CCS Technical Status Brief – October 2016

The IEA Greenhouse Gas R&D Programme (IEAGHG) is part of the IEA's Energy Technology Network and its role is to assess the potential to mitigate greenhouse gas (GHG) emissions from the use of fossil fuels in the power, oil and gas and industry sectors. The IEAGHG's remit covers all greenhouse gases but we focus on research activities primarily on assessing CO_2 mitigation options. Of the CO_2 mitigation options, Carbon Capture and Storage (CCS) is considered to offer the most potential for CO_2 mitigation from the use of fossil fuels across the sectors we consider. Further details of the activities of the IEA Greenhouse Gas R&D Programme can be found on our website at **www.ieaghg.org**.

This CCS Technical Status brief has been prepared to summarise key technical developments on CCS in the last 6 months, identified by IEAGHG providing information for both its members and the broader community. The IEAGHG provides reports and webinars, those directly relevant to this brief are referenced at the end of the document.

Key Demonstration Project Achievements

Four of the on-going CCS demonstration projects reached significant operational milestones in this half of the year. The Boundary Dam 3 CCS project which has now been operating for 2 years, captured their millionth tonne of CO_2 on 20th July[1]. The Quest project in Canada in its first year of trouble free operation also has captured and injected 1 MT/CO_2 into a deep saline aquifer on shore[2]. The Air Products CCS Demonstration Project in Texas, USA has been operating successfully for some 3 years and has captured and exported 3Mt of CO_2 for CO_2-EOR operations3. Last but not least the world's first commercial CCS demonstration project Sleipner has now completed 20 years of continuous operation and has stored some 16Mt/CO_2[4].

UK CCS Competition Reviewed

The UK CCS competition did not proceed, however an analysis of the competition findings has been completed[5,6]. The clear message from this analysis was that there were no technical barriers that would have prevented either project (Peterhead and White Rose) proceeding. The issues that were identified as to why the programme did not work were: the business model design and financial issues along with Government policy changes. One important recommendation is that dissembling the full chain CCS model might be more effective for early projects but might require Government investment on the storage and transport aspects.

Norwegian Developments on CCS

After undertaking preliminary studies the Norwegian Government has announced plans for 3 FEED studies on industrial CCS projects[7]. The projects will consider the potential for CCS on an ammonia fertiliser plant, a cement plant and a waste to energy facility. The FEED studies, will be complete by 2019, then a final investment decision will be made with the intent that at least one project is to be operational by 2022. These projects are unique in that they assess the potential for CCS in three new industrial sectors to those where projects are already underway. They will also provide valuable insights for those considering industrial CCS projects in other countries.

The Tomakomai CCS Project in Japan began injecting CO_2 (100kT/y) in April 2016 into a deep saline aquifer[8]. The CO_2 from the gas stream from the hydrogen production unit at the Tomakomai refinery is using a unique two-stage capture system including pressure swing absorption. The two injection wells are both onshore, and deviate to inject offshore, with well lengths of 3.6km and 5.8km. Injection will continue to 2018 with post injection monitoring running for a further two years. There is an intensive monitoring strategy and uniquely, as part of the public engagement campaign, monitoring data being shared in real-time at the City Hall. With onshore capture and injection and offshore storage, this project is demonstrating a new configuration for CCS projects and is addressing some regulatory challenges from complex environmental baselines offshore.

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Residual Emissions from CCS Plants

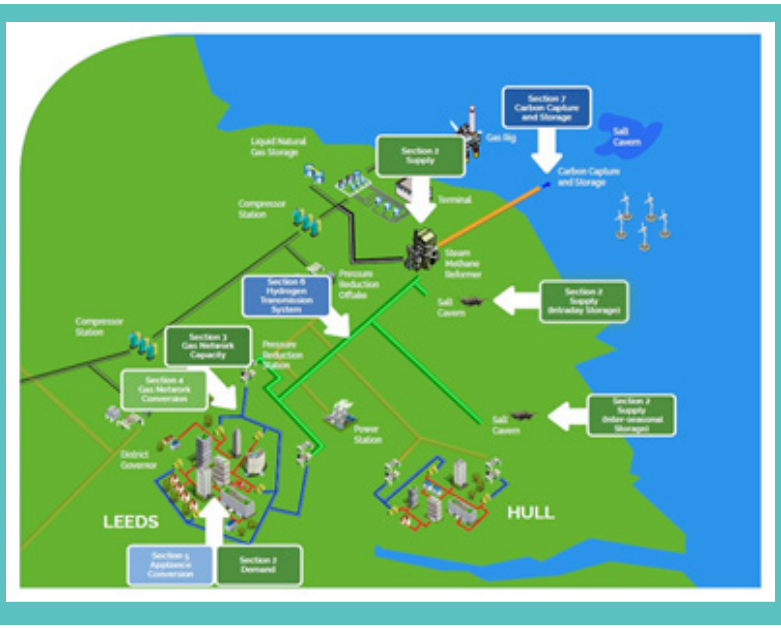
IEAGHG's work on the issue of greenhouse gases emitted from fossil fuel use in future years under a limited 'carbon budget' has suggested that residual emissions from CCS projects could be an important issue for consideration going forward[9]. Currently capture plants are being designed to capture 85 to 90% of the emitted CO_2. In future we need to look at capture rates of up to 100%. This is technically feasible but this needs to be achieved without increasing the cost of the capture island and hence the whole CCS plant. This issue will be the subject of new research in the coming years.

Post Combustion Capture (PCC) System Process Control

Electricity market models suggest power plants with CCS will need to adopt flexible operation in the future. Appropriate control strategies will therefore be needed to ensure the ability of CCS plants to operate in such a market and be profitable. IEAGHG has completed an evaluation of process control strategies for normal, flexible and upset conditions of PCC processes based on amine scrubbing. The work showed the performance of the CO_2 capture unit can be maintained even during periods of significant load fluctuation, using industry standard control techniques, thus avoiding other more expensive solutions[10].

CCS in the Domestic Heating Sector

The unique H21 Leeds City Gate project involves the roll out of hydrogen as a domestic heating fuel (replacing natural gas) for a city of 800,000 people in the UK and a new opportunity for CCS deployment[11]. The project also involves the production of hydrogen using Steam Methane Reforming (the same technology used at the Air Products Project in Texas, USA) and capture and storage of the CO_2 offshore. The SMR's will be sited at Teesside, an industrial centre in the UK and a proposed as a hub for CO_2 transport offshore[12]. The project is expected to store 1.5Mt CO_2 per annum off shore, with net savings for the region of 927,000 t per year from the domestic heating sector.



Geological Storage Assessments

Assessing a country or regions geological storage capacity is an important requirement to assess whether CCS deployment is feasible in the country/region. To advance our learnings from the geological storage assessments completed to date a survey of 15 countries who had completed national CSLF-methodology 'theoretical' storage capacity assessments has been undertaken[13]. In all cases the initial estimates were sufficient to allow policymakers to make informed decisions about priorities for follow-up actions. **Guidelines for Geological Storage Assessments** – As a follow on activity to the survey above and to help facilitate the development of geological storage assessments particularly in developing countries IEAGHG has used the knowledge base from the study to develop a set of guidelines for those countries thinking of undertaking a geological storage assessment[14].

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Offshore Geological Storage

Globally the largest geological storage resource is offshore. A workshop to assess the global needs for offshore geological CO_2 storage has been held with the aim of building an international community of parties interested in offshore storage. The workshop found that there was common recognition that there is a nexus of interests and needs converging in progressing CCS offshore, and that momentum was being created towards international collaboration, not just in knowledge-sharing, but towards developing pilot and demonstration projects[15].

CCS Project Permitting Under the London Protocol

The injection of CO_2 under the sea bed is governed under the Protocol. The Protocol's *Guidelines for Assessment of Carbon Dioxide Streams for Disposal into Sub-seabed Geological Formations* were developed to allow countries to assess permit applications for projects in their territorial waters. One permit has been approved to date for the ROAD Project in the Netherlands. To assist other countries considering permit applications IEAGHG under took a review of the ROAD permit. Overall, this exercise demonstrated that the requirements of the CO_2 Specific Guidelines are relevant and achievable by national regulators and CCS projects, and that transparency of compliance assessment is possible[16].

Using the modelling-monitoring loop to demonstrate storage performance more effectively

Key findings from the recent Monitoring Network and Modelling Network meeting in Edinburgh showed that good progress is being made with learning from the demonstration and pilot projects in both monitoring and modelling which is then able to be shared with the international community at these meetings, and that there is progress in streamlining MMV at large-scale projects and so reducing the costs of monitoring. We now have several sites demonstrating conformance of the modelling-monitoring loop, so that the understanding of conformance is becoming more mature[17].

Review of GHG Accounting Rules for CCS

There is ongoing work around the world in emissions accounting for CCS, such as in ISO, which IEAGHG has helped inform by reviewing twelve GHG accounting schemes and nine CCS-specific accounting schemes[18]. It was found that existing GHG accounting rules do account for emissions and emissions reductions associated with 'standard' CCS projects. Some specific gaps, challenges and issues arise however when considering the following 'special cases' which include: recognition of negative emissions from bio-CCS, accounting for CO_2-EOR and accounting for CO_2 utilisation. These three areas require further consideration.

First MRV plan approved by a Regulator

In December 2015 the US EPA gave its approval for the first monitoring, reporting and verification (MRV) plan for a project under the US greenhouse gas reporting rule for CO_2 geological storage. The project is the Occidental Permian Ltd's (Oxy) Denver Unit CO_2-EOR operation in West Texas. The plan sets an important precedents for the level of information and detail that will be required in the USA for greenhouse gas reporting from CO_2 geological storage projects[19].

Utilisation opens new opportunities for capture demonstration

In a unique development Toshiba have begun operation in August 2016 of a 10tpd CO_2 capture facility at the Waste to Energy (WtE) Plant in Takagise Town, Saga City, Japan. This unique development is the first deployment of CCS in the WtE sector. The captured CO_2 is sold to an algae cultivation business. The algae are used as the raw material to produce cosmetics and nutritional supplements another unique feature of the project[20].

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Further Reading

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2. http://www.news1130.com/2016/09/14/shell-says-quest-project-has-captured-a-million-tonnes-of-co2-in-the-oilsands/
3. http://energy.gov/fe/articles/texas-co2-capture-demonstration-project-hits-three-million-metric-ton-milestone
4. http://www.ccsassociation.org/news-and-events/ccsa-past-events/ccs-post-paris-realising-global-ambitions-29th-june-2016/
5. IEAGHG Information Paper IEAGHG Information Paper: 2016-IP21; Lessons Learned from UK CCS Programmes, 2008 – 2015
6. CCSA Report: Lessons Learned - Lessons and Evidence Derived from UK CCS Programmes, 2008 – 2015
7. http://bellona.org/news/ccs/2016-09-norway-breaks-vicious-cycle-of-inaction-on-ccs-deployment-with-concrete-plans-for-industry
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9. IEAGHG Report no 20126/05, Can CO_2 capture and storage unlock 'unburnable carbon', May 2016,
10. IEAGHG Report NO. 2016/07, Evaluation of Process Control Strategies for Normal, Flexible and Upset Operation Conditions of CO_2 Post Combustion Capture, October 2016
11. IEAGHG Information Paper: 2016-IP22; Leeds City Hydrogen Project: A new opportunity for CCS in the heat market
12. http://www.ieaghg.org/about-us/49-publications/technical-reports/572-2015-03-ccs-cluster-projects
13. IEAGHG Technical Review 2016/TR1, Evaluation of Barriers to National Geological Storage Assessments, February 2016
14. IEAGHG Technical Review 2016/TR6, National CO_2 Storage Assessment Guidance, October 2016
15. IEAGHG Technical Review, 2016/TR2, International Workshop on Offshore Geological Storage, May 2016,
16. IEAGHG Technical Review, 2016 TR4, Review of project permits under the London Protocol – An assessment of the proposed P18-4 CO_2 storage site, May 2016
17. IEAGHG Technical Report No. 2016/08, Summary report of the Risk Management and Environmental Research Networks Combined Meeting
18. IEAGHG Technical Review TR3, Review of GHG Accounting Rules for CCS, May 2016
19. IEAGHG Information Paper: 2016-IP16; the first MRV plan approved by the US EPA for greenhouse gas reporting of CO_2 geological storage is for a CO_2-EOR operation.
20. IEAGHG Information Paper 2016/43, Waste Power CCU Project in Japan, October 2016