UK ENERGY RESEARCH CENTRE

Response to the House of Commons Environmental Audit Committee inquiry on Carbon Capture and Storage

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Prepared by Prof S Haszeldine of Edinburgh University with assistance from H Chalmers, Dr J Gibbins, Dr N Markusson, Prof J Skea
UK Energy Research Centre
58 Prince's Gate
Exhibition Road
London
SW7 2PG

Submitted on behalf of UKERC by Dr Jeff Hardy
Tel: +44 (0) 207 594 1572
E mail to: jeff.hardy@ukerc.ac.uk
www.ukerc.ac.uk

Environmental Audit Committee inquiry on CCS: Response by the UK Energy Research Centre

Summary of points
• Carbon capture and storage (CCS) can be a critical CO_2 reduction technology for the UK. CCS is now commencing the early *pre-commercial demonstration* stages worldwide, with the objective of widespread *commercial deployment* by 2020 - 2025.
• Capture ready design is a very important set of practical actions during the design and building of new power plant, which can be utilised at a later date, to enable the avoidance of "locked-in" high carbon emissions in future.
• BERR has already given Section 36 planning consent to Natural Gas Combined Cycle (NGCC) power plants including a condition that they are capture ready, but without a clear definition of this condition.
• The Kingsnorth plant is currently awaiting a decision on capture ready requirements for coal-fired power plants in the UK. This has become a focus for objectors.
• A wide and encompassing specification of capture ready is needed, to ensure feasible conversion to CCS, when it is required by regulation and/or economically justified.
• It is very unlikely that a CCS plant will operate in the UK until additional costs are covered by appropriate financial support.
• Many estimates exist of the support needed to avoid losses on demonstration plant, typically stated to be a total of € 70-100 per ton CO_2. Several approaches are suggested here to regulate or incentivise CCS.

1) The UK Energy Research Centre (UKERC) was established in 2004. Its mission is to be the UK's pre-eminent centre of research, and source of authoritative information and leadership, on sustainable energy systems.

2) Carbon Capture and Storage can become one of the UK's options for sustainable generation of low carbon electricity in the near to mid-future. Government estimates of cost show that retrofit CCS is expected to be cheaper than many other options (Energy White Paper 2007[i] fig 10.2). CCS components, and small-scale whole systems, are now at different stages of demonstration in countries worldwide, but no full-size power plant has yet been fitted with CCS. Several variants of CCS can be envisaged in the UK, using gas, coal, or petroleum coke as fuel. A unique attribute of CCS is its capability to directly reduce CO_2 emissions from very large centralised power plants. It is generally expected that 85-95% of CO_2 produced at a power plant fitted with CCS could be captured and stored[ii]. This capture percentage depends on the detail of technology chosen and how the capture plant is operated. Pre-combustion variants of CCS are capable of using coal or gas to produce hydrogen, or liquid hydrocarbon fuel for transport, as well as electricity, but with hydrocarbon fuels additional CO_2 will enter the atmosphere.

Aspirational benefits of CCS for the UK are:
i) The ability to continue burning coal or gas with minimal CO_2 emissions, as a transitional technology whilst other low carbon technologies such as renewables are perfected to be deployed at large scale;
ii) The possibility to deploy CCS with significant impact in the UK before 2020;
iii) The potential to commence transfer of CCS expertise to developing economies before 2015, within a series of demonstrations in the EU and worldwide;
iv) Continued improvement in power plant CCS components, even whilst the first commercially deployed CCS plant are operating – similar to the way conventional coal Pulverised Fuel plant has continued to increase in efficiency from 1945 to 2008;
v) Mitigation of world CO_2 emissions from 2015, significant from 2020. Developed countries will implement CCS first. If CDM routes are created, then CCS projects can quickly occur in developing economies, which can help to offset UK emissions and create opportunities to make profits for UK project management, manufacture, and trading.

Major effort is required to make these benefits a reality on the timescales suggested. But if the necessary financial and policy support is forthcoming, then it is quite possible that this challenging programme could be successfully implemented from a technical perspective. This implies that initial demonstration projects to become operational by 2015, overlapping with a successor second tranche of plants from (say) 2015 to 2022 to implement learn-by-doing, overlapping with full commercial rollout commencing in 2020. For example, the impact assessment of the European Commission draft directive on geological storage of CCS[iii] stated that:

"Assessments have been made that if widespread global deployment of CCS is required from a particular date (say 2025 onwards), two generations of learning are required prior to that in order to progress along the initially steep learning curve and reduce the costs of the global rollout. [Gibbins and Chalmers, 2008] This is shown in schematic terms in [Figure 1] below, which also shows the timeline for development of the projects and the timing of learning feedback from one tranche to the next"

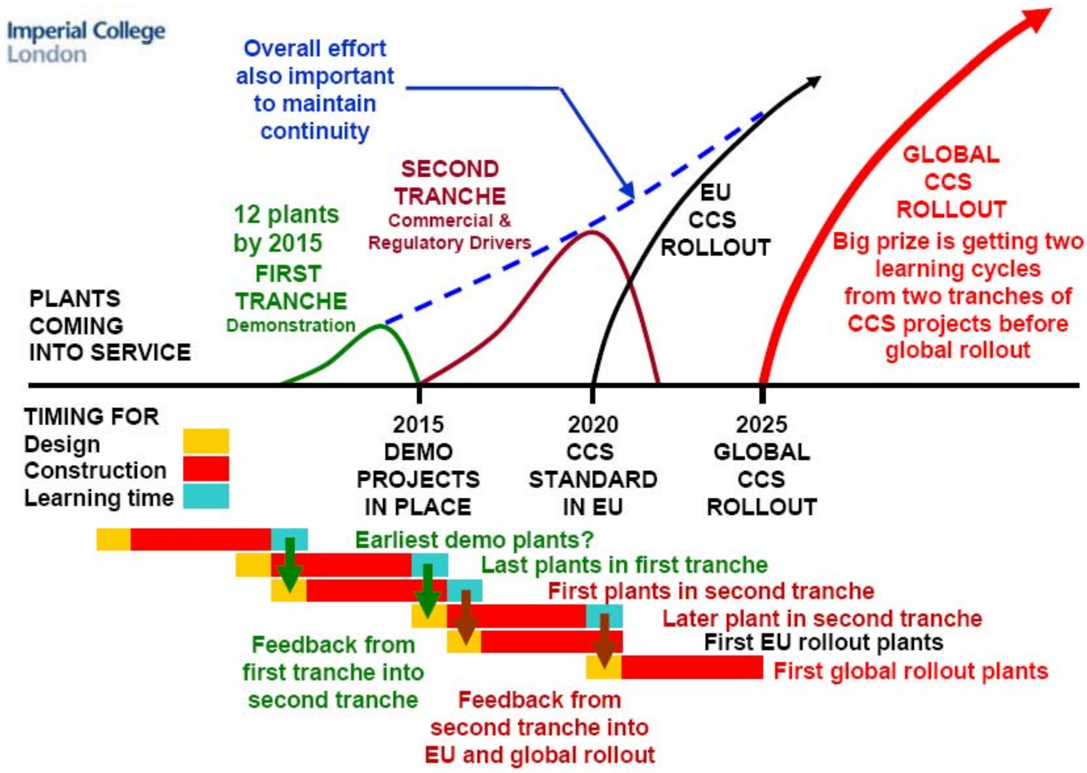

Figure 1

3) Capture Ready (CR) is a term describing deliberate design of a fossil-fuel-fired plant to ensure that it can operate with CCS at a future date, if it is not built with CCS initially. Although the concept has been discussed for several years, there is no agreed definition within the UK, Europe or globally.

Recent analysis of the CR concept commissioned by WWF[iv] recommends a wide definition of CR which considers how to make the whole system CCS-ready. This approach stresses the importance of ensuring that transport and storage for CO_2 is possible, in addition to being able to fit capture equipment at the power plant. In this approach, crucial endeavours to enable assurance that CR can be converted to CCS, are:

- Design to fit capture equipment at the power plant (see below)
- Plan a detailed route to storage, either by pipe or boat
- Outline assessment of storage volume, security, and availability
- Creation of business links along the CCS value chain
- Development of design, engineering and operation skills within the power company

• Stated criteria for the date of transfer to CCS operation, and penalties for failure.

A detailed, peer-reviewed study on how power plants should be designed to ensure that capture equipment can be retrofitted was undertaken in 2007 commissioned by the IEA Greenhouse Gas R&D Programme as part of the G8 Gleneagles plan of action[v] . This work details requirements for plant design for pulverised coal-fired power plants, Integrated Gasification Combined Cycle (IGCC) and NGCC and concludes that a number of low-cost or no-cost alterations are essential requirements for capture readiness. Further non-essential pre-investments can also be considered. The authors suggested that CR status should be linked to a process where “competent authorities [are] provided with sufficient information to be able to judge whether the developer has met [CR] criteria” which might include “identification of reasonable route(s) to storage of CO_2” as well as power plant design considerations.

It should be noted that designing a plant to be CR does not necessarily guarantee that CCS will be fitted. For CR to be converted to CCS operation, it is also necessary that Government provides the legal framework both onshore and offshore. Sufficient financial incentives or regulatory requirements for CCS deployment are also required. These are needed so that investors are able to recover the increased capital and operational costs of generating decarbonised electricity, compared to fossil-fired plants without CCS. One method to achieve this could mean the implementation of current EU proposals to recycle revenue gained from auctioning of EU-Allowances for emissions (see section 4 below).

Operation of CCS plants, and hence the finances required, will also be influenced by other developments in the electricity system. For example, one scenario can be argued that a CCS plant will be run continually as a baseload supply of electricity. By contrast, if high penetration of nuclear and renewables occurs, it is possible that the main role for fossil-fired plants would be as back-up to ensure security and quality of supply. CCS would then be used to ensure that these support services are provided by low carbon sources.

At the nascent stage of a new large-scale technology, there can be a role for Government to provide public education, not least to enable informed decisions to be made by citizens directly affected by any development. BERR intends to undertake a Consultation during 2008 on the role of CR in the UK. It is likely that this will be important in both informing public on CR issues and ensuring that the public are able to express their views as part of the development of the regulatory regime for CCS in the UK.

Although DTI/BERR have already licensed four gas plants as CR, there is some uncertainty over how CR requirements will develop for coal-fired power plants in the UK. In particular, E.ON have applied to build a replacement supercritical steam coal plant at Kingsnorth which is also described as capture ready. Several environmental NGO’s have used this as a focus to query the reality of the CR concept, and have pointed out that building new coal plants has the potential to increase UK emissions of CO_2 if not regulated properly. Since Government had not developed policy on CR before the Kingsnorth planning application process began, this has created an opportunity for vocal and organised single-issue groups to create a campaign around Kingsnorth. Such a campaign has the potential to shape public perception on issues such as “new coal”, “clean coal”, “greenhouse gas”, “capture ready”, and “carbon storage”. Consequently, the BERR consultation process could come into conflict with continued campaigning activity around Kingsnorth, and could significantly shape national perception of CR and CCS. Ultimately, the outcomes of these activities are likely to determine whether CCS is seen as an acceptable technology for Government to include within the suite of options it uses to control CO_2 emissions in the UK.

4) Incentives for CCS deployment, including EU actions, are important in shaping the future of CCS. The European Commission has proposed aligning energy strategy with climate strategy[vi] . A proposed Directive on CCS[vii] outlines a common methodology across the EU for conditions relating to permitting, operation, monitoring, and eventual transfer of ownership to the state. The Communication[viii] on Demonstration plants recognises the large finance involved, includes CCS in the EU-ETS and supports a coordinated programme that seeks to share lessons learned from up to 12 flagship demonstration projects.

Funding the capital and operating costs of CCS demonstrations is a large item with an uncertain cost in the UK and elsewhere, deterring investment. Companies could be assisted with capital costs by a variety of Government mechanisms, ranging from tax credits, to direct support. The EU communication on CCS Demonstration specifically includes CCS research facilities as eligible for State Aid.

Additional measures are required to fund the operational cost of CCS demonstrations. These are important since CR plant consented, or proposed, in the UK will not have CCS technology fitted and operated unless investors can expect to receive a reasonable return on their investment. A number of different approaches can be considered (below).

It is often argued that a CO_2 price (tax/penalty or emissions trading certificate price) which is long term and high enough should be sufficient to ensure that CCS is fitted and operated. This additional price has been analysed many times, and is typically stated to be a total of € 70-100 per ton CO_2 for the initial projects. However this is significantly more than the current EU-ETS price of €25, or the predicted EU-ETS phase 3 price of €30 per ton CO_2.

A large price gap needs to be overcome initially, but it is generally accepted that this is for a few projects for a time period of 10-15 years on those projects. By making best use of shared learning from the proposed European flagship demonstration programme[vi] it is expected that the costs for will be significantly reduced for later plants. For example, the European Commission has a stated aim of reducing CCS costs to EU-ETS levels of €30 per ton CO_2 from 2020.

Deployment of CCS after 2020 is not planned to require special funding, since it is anticipated that CCS will compete successfully with other low carbon technologies in the context of an EU and/or global agreement to significantly reduce CO_2 emissions. The UK appears to expect this to be as part of a market-based system that identifies the lowest-cost opportunities for mitigation (and penalises CO_2 emitters). In such an EU, or world, market, routine CCS would not need any special incentives, unless other technologies receive incentives which distort the market.

The UK has not yet provided any general funding for CCS demonstration or deployment, but has instead focused on a Competition to demonstrate a restricted amount (300-400MW) of post-combustion (or oxyfuel) capture at commercial scale at part of one coal-fired power plant (which could be generating 800MW or more in total).

In addition to this Competition, there are still several opportunities to fund transitional CCS arrangements, by methods which can be ‘blind’ to the choice of CCS technology, or can support particular strategic developments. Funding to support such projects can be available from EU arrangements. From 2013 the EU-ETS phase 3 is proposed to auction all CO_2 emissions allowances for power plants. It is expected that this will provide the UK Government with about €4,800 Million per year of new income. A number of methods could be used to fund CCS demonstrations in the UK, including:

- EU-ETS income could be used by the UK to provide funding to power companies as infill for the gap between the variable EU-ETS price and a fixed base price for CO_2 sufficient to avoid financial losses in operating CCS plant. No additional costs would pass to consumers, but the Treasury has to pay.

- Free EU allowances could be given by the UK or EU to reward CO_2 actually stored from CCS demonstration plant. More than one allowance will be needed, to enable companies to derive sufficient income from their sale. No additional costs pass to consumers, as EU allowances are already priced into UK electricity[ix].

• The UK could create a Decarbonised ROC, parallel to, but separate from, the ROCs for renewable technologies already in place. The extra DROC cost is spread amongst all electricity supplied to consumers.

Emissions standards could also form an important element of CCS/CR legislation and incentivisation. If this approach is adopted then Government would focus on determining acceptable emissions from power generation, but leave technology choice to electricity suppliers. This type of approach is similar in principle to car emissions standards, and has been adopted by legislators in California. Here a maximum of 500 kg CO_2 / MWh is being applied initially; this enables NGCC plants to continue operation without emission reduction technology, however, coal-fired plants, because of higher CO_2 emissions, are required to fit CCS or, eventually, to close. Environmental NGO's and others in the UK have suggested tougher standards for the UK, although it is not clear when it would be feasible to introduce these.

It seems likely that careful choice of incentives and/or regulation (using one or more of the methods identified here or other approaches), combined with commitment to the long-term value of CCS, can create an environment in the UK that would foster several successful commercial-scale demonstrations and deployment of CCS. Many of the companies involved in developing CCS projects are international. Such companies may choose to develop CCS technologies (and invest in power generation plant) elsewhere if sufficient incentives are not available in the UK. For example, a BP-SSE project proposed at Peterhead (near Aberdeen) has now been transferred to Abu Dhabi. Most (probably all) of the nine or more demonstration projects currently proposed for the UK would require some form of Government intervention for profitable operation. CCS projects that are additional to the current BERR-run competition can provide advantage to the UK by:

a) demonstrating world leadership in projects as well as legislation;
b) creating skills and learning in UK companies and workforce which confer a competitive advantage on UK business; and
c) directly reducing UK CO_2 emissions.

5) In summary, to create an option to use CCS as a fossil fuel CO_2 mitigation measure, it is necessary to act now. Rules to enable gas and coal power plants to be built 'capture ready' are important to maintain electricity supply and commercial interest in UK CCS leadership. Capture ready can be achieved either by detailed specification of the preparations made for deploying the CCS chain for the plant, or (assuming a rational response from project developers) by stipulating the emissions standard(s) that the plant will have to meet. To enable actual operation of CCS, a financial mechanism to avoid commercial losses in capital and operation costs is essential.

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[i] DTI Energy White Paper 2007 CM7124 Fig 10.2 cost curves including retrofit CCS
[ii] Intergovernment Panel on Climate Change 2005 Special report on CCS www.ipcc.ch
[iii] European Commission 2008 Impact assessment Draft Directive on Geological Storage; Paragraph 43 http://ec.europa.eu/environment/climat/ccs/pdf/ccs_ia_jan2008.pdf
[iv] University of Edinburgh (2008) How ready is 'capture ready'? - Preparing the UK power sector for carbon capture and storage www.geos.ed.ac.uk/sccs/
[v] IEA GHG (2007) *CO_2 capture ready plants*, 2007/4 www.ieagreen.org.uk/2007.html
[vi] EU Com (2008) 30 20 20 by 2020 Europe's climate change opportunity. http://ec.europa.eu/commission_barroso/president/pdf/COM2008_030_en.pdf
[vii] EU COM(2008) 18 Directive on the geological storage of carbon dioxide. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52008PC0018:EN:NOT
[viii] EU COM:2008:0013 Supporting Early Demonstration of Sustainable Power Generation from Fossil Fuels. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0013:FIN:EN:PDF
[ix] *Ofgem Jan 2007 Response to Consultation on Renewables Obligation* http://www.ofgem.gov.uk/Sustainability/Environmnt/Policy/Documents1/16669-ROrespJan.pdf