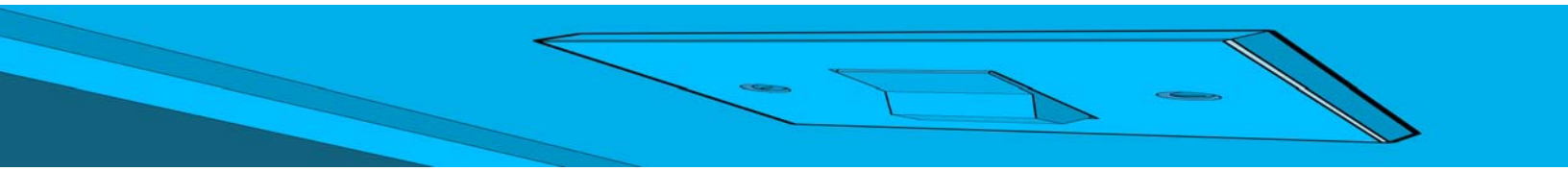

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UK ENERGY RESEARCH CENTRE

UKERC response to the BERR consultation 'Towards Carbon Capture and Storage'.

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THE UK ENERGY RESEARCH CENTRE

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The UK Energy Research Centre's mission is to be the UK's pre-eminent centre of research, and source of authoritative information and leadership, on sustainable energy systems.

UKERC undertakes world-class research addressing the whole-systems aspects of energy supply and use while developing and maintaining the means to enable cohesive research in energy.

To achieve this we are establishing a comprehensive database of energy research, development and demonstration competences in the UK. We will also act as the portal for the UK energy research community to and from both UK stakeholders and the international energy research community.

We are funded by three research councils: the Engineering and Physical Sciences Research Council (EPSRC), the Natural Environment Research Council (NERC) and the Economic and Social Research Council (ESRC).

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Summary

- 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.
- 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.
- At the nascent stage of CCS development and deployment, there is a role for Government to provide public education so as to enable citizens directly affected by CCS to understand and make decision about the technology.
- Lessons learned in UK and EU CCS demonstration projects should be shared globally.
- 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.
- Capture ready design is a very important set of practical actions during the design and building of new power plant or other combustion plant, which can be utilised to ensure that CCS retrofit is possible and, hence, avoid “locked-in” high carbon emissions from fossil fuel use 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.
- There is potential for strategic planning of the transport and storage system to provide significant benefits.

Section 1: Fossil Fuels: electricity generation and climate change

Question 1: We would welcome views on what more the Government might do to promote the development and deployment of CCS technologies in the UK, EU and globally.

Background: the scale of effort required

CCS could lead to mitigation of world CO_2 emissions from 2015, with more significant impact possible from around 2020 depending on the pace of commercial scale demonstration supported in the next decade. In the UK there is a genuine possibility to deploy CCS nationally with significant impact before (and beyond) 2020. Additional financial and policy support must, however, be forthcoming if this is to become reality. Changes to government support could bring forward the operation of the first commercial-scale plants to 2013.

CCS components, and small-scale whole systems, are now at different stages of demonstration in countries worldwide, but no full-size CCS plant has yet been fitted at a power plant. CCS systems are now commencing the early *pre-commercial demonstration* stages worldwide, with the objective of widespread *commercial deployment* by 2020 - 2025. This objective implies that initial demonstration projects become operational by 2015, overlapping with a successor second tranche of plants from (for example) 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[1] 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][2] 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"

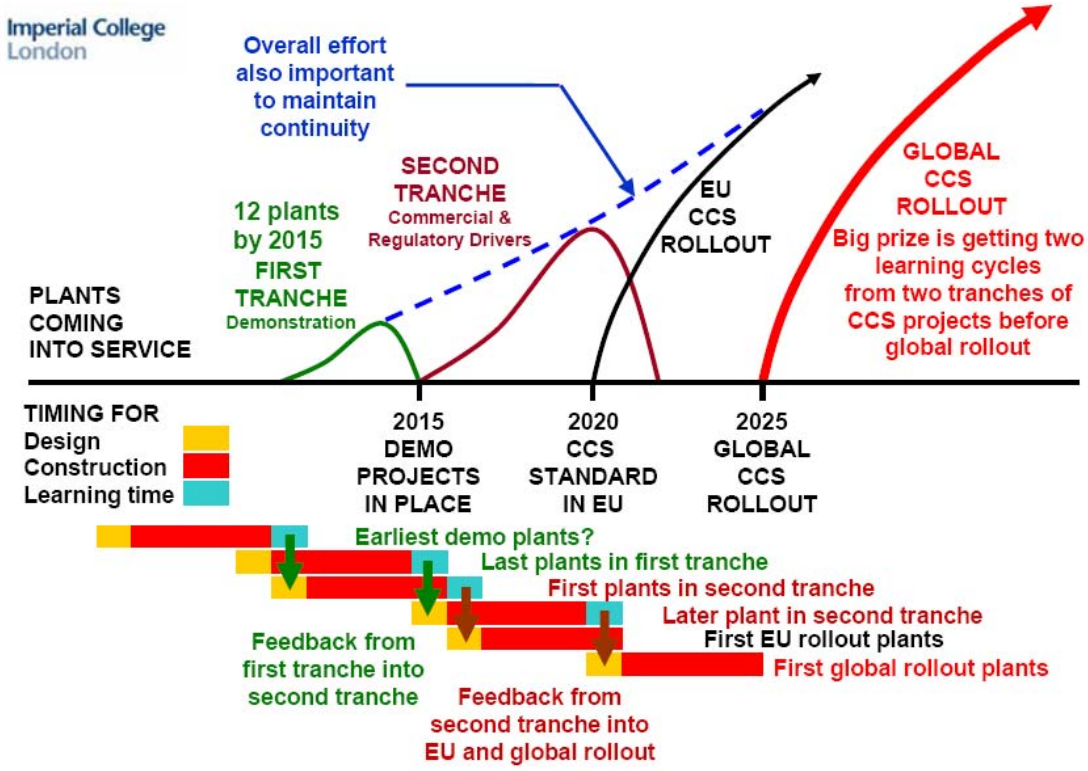


Figure 1

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. The ways in which the Government might promote the development and deployment of CCS technologies in the UK, EU and globally are discussed next.

Promoting the development and deployment of CCS technologies

Incentives for CCS deployment, including EU actions, are important in shaping the future of CCS. A significant barrier deterring investment in CCS (in the UK and elsewhere) is funding for the capital and operating costs of CCS demonstrations.

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[Error! Bookmark not defined.] specifically includes CCS research facilities as eligible for State Aid. In a recent test-case the 16 July 2008 European Free Trade

Association (EFTA) decision on the Mongstad CCS test centre has agreed to 80% aid, and 20% private contribution. Additional measures are also likely to be required to incentivise the operational cost of CCS demonstrations. A number of different approaches are considered below.

It has been stated that a CO_2 price (e.g. tax/penalty or emissions trading certificate price) which is long term and sufficiently high should ensure that CCS is fitted and operated. Analysis has shown that a price range €70-100 per ton CO_2 would be adequate for the initial **demonstration projects**. This is significantly more than the current EU-ETS price of €25, or the predicted EU-ETS phase 3 price of €30 - 40 per ton CO_2. Therefore this large CO_2 price gap needs to be overcome for the lifetime of early demonstration projects (perhaps 10-15 years).

By making best use of shared learning from the proposed European flagship demonstration programme[2] it is expected that the CCS costs 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.

The UK, to date, has not yet provided any generic funding mechanism 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 much more than 400MW in total).

There are still several opportunities for the UK to fund additional 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 could be available from EU arrangements if Government decides that it is appropriate to use of some of the auction revenues expected from the current proposals for EU-ETS phase 3. 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 if EU-ETS prices remain relatively low. No additional costs pass to consumers, as EU allowances at the time will already be priced into UK electricity[3].

- The UK could create a Decarbonised Renewable Obligation Certificate (DROC), 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/CCR 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 per unit of electricity produced, are required to fit CCS or, eventually, to close. Emissions standards should be progressively reduced, to bring all fossil-fired plant into the requirement.[1] 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 should also be noted that operation of CCS plants will be influenced by other developments in the electricity system. For example, CCS studies usually assume that CCS plants will be run continually as a baseload supply of electricity. By contrast, if there is high penetration of nuclear and renewable power, then the role for fossil-fired plants could be as back-up to ensure security and quality of supply.

[1] Note that fitting CCS to a biomass-fired plant can result in negative CO_2 emissions. This is because the CO_2 captured from biomass was fixed from the atmosphere during the biomass growth cycle.

CCS would then be used to ensure that these support services are provided by low carbon sources. This could affect appropriate incentivisation levels and which mechanisms are likely to be most effective to encourage CCS deployment.

Potential for further UK actions

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 could provide advantage to the UK by:

- demonstrating world leadership in projects as well as legislation;
- creating skills and learning in UK companies and workforce which confer a competitive advantage on UK business;
- directly reducing UK CO_2 emissions; and
- catalysing progressive development of a CCS transport network.

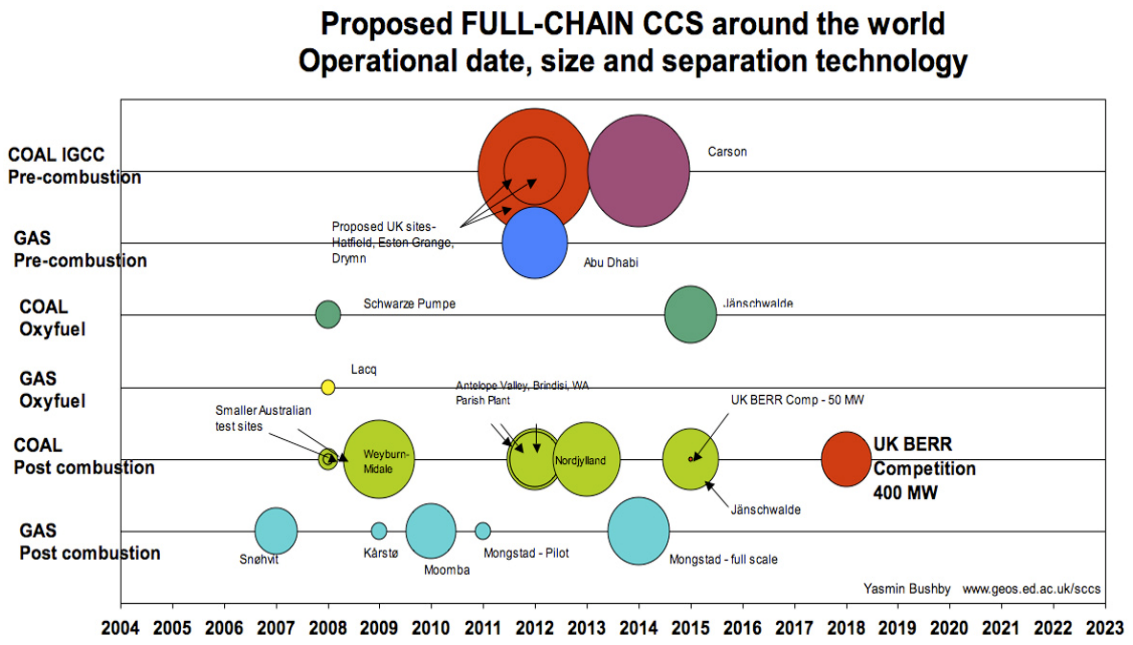
Also, at the nascent stage of a new large-scale technology, there is a role for Government to provide public education, not least to enable informed decisions to be made by citizens directly affected by any development. It is important that the public are able to express their views as part of the development of the regulatory regime for CCS in the UK.

World impact of the UK BERR competition

Activity and interest in CCS is growing rapidly worldwide. When BERR initially considered CCS demonstration and deployment in the UK, only a few projects were explicit around the world. That situation now changes monthly. We have concern

that the timescale for delivery of a UK demonstration project under the control of BERR may lag behind the free-market and state-aided competition around the world. That may be relevant for two reasons: firstly the large expense from UK taxpayers may be pre-empted by development of similar post-combustion capture technology in rival nations; secondly that the UK claims of leadership may be undermined.

As an illustration of this, a tabulation produced by the Scottish Centre for Carbon Storage forms Figure 2. This plots commercially significant plants with full-chain of CCS (capture , transport, storage) proposed worldwide, effective at June 2008, categorised by capture type, and coloured by nation state. This has displayed the BERR plant becoming available from 2018 – as permitted by the competition rules. Obviously there is no guarantee that all these independent projects will occur, as there is also no guarantee that the BERR project will be funded and successful. However it is clear firstly that the UK BERR competition will only be 'amongst the first', and secondly that full-size pre-combustion gas and coal plant could develop several years earlier. From this evidence, we caution that the UK cannot be complacent. If UK commercial advantage, or a leadership position, is sought, the timescale for full delivery of the BERR project should not slip to later than 2014.



International actions

To increase the pace of global action to reduce CO_2 emissions it would also be valuable for Government to aim to commence transfer of CCS expertise to developing economies before 2015, depending on how quickly finance and other issues can be resolved for initial demonstration projects within the developed world. This could form part of a series of demonstrations in the UK, EU and worldwide. For example, including the nZEC project examining the potential for near zero emissions from coal in China, could be used as a foundation for UK Government to encourage or support international demonstration and deployment of CCS in China.

International engagement to encourage rapid demonstration of CCS in developed countries is also important. One important action here could be to ensure that regulatory, licensing, and technology lessons learned from the ongoing UK demonstration competition are shared as a contribution to designing effective processes, which could incentivise the proposed EU flagship programme.

Section 3: Article 32 of the Draft CCS Directive. Carbon Capture Ready

UKERC would like to make the following generic points about Carbon Capture Ready (CCR) in response to Section 3 of the consultation document.

Although BERR have already licensed four Natural Gas Combined Cycle (NGCC) plants as CCR, there is some uncertainty over how CCR requirements will develop for coal-fired power plants in the UK. In particular, E.ON have applied to build a replacement coal-fired 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 CCR concept, and have pointed out that building new coal plants has the potential to increase UK emissions of CO_2 if not regulated properly. This has resulted in the BERR CCR consultation process being conducted in parallel with, and in conflict with, campaigning activity around Kingsnorth. Ultimately, the outcomes of these linked activities are likely to make an important contribution in determining 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.

Although the CCR concept has been discussed for several years, there is no agreed definition within the UK, Europe or globally. Recent analysis of the CCR concept commissioned by WWF[4] recommends a wide definition of CCR 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, the critical steps to provide assurance that CCR 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 peer-reviewed study on how power plants should be designed so that capture equipment can be retrofitted was undertaken in 2007 commissioned by the International Energy Agency (IEA) Greenhouse Gas R&D Programme as part of the G8 Gleneagles plan of action[5], as noted in Chapter 3 of the consultation document. This study details requirements for plant design for pulverised coal-fired power plants, Integrated Gasification Combined Cycle (IGCC) and Natural Gas Combined Cycle (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 CCR 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 [CCR] criteria" which might include "identification of reasonable route(s) to storage of CO_2" as well as power plant design considerations.

Finally, it should be noted that designing a plant to be CCR does not necessarily guarantee that CCS will be fitted. For CCR 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 so that investors are able to recover the increased capital and operational costs of CCS (see answer to question 1).

Section 5: Other Aspects of the Draft Directive

Question 38: Although we think the proposed Directive provides sufficient scope for Government intervention in the future should it be necessary, we would welcome any views you have on the way in which the transport and storage network might develop in both the UK and EU.

It is not clear how the transport and storage network in the UK and EU will develop. Some initial studies[6,7] have, however, explored the potential for strategic planning of the transport and storage system to provide significant benefits. Further work should be carried out to assess in more detail whether Government intervention is appropriate in this case and, if so, what form this intervention should take.

It remains very unclear how a pipeline transport network for CO_2 could or would develop from the current BERR competition to build a one-off power plant. In particular, it is unclear how a business model will be created to enable the chain of actors to pass profitable revenue, and legal responsibility, from power plant to final storage. It is also unclear why any private developer would build pipeline capacity larger than the requirement for their own project. To avoid such a situation, and encourage strategic private investment, a prognosis of future CO_2 tonnage and flow is needed at a UK (and, possibly, European) level for future points in time. This could easily be enacted by publication of aspirational UK targets for tonnage of CO_2 to be captured and stored by 2015, 2020 and 2025.

The UK has a significant opportunity to provide storage in geological reservoirs deep beneath the North Sea, for CO_2 derived from mainland Europe. To realise this opportunity, the cross-border movement of CO_2 with minor impurities, must be made legal. Further work on international treaties, such as the London Convention, appears to be necessary for this to occur.

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[1] European Commission 2008 Impact assessment Draft Directive on Geological Storage; Paragraph 43 http://ec.europa.eu/environment/climat/ccs/pdf/ccs_ia_jan2008.pdf
[2] Jon Gibbins, Hannah Chalmers, Preparing for global rollout: A 'developed country first' demonstration programme for rapid CCS deployment, Energy Policy, 36 (2008) 501–507
[3] *Ofgem Jan 2007 Response to Consultation on Renewables Obligation* http://www.ofgem.gov.uk/Sustainability/Environmnt/Policy/Documents1/16669-ROrespJan.pdf
[4] 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/
[5] IEA GHG (2007) *CO_2 capture ready plants*, 2007/4 www.ieagreen.org.uk/2007.html
[6] Element Energy Ltd et. al. (2007) Development of a CO_2 transport and storage network in the North Sea. http://www.nsbtf.org/documents/file42476.pdf

[7] Poyry Energy Consulting (2007) Analysis of Carbon Capture and Storage Cost-Supply Curves for the UK. http://www.berr.gov.uk/files/file36782.pdf