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HSE Horizon Scanning

Carbon Capture and Storage

Issue

Status: Active monitoring

The health and safety implications of carbon capture and storage (CCS) in the UK.

Background

CCS is seen as being a key technology to help combat climate change. It is the process of capturing carbon dioxide (CO_2) produced as a result of burning fossil fuels either before or after combustion, then storing it deep underground.[1] The UK's Climate Change Act, imposes a legal obligation on future governments to cut carbon dioxide pollution by 80% or more by 2050.[2,3] CCS has the potential to help reach this target by capturing up to 95% of the CO_2 produced by coal and gas fired power stations.[4]

There are 3 stages of CCS: CO_2 capture, transport and storage.

Capture

At full sized plants there are 3 main ways to capture CO_2

- *Post-combustion*: CO_2 from the burnt fuel is captured chemically by an amine or ammonia solvent
- *Pre-combustion*: the fuel is gasified (if coal) or natural gas is chemically split to form hydrogen and CO_2[4]
- *Oxy-fuel combustion*: the fuel is burnt in almost pure oxygen producing large amounts of water vapour that needs removing before CO_2 capture can take place[5]

Transport

Captured and purified CO_2 will then require transportation to its storage location by pipelines. Although large ocean tankers have also been considered, there are practical constraints as to the capacity of any shipborne storage tanks. Such large amounts of CO_2 are produced that it would be impractical to move it as a gas so it would be converted into 'supercritical fluid' by applying high pressure; therefore it can be pumped like a liquid.[5]

Storage

Geological storage is considered the most viable and economically sound option, however other methods such as storage in the deep ocean or as a solid carbonate deposit have been suggested. There are 3 main geological storage methods[6]:

- Empty oil and gas fields, or those with dwindling reserves
- Deep saline aquifers (salt water underground within porous rock)
- Coal seams that cannot be mined (technology is at an early stage)

[1] http://www.hse.gov.uk/carboncapture/
[2] http://www.defra.gov.uk/environment/climatechange/uk/legislation/
[3] http://www.defra.gov.uk/environment/climatechange/uk/legislation/provisions.htm
[4] http://www.policyexchange.org.uk/Publications.aspx?id=625
[5] http://www.hse.gov.uk/consult/condocs/energyreview/energyreport.pdf
[6] http://www.parliament.uk/documents/upload/POSTpn238.pdf

CO_2 has been injected into depleted oil reserves to enhance oil recovery (EOR) for several decades and significant operational experience should be transferable to CCS. The UK oil and gas fields in the North Sea have large potential for storage.[6] Less is known about CO_2 storage in saline aquifers, but the Norwegian Sleipner project currently separates 1M tonnes of CO_2 a year from natural gas and stores it in a saline aquifer beneath the seabed, so knowledge is improving in this area.[5] Additionally geological storage of CO_2 has been occurring for a while at projects at Salah in Algeria and Weyburn in Canada.[5]

In November 2007 the Department for Business Enterprise and Regulatory Reform (BERR) set a competition to produce a full-scale demonstration of CCS, this project appears to be on track to be operational by 2014.[7] Three bidders have pre-qualified for the competition and HSE is collaborating closely with these and BERR throughout the project (this includes the condition that technical information must be provided to HSE by the winning entrant).[8] In September 2008 the world's first coal-fired CCS pilot power plant started operations in Spremberg, Germany. It is a 30 Megawatt oxyfuel plant that in 2009 will collect, cool and transport its liquefied CO_2 by lorry 150 miles to be injected into a depleted gas field in Altmark.[9]

Implications

The health and safety risks from CCS are health hazards: from carbon capture solvents, the release of gaseous CO_2, major pressure losses e.g. pipe rupture (potential impact injuries, burns from a release of supercritical CO_2 at low temperature and asphyxiation). The health risks and other occupational hygiene hazards (noise, vibration etc) will be covered under existing HSE legislation and regulations.[5] However, current understanding of the engineering hazards associated with CCS is incomplete as there is limited experience both in the UK and internationally in handling supercritical CO_2. Additionally there is no best practice to address the design, construction, operational and maintenance issues of CCS plants and pipeline systems. In response to these issues other initiatives are in development by industry stakeholders working in partnership and with government agencies.[10]

There is a need to consider the adequacy of current regulations to control the risks associated with CCS, in particular consideration of the classification of supercritical CO_2 as if it were a dangerous fluid for the purposes of pipeline legislation, given the limits in current understanding. These issues are considered in more detail in: 'Interim guidance on conveying CO_2 in pipelines in connection with carbon capture, storage and sequestration projects.'[10]

Conclusion and Recommendations

- HSE is working to address the issues associated with large scale CCS in the UK. It is working with a number of stakeholders concerning CCS in addition to BERR including the North Sea Basin Task Force, the North Sea Offshore Authorities Forum and the International CCS Regulators Forum. HSE is also aware of a number of CCS projects outside of the BERR competition.[8]

- HSE and the Futures Team need to keep a watching brief on other CCS technologies that have not been considered in the scope of the BERR competition and that may reach commercial reality over the next 10 years, for example ocean storage,[11] carbon dioxide air capture technology (which has been successfully demonstrated in prototype),[12] the recycling of CO_2 into hydrocarbon chains for fuel[13] and the storage of CO_2 permanently via a chemical reaction within silicate-based rocks such as serpentine in a reactor.[14]

7 http://nds.coi.gov.uk/environment/fullDetail.asp?ReleaseID=372398&NewsAreaID=2&NavigatedFromDepartment=True
8 http://www.hse.gov.uk/carboncapture/partners.htm
9 http://www.technologyreview.com/Biztech/21397/
10 http://www.hse.gov.uk/pipelines/co2conveying.htm
11 http://www.guardian.co.uk/environment/2008/jun/27/carboncapturestorage.carbonemissions
12 http://www.physorg.com/news96732819.html
13 http://cordis.europa.eu/fetch?CALLER=FP6_PROJ&ACTION=D&RCN=74691
14 http://www.sciencedaily.com/releases/2007/07/070727091001.htm

- There may be additional hazards associated with CCS that have not yet been considered, for example Dr Christian Klose, (a geohazards researcher at the Colombia Lamount-Doherty Earth Observatory) has estimated that 25% of the UK's recorded seismic events were caused by human activity. He worries that CO_2 storage in deposits underground could generate earthquakes that would be close to heavily populated areas (coal power stations are closer to cities).[15]

- The Centre for Innovation in Carbon Capture and Storage (CICCS) at the University of Nottingham is developing novel technologies to trap and store CO_2 with a view to becoming a world leader in novel CCS technologies through promoting an interdisciplinary approach.[14] This centre may be a useful additional stakeholder to help HSE to keep track of emerging novel CCS technologies.

Sam Bradbrook, Futures Team, January 2009

[15] http://blog.wired.com/wiredscience/2008/06/top-5-ways-that.html