Progress on Carbon Capture and Storage in the UK

Response to the Energy and Climate Change Select Committee call for evidence,

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1. Summary

1.1 CCS on electricity and industry is vital if the UK is to achieve cost-effective decarbonisation in 2030 and 2050. CCS can also store CO_2 from the atmosphere to achieve climate stabilisation.

1.2 The UK is failing to deliver on its potential for CCS. Past momentum has been lost, policy ambition has been reduced, and high quality projects have been cancelled.

1.3 The current package of the UK CCS Commercialisation Programme, plus Electricity Market Reform (EMR), plus emissions waivers is at extreme risk of repeating past failings. An overly narrow focus, with slow 'delivery' of one or at most two projects this decade will not succeed in achieving even DECC's own limited stated aims for the Commercialisation Programme and CCS roadmap.

1.4 Rapid progress occurring in the USA, Canada, and China, highlights that additional attention must be given to parallel enabling actions.

1.5 Actions are required to build pipeline and shipping infrastructures for broader CCS deployment and cost reduction; and to take liability for stored CO_2. Special action is needed to commercialise storage, and to enable CO_2 import and CO_2-EOR. CCS Certificates can enable parity between industry and power, large and small plant, in enacting CCS.

1.6 Successful results need to focus on timely partnership, not assessment, enabling better connections within DECC, and across HM Government.

2. About SCCS

2.1 Scottish Carbon Capture and Storage (SCCS) is the largest carbon capture and storage research group in the UK. With internationally renowned researchers and state-of-the-art facilities, we are unique in our connected strength across the full CCS chain, ranging from capture engineering and geoscience to public engagement, policy and economics. Founded in 2005, SCCS works with universities and researchers across Scotland. SCCS is funded by the Scottish Funding Council (SFC) and the Energy Technology Partnership (ETP).

2.2 SCCS highlights three areas, believed to be of particular importance for the Committee's consideration:

- The experience of past and present UK efforts to procure CCS projects via competitive processes, and the practical limitations on CCS investment stemming from the current approach to EMR. Mandatory CCS Certificates may be applied across the EU.

- Comparative approaches being undertaken in other countries, and implications for UK policy.

- The need for practical actions on storage and transport, with a vision of future CO_2 tonnage, to secure CCS deployment in the UK.

2.3 SCCS can provide impartial evidence on these or other questions.

3. UK CCS projects – past, present and future?

3.1 CCS in the UK emerged in 1996, when Norway started to inject CO_2 for storage. In 2003 the first commercial evaluation was made (Grangemouth-Forties), in 2005 CCS became G8 policy, in 2007 the UK first competition started, and in 2013 the UK is still at least 4 years away from its first project. The UK still has the best combination of geological, engineering, industrial and academic capabilities in the whole of Europe, together with a professed policy commitment to reduce CO_2 emissions and the foundational legislative framework required for CO_2 storage. This confluence of factors has succeeded in attracting the proposals of over 50% of Europe's CCS projects. But this enthusiasm has now been stifled via repeated bureaucratic 'competition' processes.

3.2 While other EU member states have focused efforts on individual projects, the UK has been unique in operating a formal and bureaucratic process, which is named "competition", but is actually a national procurement. This has proven to be slow, demoralising, inaccurate and ineffective at delivering a result.

3.3 Since 2007, commercial CCS projects in the UK have been mired in government bureaucracy, stifled by immensely detailed and slow examination of "competition" proposals. Requirements to tender for funding support have been more effective at killing off projects and frustrating international project consortia than they have been at securing investment. The current commercialisation programme could have secured a 'pipeline' of projects for the coming decade in pursuit of the stated outcome of cost-competitive CCS. This is now at risk.

3.4 The Commercialisation Programme saw a speedy beginning but now faces a drawn out process before funding can be confirmed for none, one, or both of the preferred projects (Peterhead and White Rose).

3.5 The inclusion of Contracts for Difference for CCS within EMR should in theory provide a route to market for these and other well-developed projects, but insufficient details have been provided. It appears that CCS pricing is bottom of the list for DECC, compared to a diverse portfolio of renewables producing intermittent generation, new-build nuclear power which appears likely to be extraordinarily expensive, and permission for unabated gas – which removes any driver for CCS.

3.6 The outcome to date is that there appears to be no visible prospect of any further CCS projects accessing CfDs during the first period of the Levy Control Framework out to 2021. Competition is the ultimate intent of EMR – but seems at present to be not an available option.

3.7 This means that the reserve projects (Teesside and Captain) and the previously de-selected (but still EU-funded) Don Valley project have no current means of accessing financial support and are at severe risk of cancellation.

3.8 The UK currently plans to support development of just one, perhaps two, commercial projects. These will start operation no earlier than 2017, and possibly several years later, to deliver about 0.8 to 1.0 GW of

generation capacity.

3.9 Fitting CCS to the majority of existing, and projected future new-build, fossil fuel plant, will be limited by the practical build-rate. That can be estimated from prior experience in the 1990s "dash for gas".

3.10 Calculating back from the 2030 target shows that at least 5 GW of CCS generation capacity should be operating by 2020, as shown in Figure 1 below. Storage capacity must be identified to commercial quality standard before each of these projects commences. Consequently it is necessary to prove about 3 Gigatonnes of CO_2 storage for decisions in 2025. Present UK actions are about 100x too slow (Fig.1).

Figure 1

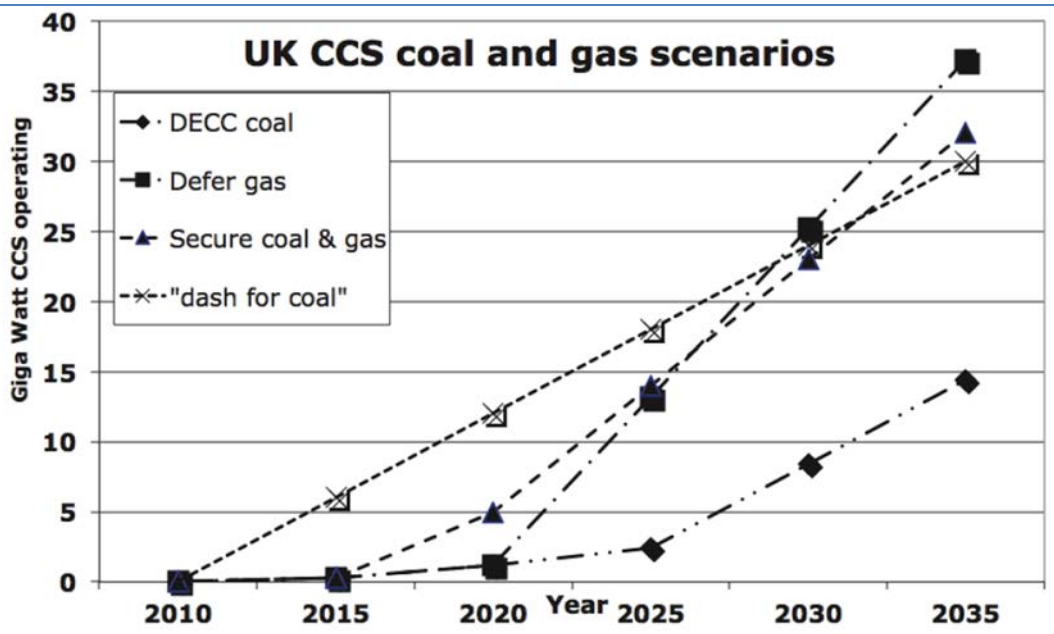

Figure 1. UK build rates of CCS under different scenario assumptions. "Dash for Coal" (crosses) are a long term slow build rate starting in 2010, including coal plant for fuel diversity, to meet Committee on Climate Change targets of substantially decarbonised electricity by 2030. Build rate is projected at half the UK "dash for gas" of the 1990's. That averaged at 2.4 GW / yr. "Secure coal" (triangles) delays building coal and gas CCS, and then needs to compensate by construction of mixed coal and gas. "Defer gas" (squares) pathway is to rely entirely on gas fossil fuel, with a build rate comparable to the dash for gas. "DECC coal" (diamonds) is an optimistic interpretation of current UK Government DECC planning. This will clearly miss climate change targets and UK legal stipulations by a substantial margin from 2025 onwards. Haszeldine RS 2012 UK CCS, where is it ? Energy and Environment 23, 437 - 450

3.11 For any of the three next best placed projects to continue, the developers need to have clear sight of the CfD value, running hours, and timescale. This has been persistently not available during the past 12 months, and consequently these project teams have been, and continue to be, progressively dismantled.

3.12 If these three dormant projects were enacted rapidly, by means of CfD

decisions, or even strongly worded letters of comfort, then the UK would immediately be back on track towards 5GW CCS construction by 2020, giving learning cycles and cost reduction to help full CCS rollout by 2030.

The current lack of planning, and especially lack of action, for what happens to complementary projects during and after the CCS competition seems destined to produce a very small number of expensive tests, which have minimal connection towards incentivising and developing a new CCS industry in the UK. The UK should also be aware that the EU may enact some CCS-Certificate support mechanism to surmount the EU-ETS, that may not fit well with UK-centric policies.

3.13 Urgent attention is required to secure a positive outcome from both the Commercialisation Programme and EMR. Lessons of speedy delivery have not been learned over recent years. Further barriers that need to be addressed include:

i) uncertain political policy, uncertain long term CO_2 ownership liability, silence on a stored tonnage of CO_2 ambition for 2030

ii) lack of will to allocate grant funding for first projects,

iii) catastrophically slow decision-making during DECC evaluations;

iv) lack of secure high carbon price to signal future CCS market;

v) lack of secure access to CfD payments to attract developers to invest in UK.

3.14 Beyond the commercialisation programme, the UK does not currently have a credible plan to secure the wider deployment of CCS on key industrial sectors. Neither does it have a strategy for accelerating the enabling infrastructure of CO_2 transport and storage that will be required for cost reduction, de-risking of investments, and the achievement of economies of scale. A proactive approach that seeks to use existing low-cost, high-value sources of CO_2 (SCCS research) as a means of developing transport and storage is urgent and essential. This will require the Office of CCS within DECC to proactively link between Government Departments.

3.15 CCS has several important applications outside of electricity. Cleanup of CO_2 emissions associated with natural methane could be undertaken (e.g. Morecambe Bay), whilst storage of atmospheric CO_2 for climate mitigation also requires guaranteed subsurface storage. CO_2-Enhanced Oil Recovery can produce more oil whilst storing CO_2 (SCCS research). These fundamental sectors are unfunded.

4. CCS progress elsewhere

4.1 It would appear at first glance that the UK fares no worse than other EU member states in its failure to deliver CCS projects. However in reality the UK is only winning in respect of not having grasped its opportunities,

and to have seen more projects cancelled than the rest of Europe put together. This is not a good advertisement for the UK being the 'first choice for investment in CCS' with four large projects that the coalition government initially claimed to be aiming for.

4.2 Beyond Europe, efforts on CCS are now showing practical progress in the USA, in Canada, and China. The failure of European multi-party funding mechanisms and carbon pricing means that Europe may now lag 10 years behind in its ability to construct and utilise CO_2 transport and storage infrastructures and geologies. This will have consequent impacts on EU ability to develop profitable new technologies and retain industrial production capacity.

4.3 In Australia, the lack of a stable policy has failed to develop commercial projects at the scale previously envisaged. Policy uncertainty, combined with equivocation of funding, is most like the UK. A world leading research industry has however been developed with CO2CRC forming and funding University industry partnerships. Additionally, the Gorgon LNG project (the world's largest) is integrating CO_2 capture and storage from gas processing operations. This points again to the benefit of encouraging low-cost, high-value CCS projects.

4.4 The USA has been most successful in progressing CCS from concept, through research, to commercial reality. The Department of Energy formulated a multi-year strategic plan:

- Phase I commenced with basic research on capture technologies coupled to continent-wide evaluation of geological storage.
- Phase II moved to small scale capture test plant coupled to forming of regional geographic partnerships to promote detailed evaluation and drilling of storage sites, linked to planned CO_2 transport networks.
- Phase III, now, has constructed full-scale capture plant at several industrial sites and is in the final stages of consenting capture at existing and new build coal power plant, linked to multi-million tonne full-scale injections into deep geological storage.

4.5 Crucial differences between the USA CCS process and the UK are:

- bottom-up innovation and creativity by companies to find solutions has been encouraged;
- realistically large scale of funding actually awarded in a timely manner based on completion of project milestones to create public-private partnerships that have moved through development stages to delivery;
- durable approach to advancing CCS via practical steps rather than jumping straight to full chain integrated projects as in the UK (notably, the early 'FutureGen' concept, that did seek to do this, has struggled to move forward);
- a stated intention to make creative use of existing clean air legislation against CO_2 emissions, for both new and existing power plants;

- adapting existing legislation on boreholes, injection, and liability for stored CO_2, rather than creating new complex procedures;
- onshore transportation and storage of CO_2 is trusted and accessible thanks to four decades of experience with CO_2-EOR.

4.6 Canada has maintained an effort on CCS research for many years. Strong groups have been persistent in University of Regina on storage, and in Ottawa CANMET on capture.

4.7 Provinces have great political and fiscal autonomy, and Saskatchewan, Alberta, and British Columbia have enacted targeted carbon taxes and / or a form of Emissions Performance Standard on power production.

4.8 This has catalysed industrial engagement, most notably by SaskPower at Boundary Dam where the world's first CCS retrofit onto an operating (brown) coal power plant is completing construction, and will be operating commercially from end 2013. This project uses existing industrial components, and is being delivered for less than the projected price; the next project will be 30% less again.

4.9 In Alberta the QUEST project will reduce emissions from Shell's oil sand upgrading operations; the ACTL pipeline will transport captured CO_2 to sites of use for Enhanced Oil Recovery and geological storage.

4.10 All these projects have been enabled by company partnerships with very large, and timely, provincial funding, with some federal support. The Canadian experience has been marked by a willingness to make sure that agreements are reached; with state-owned utilities and private companies both displaying a willingness to invest due to the need to reduce emissions to maintain operations.

4.11 China has for many years maintained a watching brief on CCS, well aware of its position as the globally largest source of CO_2, with poor air quality, and reliance on coal. About 20 CCS experiments on capture, transport, and injection have been undertaken in China within the last five years.

4.12 In April 2013, the Chinese central government issued a statement requesting all provinces to make plans for CCS enactment in the next five-year plan[1]. Historical precedents, and SCCS current research participation with China, strongly suggest that rigidly enforced top-down policy, combined with bottom-up provincial and local creativity and business insight, will start planning of specific CCS projects in 2014, and construction of commercial CCS projects in 2015. This method of operation decide-announce-control, is unlike the UK market system with its plethora of actors, but will achieve extremely rapid results.

4.13 UK-funded efforts continue to have influence in China. The NZEC process continues to limp along, but a more recent project funded by British Embassy Beijing has helped Shaanxi province to identify low-cost, high-value CCS options that would link Methanol production to CO_2-EOR. (It is ironic that no similar strategic project has been undertaken in

[1] http://cdn.globalccsinstitute.com/sites/default/files/publications/102106/notice-national-development-reform-commission-ndrc.pdf

the UK or Europe).

5. Practical enabling actions required

5.1 As a consequence of past failures, DECC is currently overly focussed on delivering none, one (or possibly two) projects. This will not be sufficient to achieve DECC's own (limited) stated goals for CCS. New, parallel, initiatives are required to address key barriers to investment and re-create momentum for CCS deployment. Also required are greater clarity on decarbonisation objectives, and a pathway for the deployment of CCS on gas-fired power stations (rather than a licence to continue un-abated). These tonnages of CO_2 provide a clearer market driver for CCS and infrastructure deployment into the next decade.

5.2 In light of the above reflections, it is possible to identify a set of actions that would help secure the wider deployment of CCS in the UK, and assist the achievement of DECC's own stated aims on cost reduction and deployment potential. These must include both practical measures and improved policy incentives.

5.3 It is increasingly recognised that access to CO_2 transport and storage is an essential enabler of the cost-effective deployment of CCS at scale. Projects in the USA and Canada have been able to move forward more rapidly in part due to the existence of CO_2 pipelines and readily available storage options as a result of decades of experience with CO_2-EOR. What will make UK actors invest in transport, when there is no stated ambition of CCS-CO_2 for 2025, or 2030?

5.4 The UK's CCS Cost Reduction Taskforce [2] has highlighted the importance of access to CO_2 transport and storage as an essential means of both reducing capital costs and effective de-risking of investment for follow-on projects.

5.5 The Central North Sea is the best location geologically (SCCS research) with clusters of emitters sharing access to clusters of CO_2 storage formations [3] Early efforts to prove and validate this CO_2 storage are essential. Such actions are additionally underlined as a key enabler for CCS in the International Energy Agency's recent CCS Roadmap.[4]

5.6 Industrial emitters especially need shared CO_2 transport and storage infrastructure. These are typically smaller scale facilities that cannot bear the costs of a stand-alone point-to-point CCS chain. This analysis is supported by the review of costs undertaken for BIS and DECC, [5] and by recent studies on behalf of specific industry sectors.[6]

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2 https://www.gov.uk/government/publications/ccs-cost-reduction-task-force-final-report

3 Central North Sea - CO_2 Storage Hub: Enabling CCS Deployment in the UK and Europe, SCCS, 2012

4 http://www.iea.org/publications/freepublications/publication/name,39359,en.html

5 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/175504/bis-13-745-the-costs-of-carbon-capture-and-storage-for-uk-industry-a-high-level-review.pdf

6 See for example the recent strategy for the UK cement industry for reducing

5.7 The policy approach to CCS in the UK (and indeed EU) to date has been centred on the power sector as a means of undertaking the demonstration of CCS at commercial scale (via financing support) to be followed by deployment (driven by the carbon price). To date, in the absence of a clear and enduring business case or ambition for captured CO_2/year this process has not delivered.

5.8 Industrial sectors, such as gas processing, or the production of Ammonia or Ethylene provide low-cost and readily available streams of CO_2. These can be used now to kick-start the testing of CO_2 storage formations and the development of pipeline networks and shipping transport of CO_2.

5.9 CCS can boost low-carbon competitiveness and enable retention of tens of thousands of jobs in energy intensive and process industries (SCCS research). Building this requires shifting activity away from the process-driven procurement of point-to-point 'demonstration' projects. Strategic anticipation of higher carbon prices and mandatory lower carbon intensities, leads to reliable estimates of CO_2 stored. Bottom-up industry-government partnerships, funded by UK-EMR and/or EU-CCS Certificates can catalyse private sector investment in multiple rapid CCS projects across industry and power generation sectors.

5.10 The UK has immense potential value in its offshore CO_2 storage resource. This comprises about 35% of all CO_2 storage for Europe. None of the onshore storage for leading industrial states in Europe is currently available, due to adverse public opinion. Consequently, the UK has a very large opportunity to become the first developer of commercially proven, secure, and well-licensed CO_2 storage for Europe. Crucial gaps in enabling this include the legal ability to import CO_2 for storage from European or other states, and liability. It is inevitable that the UK state must take long-term ownership of stored CO_2. Transfer of ownership needs to be explicitly guaranteed, and at a date soon after completion of an injection project.

5.11 It is very unclear how this theoretical storage resource will be converted commercially into viable storage reserves. At present the subsurface expertise, is held by multinational oil companies. This is not attracted into UK CO_2 storage because of the uncertain investment climate, the lack of guaranteed profitability, and the total lack of forward projections for CO_2 supply as a revenue stream. It is possible to envisage state-led investigations of storage, but this will require hundreds of millions, or billions, of pounds investment during the next decade.

emissions to 2050 http://cement.mineralproducts.org/documents/MPA_Cement_2050_Strategy.pdf

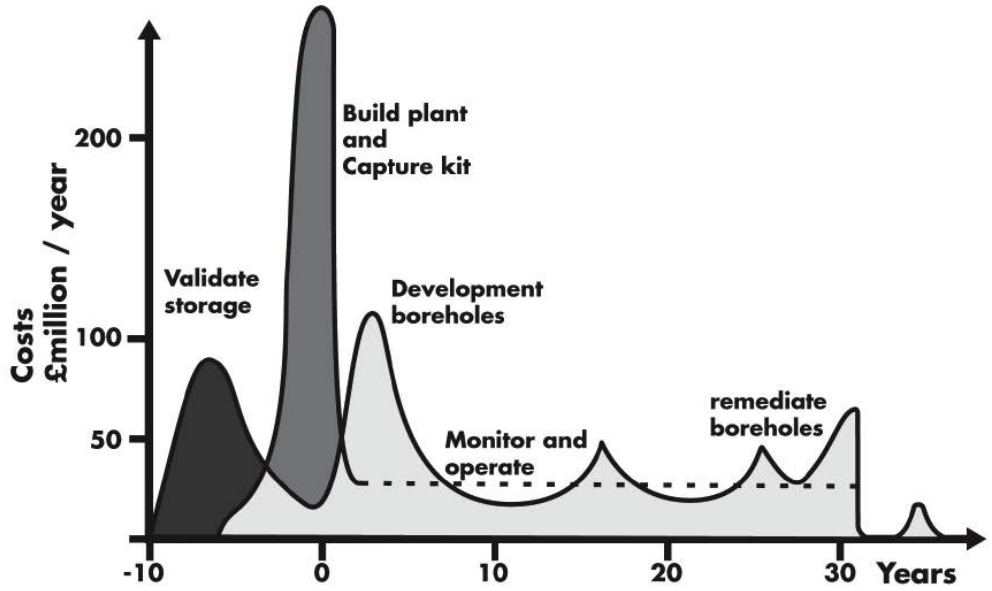

Figure 2. Projected cost comparisions, for illustration only, showing that the conventional consideration of powerplant costs to built and operate (mid-grey curve and dashed line) are incurred shortly before profitable operation starts. These are balanced by low-risk income from electricity sales in a utility business. By contrast, the exploration costs to investigate storage, in just part of one saline formation suitable to accept CO2 from this powerplant and capture project, are committed several years in advance of any income (dark grey graph). Those sunk costs do not inevitably guarantee successful storage, so are a risk. In a good case, if viable storage is confirmed, there will be additional development borehole costs near the commencement of storage (pale grey). Additional costs will occur during the project lifetime for remediation and control of the injected CO2, as well as borehole sealing work at the end of injection life and at least one monitoring survey after site closure (pale grey). This compilation ignores the pipeline construction and transport costs. Subsurface expenditure could approach that of the surface powerplant and capture equipment. Haszeldine RS 2012 Energy and Environment 23, 437 - 450

5.12 Lack of commercially proven storage is likely to become a blockage in approving end-to-end commercial CCS projects. Whoever investigates CO_2 storage offshore, it is essential that the data gained are freely available to undertake academic research at no charge, and to be used as incentives to attract investigations by additional developers.

5.13 Continued inconsistencies between carbon budgets, gas strategy, EMR aims and industrial policy have swamped past signals of a growing market for CCS in the UK. The Office of CCS within DECC is also responsible for fossil fuel policy, but current policy proposals are biased towards continued unabated gas use with CCS noticeable by its absence.

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