CCS Technical Status Brief - April 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.

The Paris Agreement and Outcomes for CCS

CCS did not feature strongly in the INDCs submitted by countries prior to COP21[1]. The mitigation measures in the INDCs cover the period up to 2030. In the period up to 2030, more CCS demonstration projects will come on line, mainly in industrial sectors which will contribute to a growing confidence in the technology that should assist future larger scale deployment. Also, in that period there will be a need to: develop next generation capture technologies that will drive down the cost of CCS, assess the geological storage resources around the globe, develop CO_2 utilisation as well as policies, develop the infrastructure for large scale deployment offshore in regions and approaches to facilitate take-up of CCS in industrial sectors. From 2030 onwards, CCS will become an increasingly important mitigation option as the need for increased action to mitigate emissions from fossil fuel power plants built before that date will be needed[2]. Negative emissions concepts, like bio-CCS, may well become increasingly important if early commitments to reduce greenhouse gas emissions are not met. The Mission Innovation initiative, launched at COP21 to accelerate R&D spend on low carbon technology, may offer an opportunity to accelerate the deployment of CCS.

New Opportunities for CCS Deployment

At COP21, the Asian Development Bank and the NDRC of China publically announced the release of a joint report on a Road Map for CCS Deployment in China[3]. This significant report assesses the potential, the barriers and the challenges in demonstrating and deploying CCS in China. For China, prior and up to 2030, CCS activities will focus on R&D and early deployment of industry sources from fertiliser/chemical and CTL (coal-to-liquid) plants coupled with CO_2-EOR. This represents a significant new early opportunity for CCS deployment in a new industrial sector. After 2030, CCS deployment in the power sector is envisaged.

CCS Demonstration in the Power Sector

In 2014, the SaskPower Boundary Dam 3 (BD3) power plant became the first power sector deployment of post combustion capture (PCC) at a commercial scale. The capture technology is the Shell Cansolv process. SaskPower and IEAGHG collaborated to produce a report that outlined the following: why CCS was the technology of choice, the planning/permitting/construction challenges faced and a review of the first year of operation. It provides a valuable reference resource for policy makers, project developers and academia alike[4,5]. One of the key messages from the report was the potential for future cost reduction identified (the potential to save up to 30% of the capital cost for future CCS projects has been identified) based on the experiences of building this first project.

In two related developments:

- The Shand Carbon Capture Test Facility (CCTF) at Estevan in Canada, began operation in autumn 2015[6]. After initial testing of their solvent, Hitachi Power Systems Ltd will hand the CCTF back to SaskPower who will then use it to test new capture developments that could be used in the future by the company. The CCTF will also be accessible to other technology developers to test their processes.
- SaskPower and BHP Billiton have signed an agreement to establish a CCS Global Consortium[7], to help accelerate development in carbon capture, by sharing its knowledge and experience from BD3. Further details are expected this year. IEAGHG has joined the consortium.

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In March 2016, an update on the status of the carbon capture process at SaskPower's BD3 CCS demonstration plant[8] showed that:

•For the first quarter of 2016, the overall reliability factor was 90 per cent,

•A total of 83,497 tonnes of carbon dioxide were captured in March 2016,

•A total of 217,000 tonnes have been captured so far this year,

The process is well on its way to meeting its 2016 target of 800,000 tonnes.

CCS Demonstration In Industry

The first deployment of CCS in the tar sands sector took place in November 2015 with the opening of the Shell Quest project[9],[10]. Quest captures 33% of the CO_2 emissions from Shell's Scotford Upgrader in Alberta, Canada. The CO_2 is transported through a 65-kilometre pipeline and injected 2km underground. It is novel in North America in that the CO_2 is injected into a deep saline formation and not used for CO_2-EOR. The project uses the Shell ADIP-X technology; an amine based capture technology designed for CO_2 removal from natural gas. Shell will share information about Quest's design/ processes and lessons learnt to help make CCS technologies more accessible and drive down costs of future projects.

Developments in Supercritical CO_2 Cycles

One of IEAGHG's core activities is to assess the potential of new technical development in the CCS area. A new technology that has gained considerable interest is that of Supercritical CO_2 or oxy fired combustion cycles. In these cycles, fuel gas is combusted at high pressure using high purity oxygen, moderated by recycled CO_2 and/or H_2O, and the resulting hot high pressure gas is expanded in a turbine to generate electricity. The IEAGHG's evaluation of this technology is that it shows considerable promise compared to conventional natural gas cycles with CCS[11]. Cycle efficiencies up to 55% were considered feasible with levelised costs of electricity (LCOE) of the order 84-95 €/MWh estimated. Such plants offer advantages in their compact size and also they can be net producers and not consumers of water. IEAGHG notes that in March 2016, NETPower (one of the developers of these supercritical CO_2 cycles IEAGHG evaluated in its study) began construction of a 50MWth plant that should demonstrate the key aspects of the technology. Commissioning is expected to begin in late 2016[12].

Developments on Oxy Combustion Capture

The IEAGHG's 5th Oxyfuel Combustion Research Network meeting was held in Wuhan, China in autumn 2015[10], [13]. The network visited the recently commissioned 35MWth oxyfuel combustion test facility at the Huazhong University of Science and Technology (HUST). IEAGHG notes that is similar in concept to the 30MWth oxy combustion, coal fired boiler at Vattenfall's Schwarze Pumpe plant in Germany. One unique feature of the HUST project is the demonstration of a 3 column air separation unit. Like the Vattenfall facility, the facility at HUST is expected to provide an important knowledge

base for the development of full scale demonstration of oxy combustion technology. The meeting focused on the presentation of the results from the Callide 30 MWth Oxyfuel retrofit Project in Australia[14]. The project was successfull and the technology is ready to move to the full commercial scale.

The Callide Oxyfuel Combustion Project achievements were:

- *An Excellent Safety and Environmental performance*
- *14,800 Generation hours with 10,200 hours of actual oxy-firing operation and 5,600 hours of CO_2 capture plant operation*
- *A boiler turn-down to 50% Load Factor was demonstrated*
- *> 95% capture of SO_x, NO_x, particulates and trace metals*
- *A high purity of CO_2 product (> 99.9%) was produced*
- *Successful injection of CO_2 from Callide Power Plant into the Paaratte Sandstone formation ~1400 m deep.*

Geological Storage Assessments

These are an essential element to confirm national and regional CO_2 storage potentials and give confidence that there is sufficient capacity to store CO_2. The IEAGHG has facilitated a study of the barriers to completing such assessments which typically can take 5 to 10 years to develop. Key barriers identified included: data availability, data quality (often due to the age of the available data), lack of industrial support and an absence of political and regulatory support for CCS in general; thus creating uncertainty for undertaking storage assessments. Countries like the USA, Canada, Norway and the UK have expertise in producing these assessments and in data management that can be used to help inform or provide examples to other countries. International co-operation built on this experience is an obvious route to improve and enhance national assessments[15],. This work will be reported to the Carbon Sequestration Leadership Forum (CSLF) in June 2016 for detailed consideration

Assessing the Risks of Offshore Storage

The IEAGHG recently organised a joint meeting of its Risk Management and Environmental Research Networks at the National Oceanography Centre (NOC) in Southampton, UK[16]. The meeting covered the latest developments in risk assessment methodologies, mitigation strategies and impacts of CO_2 in the ocean, amongst many others. The meeting concluded that the risk assessment for CO_2 geological storage is maturing, recognising that leaks from storage, if they occur, are likely to have low environmental impacts. Wellbore issues are still the predominant risk; an area of known (and improving?) technology solutions but more work to test and apply these was suggested.

Developments in Offshore Monitoring

The monitoring of the fate of injected CO_2 is important for assuring all parties of the safety of geological storage. A new IEAGHG report provides a comprehensive review of the status of monitoring technologies for offshore use[17]. It will act as a key reference for regulators, project developers and academics alike. Whilst there are currently only a few offshore CCS projects, interest is growing in countries like the USA and Mexico. This report provided input to a much larger report by the CSLF Task Force on Technical Barriers and R&D Opportunities for Offshore, Sub-Seabed Geologic Storage of Carbon Dioxide that was presented at the 6th CSLF[18]. The IEAGHG will use the report to update its online Monitoring Selection Tool[19]. This open access interactive tool has been created to identify and prioritise techniques that could form part of a monitoring programme. The tool aims to help users to design a monitoring programme to monitor a CO_2 storage project during all stages from site characterisation through to post-injection.

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Further Reading

1. IEAGHG Information Paper: 2015-IP24; INDC's and Implications for CCS, http://www.ieaghg.org/docs/General_Docs/Publications/Information_Papers/2015-IP24.pdf
2. IEAGHG webinar, a reflection on COP21 and Outcomes for CCS. https://www.youtube.com/watch?v=v7yXotkGn5w
3. http://www.adb.org/publications/roadmap-carbon-capture-and-storage-demonstration-and-deployment-prc
4. http://www.ieaghg.org/docs/General_Docs/Reports/2015-06.pdf
5. https://www.youtube.com/watch?v=JQcxy4hbet8
6. http://www.saskpowerccs.com/ccs-projects/shand-carbon-capture-test-facility/
7. http://www.saskpowerccs.com/consortium/
8. http://www.estevanmercury.ca/news/business-energy/strong-results-in-march-for-boundary-dam-1.2232571
9. http://www.shell.ca/en/aboutshell/our-business-tpkg/downstream/oil-sands/quest.html
10. http://www.ieaghg.org/docs/General_Docs/Newsletter/IEAGHG_Newsletter_December_2015_LR.pdf
11. https://www.youtube.com/watch?v=tCZRP9mZGe8&feature=youtu.be
12. https://netpower.com/news-posts/net-power-breaks-ground-on-demonstration-plant-for-worlds-first-emissions-free-low-cost-fossil-fuel-power-technology/
13. http://www.ieaghg.org/publications/blog
14. http://www.callideoxyfuel.com/what/callideoxyfuelproject.aspx
15. http://www.ieaghg.org/publications/2015-reports/49-publications/technical-reports/646-2016-tr1-evaluation-of-barriers-to-national-co2-geological-storage-assesments
16. http://www.ieaghg.org/publications/blog/119-meetings-and-conferences/613-risk-management-network-and-environment-research-network-combined-meeting-concludes
17. https://www.youtube.com/watch?v=Bj2Rl6g6JUk&feature=youtu.be
18. http://www.cslforum.org/meetings/riyadh2015/index.html
19. http://www.ieaghg.org/ccs-resources/monitoring-selection-tool1