Progress with the UK Carbon Capture and Storage Consortium

Jon Gibbins

“Mechanical Engineering Department, Imperial College, Exhibition Road, London, SW7 2AZ, UK

Abstract

The UK carbon capture and storage consortium (UKCCSC) is a £2M multidisciplinary project involving academics from 15 universities and research institutes in the UK. The project has sought to improve understanding of CCS with a UK perspective in a global context. This paper outlines the broad range of activities undertaken by the consortium, including science and engineering achievements, contributions to the ongoing policy debate and capacity building.

Keywords: CCS, CO2 capture, CO2 transport, CO2 storage, environmental impacts, incentive mechanisms, media tracking

1. Introduction

The UK carbon capture and storage consortium (UKCCSC) is a £2M multidisciplinary project involving academics from 15 universities and research institutes in the UK. A list of selected senior researchers is included as Appendix A. Its mission is to promote an understanding of how options for decoupling fossil fuel use from carbon emissions through the use of carbon capture and storage (CCS) could be used to assist the UK in achieving an energy system which is environmentally sustainable, socially acceptable and meets energy needs securely and affordably. Since UKCCSC work started in summer 2005, project participants have contributed to a number of Government reviews and public outreach events, in addition to completing a broad research programme, illustrated in Figure 1, including:

- engineering of CO2 capture systems and pipelines,
- improved understanding of geology for CO2 storage,
- underpinning science and life cycle analysis to understand potential environmental impacts,
- exploration of CCS economics including novel support mechanisms, and
- media tracking and other social science-led work

This paper will highlight some of the research results obtained by work completed in the past three years and provide an overview of some of UKCCSC’s key contributions to the ongoing political and public debate on the potential for CCS in the UK and elsewhere. Projects in UKCCSC have included both detailed studies in single disciplines and interdisciplinary work. This mixture of activities undertaken has helped to develop a university R&D community in the UK with a broad understanding of the complex issues involved in developing and deploying CCS in the UK. Some capacity building aspects of UKCCSC’s work are also discussed.

2. CO2 capture and transport science and engineering

Science and engineering of CO2 capture transport and engineering played an important role within theme A of UKCCSC. Some practical work drew on expertise developing novel CO2 capture techniques including laboratory development and testing of PEI adsorbents at Nottingham University [1] and pilot scale development of lime carbonation/calcinations cycles at Cranfield University [2]. Imperial College contributed expertise on CO2 capture systems closer to commercial deployment including initial development of concepts for flexible operation of coal-fired power plants with post-combustion capture [3].

One research highlight in this area has been the development of concepts for capture-ready steam turbines [4,5] which contributed to an IEA Greenhouse Gas R&D Programme (IEA GHG) study on capture-ready power plants [6] that is likely to be a significant benchmarking document for developing capture-ready principles to guide, e.g. [7].

UKCCSC work on CO2 transport has also been recognised as internationally leading with Patricia Seevam being awarded best paper awards at international conferences for her work developing CO2 transport modelling capabilities at the University of Newcastle, e.g. [8]. Research at the University of Newcastle has also demonstrated the value of developing good working relationships with industry and working across national boundaries to inform and focus some academic work, including collaborative work with US, French and Norwegian companies.

3. CO2 storage science and engineering

The UKCCSC theme focussing on science and engineering for CO2 storage was the largest, covering a wide range of experimental and theoretical work under the broad themes of:

- CO2 storage integrity;
- UK hydrocarbon fields and added value from CO2; and
- UK offshore and onshore aquifers: injectivity and storage volumes

Work on CO2 storage integrity included permeability modelling [9] and field studies of natural analogues including improving understanding of noble gas chemistry in CO2 reservoirs [10]. A range of activities exploring geochemical responses to storage and improving geophysical monitoring were also included in this theme with expertise drawn from the British Geological Survey, Bristol University, University of Cambridge and University of Leeds, e.g. [11].

Technical work on UK hydrocarbon fields and added value from CO2 considered near-field and reservoir characterisation, subsurface flow modelling, phase behaviour and injectivity for CO2/EOR processes. For example, Heriot Watt University have developed their expertise in modelling reservoir management [12] and Imperial College...
have continued to develop techniques for both pore-scale and streamline-based modelling of CO2 storage [13, 14].

British Geological Survey and the University of Edinburgh were the main contributors to the work on aquifer injectivity and storage prospectivity, which has already led to a more detailed project, involving 5 industry partners and 4 academic institutions, carrying out the first methodological investigation to explore for saline aquifer sites close to coal fired power plant in the UK [15]. This work has also been linked to continued development of a GIS (geographic information system) developed and maintained by the British Geological Survey [16].

4. CCS and the environment

Some UKCCSC participants have focussed on improving the understanding of potential environmental impacts of CCS, both in developing the environmental science base required for accurate risk assessment of proposed CCS projects and contributing to the currently limited literature on lifecycle analysis (LCA) of CCS. The LCA work carried out by Odeh and Cockerill [17,18] was closely linked to the CO2 capture and transport engineering activities and, hence, was included within theme A while other activities in this area formed UKCCSC theme C.

Since it is expected that the majority of UK CO2 storage will occur in geological formations underneath the North Sea, it is particularly important to develop a good understanding of the potential impact of leaks into the marine environment. Plymouth Marine Laboratory have considered several aspects of the required risk analysis including by:

- modelling the likely environmental perturbation that could arise from a failure of geological storage schemes under the North Sea using a marine system model of the North West European shelf [19]; and
- carrying out a series of mesocosm experiments, to assess the direct (e.g. changing seawater pH) and indirect (e.g. exposure to other contaminants) of CO2 leakage for key sediment dwelling organisms and biogeochemical processes [20,21].

Complimentary work on the potential for onshore leaks of CO2 to have an environmental impact on the terrestrial environment was carried out at the Artificial Soil Gassing and Response Detection (ASGARD) facility at the University of Nottingham [22]. This experimental facility has been used to carry out initial experiments on pasture grass, spring barley and linseed with a measurement programme that includes routine gas analysis, growth samples and regular monitoring of spectral reflectance.

5. Social processes in relation to CCS and other social-science led work

The University of Aberdeen has provided economic expertise within UKCCSC with contributions planned in themes A and B. A series of research papers have been produced including a detailed examination on the potential use of long term option contracts for regulating CO2 emissions [23]. This work is one example of UKCCSC work that has been used to inform the ongoing policy development process since it has informed discussions with both UK and Scottish Government (see Section 6 for further examples of stakeholder engagement).

Other social-science led work in UKCCSC includes ongoing work on tracking media coverage of CCS, developing improved understanding of potential business models for CCS projects. For example, the University of Cambridge has reported results of a survey of public communications activities for CCS technologies [24] and a road map for CCS development in the UK has been developed in close collaboration with UK Energy Research Centre activities on CCS [25].
6. Stakeholder engagement and dissemination

Stakeholder engagement and dissemination within UKCCSC has used a wide variety of routes. For example, theme A held a one-off stakeholder workshop to review interim results and identify priorities for future work and theme C activities were discussed with an established reference user group including representatives from industry, regulators and non-Governmental organisations.

One strength of UKCCSC has been its ability to deliver publications and advice drawing on perspectives from more than one discipline. For example, a paper on the scope for future CO2 emission reductions from electricity generation through the deployment of CCS technologies was presented at a conference organised to shape the agenda for the UK G8 Presidency in 2005 [26]. UKCCSC has also submitted written and oral evidence to a number of UK and Scottish Government consultations on and reviews of CCS in the UK including a 2005 review by the House of Commons Science and Technology Committee [27] and provided expert advice to policy-makers during negotiations to amend the London and OSPAR treaties.

UKCCSC academics have also been active in international, particularly European, policy developments. Gibbins and Chalmers work on potential timing for CCS demonstration and deployment [28] was cited in the impact assessment for the 2008 European Commission draft directive on geological storage of CO2 [29]. In addition, two academics from Newcastle University (Downie and Race) sat on EU Zero Emissions Technology Platform committees. Another successful example of collaboration was a seminar organised in collaboration with the science department of the French Embassy in London which was attended by around 120 people.

Stakeholder engagement activities have also included presentations to industry focus groups, detailed discussions with a range of non-Governmental organisations and a sustained input to news (and other) media. For example, researchers at Edinburgh University were commissioned by WWF-UK and Policy Exchange to inform their work on CCS [31,32] and Imperial College contributed to a recent series of essays produced by Green Alliance to inform current discussions on the future of coal-fired power plants in Europe [33]. Media contributions have included regular quotes by a number of UKCCS members in newspaper, radio and television news as well as contributions to series such as Radio 4’s 2006 series on Britain’s Modern Brunels [34] and group letters on major topics.

7. Capacity building

Since it involved a wide range of institutions, UKCCSC has provided a valuable opportunity to develop an integrated understanding of CCS within the UK academic community and project participants have heard regular reports from all disciplines as part of their attendance at 6-monthly progress meetings. Many of the researchers involved in UKCCSC have also used this project to begin to develop further expertise in CCS and early career researchers (PhD students and early post-docs) have been encouraged to participate fully in project meetings, often presenting their work to the group. The UKCCSC network also made a valuable contribution to UK Energy Research Centre activities mapping CCS activities in the UK [35].

As UKCCSC enters its final phases funding for CCS research in the UK is growing and being delivered through a much larger number of consortia and individual institution grants. While highly desirable, a significant challenge now is reshaping the UK CCS R&D landscape so that the inter-disciplinary ties that have been developed in UKCCSC can be maintained and new researchers beginning to work in CCS in the UK can be supported (both experienced researchers transferring skills developed in other fields and early career researchers who are new to research as well as CCS). It is not yet clear what the final outcome will be, but it is hoped that a workshop organised by UKCCSC in conjunction with the UK Research Councils in early 2008 attended by ~50 academics (~1/3 not in original consortium) and ~15 invited stakeholders will provide useful inputs to this ongoing process. A detailed research agenda for academic CCS arising from this meeting, including outline proposal descriptions and possible consortia, has been circulated to the Research Councils, other funding bodies and industry to demonstrate
the needs and capacity of the UK academic CCS research community.

8. Conclusions

The UK Carbon Capture and Storage Consortium (UKCCSC) is a £2M multidisciplinary project involving academics from 15 universities and research institutes in the UK. It was established with the aim of promoting an understanding of how options for decoupling fossil fuel use from carbon emissions through the use of CCS could be used to assist the UK in achieving an energy system which is environmentally sustainable, socially acceptable and meets energy needs securely and affordably. The multi-disciplinary programme has produced a diverse range of research outputs and helped to develop an integrated CCS R&D community in the UK. In addition to traditional academic contributions, UKCCSC participants have made significant contributions to ongoing policy developments related to CCS in response to a number of requests for academic participation. Capacity building has also been encouraged by the involvement of groups new to CCS and active engagement of early career researchers in most, if not all, UKCCSC activities.

Acknowledgements

Financial support for the UK Carbon Capture and Storage Consortium was provided by the Natural Environment Research Council, Engineering and Physical Sciences Research Council and Economic and Social Research Council through the Towards a Sustainable Energy Economy (TSEC) programme. The assistance of UKCCSC members in preparing material and of Ms H. Chalmers in collating and organising it for this paper is gratefully acknowledged. Mentoring from Philip Sharman and Rae Mackay is gratefully acknowledged and guidance from Chris Baker at NERC.

References

23. A.G. Kemp and J. Swoerzbinski, Long-Term Option Contracts for Carbon Emission North Sea Study Occasional Paper 105, ISSN 0143-022X
Appendix A. UKCCSC senior researchers

This table focuses on senior researchers who led activities but the consortium involved inputs from wide a range of other researchers including students, other early career researchers and other senior researchers.

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alex Kemp</td>
<td>Aberdeen</td>
</tr>
<tr>
<td>Mike Kendall</td>
<td>Bristol</td>
</tr>
<tr>
<td>Andy Chadwick</td>
<td>British Geological Survey</td>
</tr>
<tr>
<td>Sam Holloway</td>
<td>British Geological Survey</td>
</tr>
<tr>
<td>Jonathan Pearce</td>
<td>British Geological Survey</td>
</tr>
<tr>
<td>Mike Bickle</td>
<td>Cambridge</td>
</tr>
<tr>
<td>David Reiner</td>
<td>Cambridge</td>
</tr>
<tr>
<td>Adina Bosoaga</td>
<td>Cranfield (now non-academic)</td>
</tr>
<tr>
<td>John Oakey</td>
<td>Cranfield</td>
</tr>
<tr>
<td>Stuart Haszeldine</td>
<td>Edinburgh</td>
</tr>
<tr>
<td>Mark Wilkinson</td>
<td>Edinburgh</td>
</tr>
<tr>
<td>Zoe Shipton</td>
<td>Glasgow</td>
</tr>
<tr>
<td>Patrick Corbett</td>
<td>Heriot Watt</td>
</tr>
<tr>
<td>Mehran Sohrabi</td>
<td>Heriot Watt</td>
</tr>
<tr>
<td>Martin Blunt</td>
<td>Imperial College London</td>
</tr>
<tr>
<td>Amparo Galindo</td>
<td>Imperial College London</td>
</tr>
<tr>
<td>Jon Gibbins</td>
<td>Imperial College London</td>
</tr>
<tr>
<td>Geoff Maitland</td>
<td>Imperial College London</td>
</tr>
<tr>
<td>Quentin Fisher</td>
<td>Leeds</td>
</tr>
<tr>
<td>Bruce Yardley</td>
<td>Leeds</td>
</tr>
<tr>
<td>Clair Gough</td>
<td>Manchester</td>
</tr>
<tr>
<td>Sarah Mander</td>
<td>Manchester</td>
</tr>
<tr>
<td>Andy Aplin</td>
<td>Newcastle</td>
</tr>
<tr>
<td>Martin Downie</td>
<td>Newcastle</td>
</tr>
<tr>
<td>Kuncho Kurtev</td>
<td>Newcastle</td>
</tr>
<tr>
<td>Julia Race</td>
<td>Newcastle</td>
</tr>
<tr>
<td>Jeremy Colls</td>
<td>Nottingham</td>
</tr>
<tr>
<td>Trevor Drage</td>
<td>Nottingham</td>
</tr>
<tr>
<td>Mike George</td>
<td>Nottingham</td>
</tr>
<tr>
<td>Colin Snape</td>
<td>Nottingham</td>
</tr>
<tr>
<td>Jerry Blackford</td>
<td>Plymouth Marine Laboratory</td>
</tr>
<tr>
<td>Carol Turley</td>
<td>Plymouth Marine Laboratory</td>
</tr>
<tr>
<td>Steve Widdicome</td>
<td>Plymouth Marine Laboratory</td>
</tr>
<tr>
<td>Tim Cockerill</td>
<td>Reading (now Imperial College)</td>
</tr>
</tbody>
</table>