Programme Area: Carbon Capture and Storage

Project: Storage Appraisal

Title: Executive Summary

Abstract:

The objective of the CCS UK Storage Appraisal Project was to provide a fully auditable and defensible overall estimate of UK CO2 storage capacity in offshore geological formations. Emitters committing to major capital investment as major CCS roll out occurs in the 2020s will require confidence in the availability of sufficient, suitable storage sites to accept the emissions over the project lifetime. Total UK capacity requirement is expected to be ~15 Gt (including industrial sources) to store 100 years of emissions. The project started in September 2009, and the project team (led by Senergy Alternative Energy) has populated almost 600 potential storage units in the North Sea, Western Channel and Eastern Irish Sea with geological data, security of storage and economic assessments. These units cover both depleted oil and gas reservoirs and saline aquifers. Comprehensive and consistent methodologies have been developed and peer reviewed within the team for calculating storage capacity for each unit. These take into account both 'static' effects (e.g. how much CO2 can be stored before a maximum pressure is reached) and 'dynamic effects' (e.g. how much CO2 can be injected into a large open aquifer before there is a risk of migration beyond the bounds of the storage unit; how fast can CO2 be injected into a 'closed' unit through one well).

Context:

This £4m project produced the UK's first carbon dioxide storage appraisal database enabling more informed decisions on the economics of CO2 storage opportunities. It was delivered by a consortium of partners from across academia and industry - LR Senergy Limited, BGS, the Scottish Centre for Carbon Storage (University of Edinburgh, Heriot-Watt University), Durham University, GeoPressure Technology Ltd, Geospatial Research Ltd, Imperial College London, RPS Energy and Element Energy Ltd. The outputs were licensed to The Crown Estate and the British Geological Survey (BGS) who have hosted and further developed an online database of mapped UK offshore carbon dioxide storage capacity. This is publically available under the name CO2 Stored. It can be accessed via www.co2stored.co.uk.

ETI Executive Summary

Programme: Carbon Capture & Storage

Project Name: Storage Appraisal

Deliverable: CC1001 / MS6.1

Introduction

The objective of the CCS UK Storage Appraisal Project (UKSAP) has been to provide a fully auditable and defensible overall estimate of UK CO_2 storage capacity in offshore geological formations, to inform future roll out of CCS in the UK.

Emitters committing to major capital investment as major CCS roll out occurs in the 2020s will need to have confidence in the availability of sufficient, suitable storage sites to accept the emissions over the project lifetime. Based on ESME pathway analysis to 2050, 2 Gt[1] storage needs to be available by 2020, rising to 5 - 7 Gt in 2030 and 6 - 8 Gt by 2050 (assuming new assets will require identified storage for 25 - 40 years operation). Total UK capacity requirement is expected to be ~15 Gt (including industrial sources) to store 100 years of emissions.

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The key project deliverables are a comprehensive technical report and a web-enabled database and GIS (WDG). The WDG is currently available through the Carbonstore website, via the developers (Senergy Survey & Geo-engineering).

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[1] Gt = gigatonne = 1,000 million tonnes. For reference, Drax emits ~21 million tonnes CO_2 per annum

[2] P90 = there is a 90% probability that the storage capacity is greater than this figure

Key findings

1. Overall Storage Capacity

- Storage resource that is potentially technically viable has been identified in all five regions of study (Southern, Central and Northern North Sea, East Irish Sea Basin and Western Channel).
- A total of 572 storage units have been identified, although 98% of the potential capacity is contained within 274 larger units (with estimated capacity of the unit at least 20 Mt). Stores below 20 Mt are unlikely to be practical unless they are clustered around others. For context, a 20Mt store would store the emissions from an 800MW CCGT station for 8 years or Drax for less than a year.
- Potentially viable storage units around the UK occur at a range of depths below the sea bed (typically 1 – 4 km). In many locations there are multiple storage units at different depths, with deeper stores overlain by shallower ones. This is likely to influence the manner in which the overall storage capacity available is most efficiently exploited.
- In accordance with the methodologies developed by the Project the UK has theoretical storage capacity of some 71 Gt at 90% confidence level (P_{90}), rising to 85 Gt at the 10% confidence level (P_{10}). These confidence levels refer only to uncertainty in the quantified pore volume, the percentage of that pore volume that may be occupied by stored CO_2, and density of the stored CO_2 itself; they do not include consideration of security of storage nor economics. Overall storage volume is dominated by saline aquifers, though significant capacity exists in depleted oil and gas reservoirs (Figure 1). These numbers should be compared with an overall UK requirement for ~15Gt storage over the next 100 years.

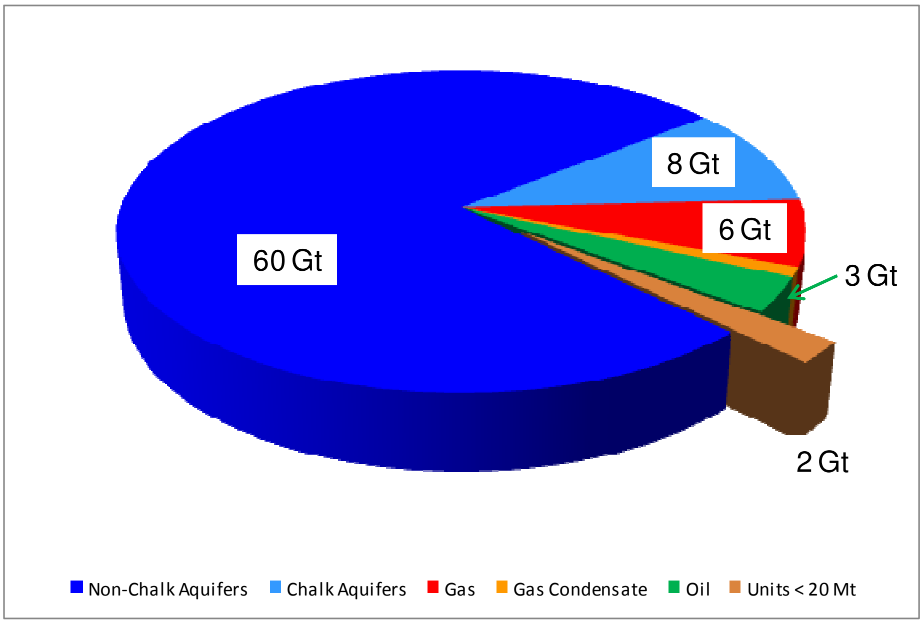

Figure 1: Overall UK CO2 Storage Capacity in Offshore Geological Formations (P50)

2. Storage Characteristics

- 'Saline Aquifers' fall into three broad subcategories:
    - Pressure cells (i.e. closed boxes). For these, the storage capacity is determined by considering how much CO_2 can be injected before the pressure rises to a level where there is a risk of breaching the seal;
    - Aquifers with structural 'traps' (e.g. the Bunter Domes in the Southern North Sea). The storage capacity is determined by considering how much of the (buoyant) CO_2 can be injected before 'spilling' out of the trap;
    - Large open aquifers, without identified structures. Capacities have been determined through the dynamic simulation work which has provided estimates of how much CO_2 can be injected before significant migration over a large distance occurs. For such units, the criteria that define 'permanent and stable' storage will have a direct bearing on assessed capacity.
- The capacity of a unit can potentially be increased by use of engineering approaches (e.g. by producing water from a saline aquifer to relieve pressure build up or 'steer' the CO_2 plume). UKSAP has not considered such approaches, so the capacity figures quoted may be conservative.
- For depleted oil and gas reservoirs, storage capacity is determined on an 'in for out' basis, i.e. assuming that the volume of CO_2 injected is equal to the net volume of fluid produced (allowing for any water injection etc).
- The reliability or degree of confidence that may be placed in individual storage unit assessments varies according to the quality and quantity of information available. Through a shared, web-enabled database, guidance was provided to promote a consistent approach from all participant organisations and assessors. Information sources have been recorded and computational methods have been applied uniformly, dependent on the identified storage unit type. Thus the basis upon which each estimate of storage resource has been made may be fully understood, and an audit trail exists to support revision as new or additional data become available.
- For 'open' aquifer stores that rely on residual saturation trapping rather than structural confinement of injected CO_2, the combination of formation permeability, dip, and density difference between CO_2 and in-situ fluids has a key bearing on the technically accessible pore volume, and hence amount of CO_2 that may be securely stored.
- The degree to which the technically accessible storage resource may be practically utilised is influenced by achievable injection rates and the supply of CO_2. The former may be tackled by appropriate selection of injection well location, completion and/ or stimulation; the latter may involve CO_2 transport over considerable distances to match capture sources with available sinks, requiring careful planning of infrastructure.

3. Security of Storage and Economics

- All saline aquifer units have undergone a comprehensive security of storage assessment, taking into account containment issues (susceptibility to upward or lateral migration of CO_2 out of the storage volume) and operational issues (susceptibility to change in achievable storage capacity or injection rate). In the context of *overall* UK capacity, controls on lateral migration of CO_2 in 'open' aquifers were identified as important features, as were the density and vintage of existing well penetrations. All storage units have some risks associated with them, but all risk factors were assessed in terms of manageability.

- An assessment has been made of the economics of each storage unit. Key parameters affecting storage costs are:
    - Unit size;
    - Distance from shore;
    - Water depth;
    - Depth of storage unit below the seabed;
    - Number of wells required to achieve practical injection rates.

  Overall storage and offshore transport costs range from £4 – 40/tonne CO_2 stored for most of available storage capacity. These are undiscounted costs (i.e. do not take into account the average Weighted Average Cost of Capital, WACC). Costs are very sensitive to WACC. For example a WACC of 5% increases costs typically by around 50%: a WACC of 15% gives typically a threefold increase in costs.

4. Storage Development Pathways

- A total technically assessable capacity of around 8Gt has been identified for depleted oil and gas reservoirs (excluding small < 20Mt stores). In practice not all of this will be practically or economically useable. Based on (confidential) DECC data on close of production of these assets, CO_2 storage capacity is likely to become available on an approximately linear basis between now and 2030.
- Based on ESME pathway analysis to 2050, 2Gt storage needs to be available by 2020, rising to 5 – 7 Gt in 2030 and 6 – 8 Gt by 2050 (assuming new assets will require identified storage for 25 - 40 years operation before commitments are made). This cannot be satisfied solely by depleted oil and gas reservoirs, but could be through (in addition) use of a small number of high capacity, low risk saline aquifers (e.g. a number of the 'Bunter Domes'). This is illustrated schematically in Figure 2.
- Initial analysis of the UKSAP database indicates that commitments to store CO_2 in high security of storage saline aquifers will need to be made during the large scale roll out of CCS in the early/mid 2020s. Given the time required for appraisal of such storage units, the UK needs to start appraising one or more representative aquifers in the very near future, leading to test injection of CO_2, to ensure requirements in the 2020s can be met.
- Further insights into storage characterisation, the balance between depleted oil & gas reservoirs and saline aquifers and development pathways for the CCS storage system will be gained in a follow-up Flexible Research Project, approved by the Technical Committee in July 2011.

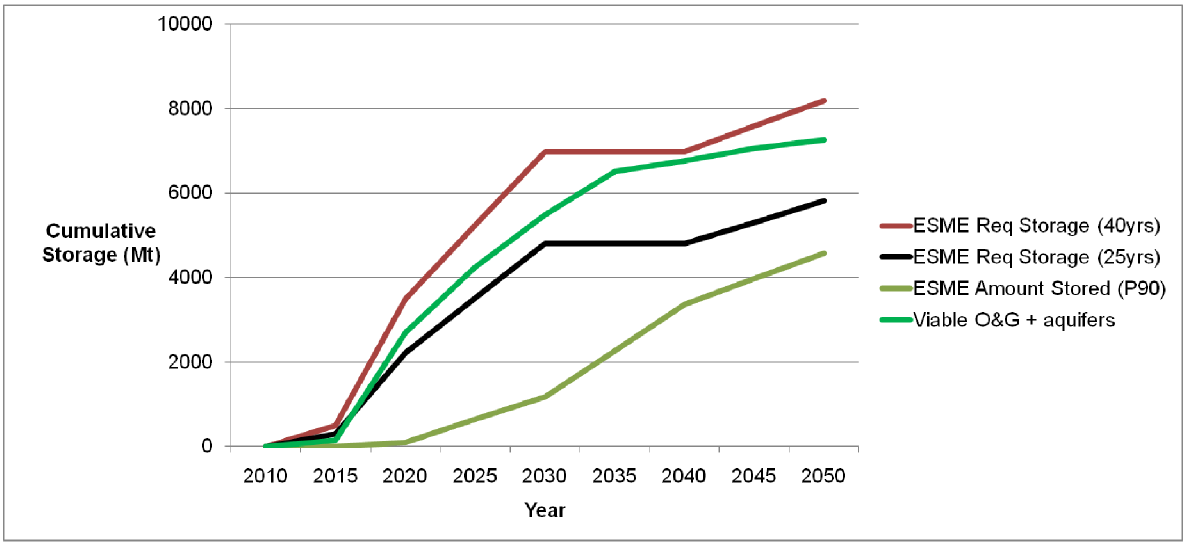

Figure 2 Storage requirements and availability (illustrative only)

Notes on Figure 2:

- Requirements based on ESME modelling (July 2011). Pathway analysis was used to estimate decadal profile, but full simulation for 2050 figure is adopted. The ESME Required Storage (black and red lines) is estimated as the sum of actual storage used to date plus either 25 or 40 years storage for last ten years deployment. Figures are based on ESME P_{90} requirements
- ESME amount stored (dark green line) is the actual amount of CO_2 which will have been stored by that year (ESME P_{90} scenario)
- The bright green line provides a potential scenario for available storage. This is based on an estimate of 'viable' oil and gas reservoirs becoming available within 5 years of predicted close of production (based on confidential DECC Close of Production data) plus 1,500 Mt appraised aquifer storage available by 2020 rising to 2,700 Mt by 2050.

5. Future Opportunities

- The UKSAP results provide a high level of confidence that the UK will have sufficient capacity to store its emissions for at least the next 100 years.
- UKSAP has identified some 60 Gt of technically accessible storage capacity over and above UK requirements. Some of this capacity is unlikely to be practically usable (e.g. there are particular concerns about the ability to inject into the chalk aquifers). Other capacity may have unacceptable risks and economics based on current knowledge and understanding. However, drawing parallels with oil and gas production experience, it is likely that other units will prove to offer greater storage than initially thought, perhaps because of better quality, more extensive reservoirs or as a result of advances in technology. Hence it is likely that the UK sector will have sufficient capacity to offer storage for other countries.

Further work

Dissemination

A dissemination plan has been produced and agreed with the PMB (see PMB/2011/08/02).

Further Projects

A follow on project is being commissioned to gain further insights from the UKSAP database and to develop enhanced economic modelling tools to support roll out of CCS in the UK.

ETI Strategy is currently working up potential future activities relating to strategic appraisal of aquifers to meet UK needs.

Project Exploitation

In addition to the proposed dissemination activities and further projects, a key exploitation route is through making the WDG available to stakeholders. A Request for Proposals has been launched to select a future host for the WDG. Handover is expected in April 2012.