samples have been taken by special logging tools as RES or MDT.

The main challenge was to take samples, after finishing drilling operations, without mud contamination or completion fluid, and trying to get them with reservoir properties and with enough volume.

Several technical and economical risks are associated to the operations with special logging tools for taking samples in PVT conditions.

Laboratory results have shown a good correlation between data obtained in fluid samples collected and data interpreted of logging tools.

4.3.2 Core Analysis:

Petrophysical core analysis (CCA) in reservoir and caprock formations:

- Porosity and permeability (horizontal and vertical).
- Petrography (thin sections).
- Mineral count (XRD).
- Sedimentology.
- Diagenesis.

Mechanical core testing:

- Triaxial tests for cohesion, friction and tensile strength (or Brazilian test for the latter), as well as Young's modulus and Poisson's ratio.
- Uniaxial tests for poroelastic constants, compaction, depletion constants, Biot's parameter.

Special core analysis (SCAL):

- Reservoir samples:
    - Capillary entry pressure
    - Relative permeability curves with saturation end-points, for both drainage and imbibitions
- Cap-rock samples:
    - Capillary entry pressure

It can be said that:

- All tests should be conducted in CO_2/brine system.
- According to the mineralogical analyses, additional physical tests may be needed to evaluate rock-CO_2-brine interactions, e.g. changes in permeability due to salt precipitation.

<u>Challenges</u>

- Take cores in an unconsolidated sand formation (Utrillas Fm.) for testing in laboratories:
    - Special core barrels and tools (e.g. Orenoc Shoe®), and special packing for transport using techniques like Lithotarge®.
    - In laboratory: special care and handling during operations with Utrillas cores (e.g. sample freezing).

- Mechanical tests in unconsolidated sands (triaxial, uniaxial and brazilian tests): very difficult to get proper plugs for testing.
- Some laboratory results in Utrillas samples could be affected by:
    - Consolidation process.
    - Transport.
    - Sample freezing.
    - Drilling plugs.

4.3.3 Conclusions:

- 18 cores have been taken: 16 in Duero Site and 2 in Andorra-Ebro Site. 8 in caprock and 10 in reservoir formations.
- 10 fluid samples were collected: 9 in Duero Site and 1 in Andorra-Ebro Site. 4 of them were taken in reservoir conditions (PVT).
- Conventional and special core analysis, rock mechanics analysis in core samples, and geochemistry and PVT analysis in fluid samples have been done.
- Correlations among laboratory results of fluid/core samples and logging/well test data interpreted, show a good matching.

Note that the Sleipner Utsira core studies (unconsolidated sands as well) took place in the SACS project, and cored caprock in another well. Snøhvit had to be reperforated in a new reservoir section following injection problems. Some venting had to take place, but as the LNG production was not discontinued Statoil had to pay heavy taxes.
Further to the sand back production problems in the early phase, Sleipner has been injecting CO_2 continuously through a horizontal well.

Porto Tolle did conventional tests on old cores and Reservoir and Caprock will be cored at different depths in the future appraisal well (vertical) that will be converted into an injector and should inject up to 1Mt/year. Upper part of the reservoir is of good quality (200 milliDarcy and porosity of 24%). The Lower part of the reservoir contains shale intercalations. Studies are ongoing to identify the best position for the well: minimise overpressures and the risk that CO_2 would reach another well in the area. The formation considered is the same than the one where oil is extracted/produced.

The In Salah project has been injecting through 3 wells, hence with some room to manoeuvre.

In Compostilla the modelling recommended 5 wells with 3 ½ inch tubing inside. If 4 ½ inch from 5 to 4 injection wells. The project has decided to go with 5 wells for testing, flow capture of plant (1 for buffer) because of the fluctuations of the power plant. All will be vertical wells at around 2000 m depth.

ROAD has just 1 injection well with no back-up in a small reservoir.

The learning from the discussion is to look for injection potential backup at the project design phase.

4.4 Sleipner – CO_2 storage characterisation for flow assurance

A paper about this topic is to be presented at GHGT-11.

What is CO_2 flow assurance? It is a broad term first used by Petrobras. It is looking at a phenomenon across the chain, a multidisciplinary task for the successful and economical flow of CO_2 from source to storage.

Reminder of the thermodynamic behaviour of CO_2:

- The critical point is in the middle of the operating window.
- Triple point can be reached during depressurisation.
- CO_2 is heavy, non-combustible and asphyxiating.
- Risk of hydrate formation,
- Corrosion with water, O_2 and NO_2
- Strong Joule-Thomson effect.

Project results show that:

- There is a 2 phase flow at Sleipner.
- At Snøhvit, CO_2 injection dried the formation and caused salt precipitation generating pressure increase. Glycol injection took place and the injectivity was re-established.
- The Snøhvit injection also experiences pressure increase due to other reasons. This finally made it necessary to reperforate. More about the Snøhvit pressure increase and possible explanations will be published in the near future.

Note that while transport of CO_2 in unlined carbon steel pipes requires dry CO_2 to avoid corrosion, storage requires wet CO_2 to avoid drying out the formation and thus causing salt precipitation that reduced permeability in the near well area.

4.5 Porto Tolle – European CCS Directive Article 4 Selection of Storage Sites (& Annex 1) - Defining the criteria to make this high level selection. Resolution/Quality requirements for modelling activities.

The group discussed the challenges faced in Italy with article 4 of the "CCS directive". http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0114:0135:EN:PDF

Article 4: Selection of storage sites

1. Member States shall retain the right to determine the areas from which storage sites may be selected pursuant to the requirements of this Directive. This includes the right of Member States not to allow for any storage in parts or in the whole of their territory.

2. Member States which intend to allow geological storage of CO2 in their territory shall undertake an assessment of the storage capacity available in parts or in the whole of their territory, including by allowing exploration pursuant to Article 5. The Commission may organise an exchange of information and best practices between those Member States, in the context of the exchange of information provided for in Article 27.

3. The suitability of a geological formation for use as a storage site shall be determined through a characterisation and assessment of the potential storage complex and surrounding area pursuant to the criteria specified in Annex I.

4. A geological formation shall only be selected as a storage site, if under the proposed conditions of use there is no significant risk of leakage, and if no significant environmental or health risks exist.

Annex 1 (page 18 to 20 of 22 of the directive): It was mentioned that there are a number of uncertainties with the annex, namely around the quality requirement modelling activities. What criteria are used and how are they defined to make this high level selection?

As a comparison, in the UK there is not enough information but the atlas will/should be used by the policy makers.

This subject needs to be further discussed with the regulatory group.
Some criteria are:

- Data of large scale permeability of the reservoir
- Indication on how quickly Pressure dissipates
- More CO_2 can be stored
  Delta P of the reservoir, not max.

Not to exceed 85% to 90% of the fracture gradient is considered safe pressure management in the industry. The limit should be discussed with the regulators on a case by case basis if this can be acceptable practice.

It was considered that the regulator should be knowledgeable enough to understand and be able to make decisions, but how can you expect the regulator to be more knowledgeable than the experts dedicated to the project and moving it forward on a daily basis?

4.6 ROAD – Characterisation of rock pore throat diameter distribution

ROAD shared with the group how the rock pore throat diameter distribution can be characterised.

Filtering of the CO_2 gas stream can be necessary as small particles could clog the pore throats. However if the pipe is cleaned after construction and does not have epoxy coating, no particles should be generated during the transport.

4.7 Concluding remarks

If the capture component can be further developed and tested in laboratories prior to the project implementation, the storage component of a CCS project requires injection testing at site, composing with subsurface site specific complexity, legal and regulatory constraints and the social feasibility of the project from the very early stages. Taking into account the financial and regulatory constraints, it can be concluded that the project's storage site characterisation is possibly the best it can be in the current context and stage of development.

Given sufficient resources and confidence in the overall project feasibility is currently essential to complete the Baseline Surveys and the Front End Engineering Designs to reach Final Investment Decisions.

The European CCS Demonstration Project Network was established in 2009 by the European Commission to accelerate the deployment of safe, large-scale and commercially viable CCS projects. The Network that has been formed is a community of leading demonstration projects which is committed to sharing knowledge and experiences, and is united towards the goal of achieving safe and CCS. The learnings that are gained will be disseminated to other projects, stakeholders and public to help gain acceptance of the technology –and support CCS to achieve its full potential as a vital technique in our fight against climate change.

Network support provided by: