Assessing interactions between multiple geological CO_2 storage sites to optimise capacity in regionally extensive storage sandstones

M C Akhurst[1], T Mallows[2], J M Pearce[3] and E Mackay[4]

[1]British Geological Survey, Edinburgh, UK
[2]The Crown Estate, Edinburgh, UK
[3]British Geological Survey, Keyworth, Nottingham, UK
[4]Heriot-Watt University, Edinburgh, UK

The potential resource for carbon dioxide (CO_2) storage in strata underlying the North Sea is mostly within brine-saturated sandstone formations which are each hundreds to thousands of square kilometres in extent. The immense potential to store CO_2 in these rocks can only be fully achieved by the operation of more than one injection site within each formation.

Here we describe an investigation by the CO_2MultiStore project (SCCS, 2015) into issues arising from the operation of more than one injection site within a storage formation. The Captain Sandstone including the Goldeneye Field, the planned storage site for the Peterhead CCS project, was selected as a UK North Sea case study.

The UK case study anticipates two injection sites operating within a multi-user storage sandstone. A scenario comprising an initial project storing in a depleted hydrocarbon field followed by a second injection site within the surrounding saline aquifer was investigated by predictive modelling. Requirements for a plan to monitor a multi-user store, based on the prediction of storage site performance, were also developed.

Generic learning applicable to any multi-user storage sandstone was gained, from the process followed and the technical knowledge acquired, on characterisation of extensive sandstone formations, management of the planned injection operations and monitoring planning.

Key findings obtained from across the research, or those that have a regional perspective, are:

1. Development of a single predictive model for both injection projects and integration of any existing hydrocarbon field or regional models should be considered to assess interactions within a multi-user CO_2 store.
2. Access to field production data, where hydrocarbon fields are present within or adjacent to a multi-user store, is essential to validate the predictive site performance models and to inform monitoring planning. Access to such data by participation of the field operator in the storage project or via an independent third party should be arranged. Ideally, a field history database across all fields in a hydrocarbon province would inform the appraisal of fields for re-use as CO_2 stores.

3. Integrated working between all of the disciplines, including geological ‘static’ and geomechanical stability modelling and ‘dynamic’ simulation of CO_2 injection, is essential when appraising a multi-user store. This supports appraisal of any interaction of one site on another and to allow the implications of the results of one predictive modelling discipline to be assessed by other disciplines.
4. The effect of the ‘footprint’ of increased pressure from a later injection prospect on an existing injection site with the interaction and cumulative effect of two (or more) sites must remain within the maximum acceptable pressure at both sites. Interaction of pressure changes may occur even though the CO_2 may not migrate between injection sites.
5. Accurate prediction and active monitoring of the pressure response from multiple injections is identified as being the single most important tool for indicating site performance in the scenarios investigated by the case study. Extended baseline monitoring observations for a later-implemented site will be needed to define appropriate pressure thresholds which determine the storage capacity for follow-on injection sites in a multi-user store.
6. A regional, basin-scale approach must be taken if a multi-user store is being assessed and all strata that have connected pore space must be considered. Even very modest fluid conductivity in the underlying rock formations can have a beneficial cumulative impact over large areas, such as in a multi-store scenario, in dissipating pressure.
7. Where there is more than one CO_2 injection site in a multi-user store the connection and transmission of changes in pressure due to site operations, must be considered both in their extent and over time. While pressure fluctuations travel quickly over tens of kilometres, the full pressure impact of CO_2 injection in one site will not immediately be observed at another site. The duration and timing of the components of a multi-user store must be fully anticipated, so that impacts of the follow-on injection site on an existing site can be predicted and assessed. Operators of second and subsequent sites should consider how soon they need to commence injection, after start of operation of the first site, to achieve their required maximum storage capacity.
8. To optimise the CO_2 storage capacity of an extensive sandstone formation it is sensible to plan as a multi-user site. Additional monitoring infrastructure may be cost effective to optimise storage capacity if a regional approach is taken. Multiple iterations of storage scenarios should be modelled to optimise capacity by different injection scenarios. Resource-effective assessment of the predicted pressure effect for a multi-user store can be achieved using simplified basin-scale models. Pressure prediction using a simplified regional-scale model was found to be sufficient to inform a prospective storage site operator and the permitting authorities of the overall performance of a formation for CO_2 injection before undertaking more detailed site characterisation modelling.

SCCS, 2015. Optimising CO_2 storage in geological formations; a case study offshore Scotland.
www.sccs.org.uk/images/expertise/reports/co2multistore/SCCS-CO2-MULTISTORE-Report.pdf