Congestion, Capacity, Carbon: Priorities for National Infrastructure – Consultation Response

WP SCCS 2018-01

Congestion, Capacity, Carbon: Priorities for National Infrastructure – Consultation Response

SCCS response to the National Infrastructure Commission consultation on priorities for national infrastructure

January 2018

Authors:

Rebecca Bell, Policy and Research Officer,

Prof R Stuart Haszeldine, SCCS Director

Dr Peter Brownsort, Scientific Research Officer

Dr Maxine Akhurst

Prof Eric Mackay

Scottish Carbon Capture & Storage

Scottish Carbon Capture & Storage
Edinburgh Centre for Carbon Innovation
High School Yards, Infirmary Street, Edinburgh, EH1 1LZ
Telephone +44 (0)131 651 4647 www.sccs.org.uk

SCCS

Congestion, Capacity, Carbon: Priorities for National Infrastructure – Consultation Response

1 Carbon Capture and Storage

Carbon capture and storage (CCS) is a set of technologies that can reduce emissions of carbon dioxide (CO_2) at source to prevent increased atmospheric concentrations of the gas, which cause climate change. The approach of SCCS is to consider that the UK future ambition on reducing carbon emissions requires a *CO_2 removal and storage service* for industry, heat, transport, and power. That requires infrastructure consisting of pipelines, shipping, and associated gas compression and gas separation facilities. There is a market failure in the UK to provide these facilities commercially. Consequently, state intervention is needed to create these initial networks, suitable for later privatisation.

The capture, transportation and storage of CO_2 already takes place commercially, for example, in the drinks industry and for fire extinguishers and reinjection into oil fields (enhanced oil recovery, or EOR). Thousands of kilometres of CO_2 transportation pipeline have operated in North America since the early 1970s. Several CO_2 pipes are operating offshore. There is a well-established industrial capture and transportation network for CO_2 utilisation in Rotterdam. CCS will deploy this knowledge at large scale for the purposes of climate mitigation.

CCS is currently the only option that would enable deep emissions reductions for many energy-intensive and process industries, such as steel, cement, chemicals and refineries. It will thereby enable innovation and the retention of high-value jobs within Europe's high-carbon manufacturing industries.

There is active consideration of converting heat networks, which supply industry and large domestic regions of the UK, to hydrogen. CCS will enable the supply of low-carbon hydrogen derived from steam methane reforming (SMR) at a cost five to 10 times less than hydrogen derived from renewable electricity.

When CCS is used with sustainable biomass or air capture technology, it can provide "negative emissions", which actively reduce the stock of harmful CO_2 in the atmosphere. Planning for transportation infrastructure for re-captured CO_2 needs to be combined with planning for industry, power and hydrogen across the whole UK economy.

The deployment of CCS at commercial scale across the whole economy has repeatedly been calculated to reduce the overall costs of decarbonisation and enable faster emissions reductions in line with scientific advice on the risks of climate change.

Decisions on CCS infrastructure are already pressing. Commercial developers are seeking to retain existing onshore and offshore pipelines to begin to develop low-cost CO_2 transport and storage networks, in line with the Oxburgh report's recommendations[1] [add ref here?]; while, at the same time, pipeline operators are seeking to accelerate decommissioning of the same infrastructure. There

[1] *Lowest Cost Decarbonisation for the UK: The Critical Role of CCS*, Report to the Secretary of State for Business, Energy and Industrial Strategy from the Parliamentary Advisory Group on Carbon Capture and Storage (CCS), September 2016. http://www.ccsassociation.org/news-and-events/reports-and-publications/parliamentary-advisory-group-on-ccs-report/

appears to be no infrastructure oversight and coordination between BEIS, The Crown Estate, and the Oil and Gas Authority, which could result in a net loss of hundreds of millions of pounds.

CCS is recognised as an important infrastructure issue for Europe: the European Commission has identified four Projects of Common Interest (PCIs) relating to the cross-border transport of CO_2, including two to the UK. PCIs are key infrastructure projects, which link the energy systems of EU countries with the intention of helping the EU overall meet its energy policy and climate change objectives. They are eligible for funding under the Connecting Europe Facility.

2 Scottish Carbon Capture and Storage

Scottish Carbon Capture and Storage (SCCS) is the largest CCS research group in the UK. It is a partnership of the British Geological Survey, Heriot-Watt University, the University of Aberdeen, the University of Edinburgh and the University of Strathclyde working together with universities across Scotland. SCCS is funded by the Scottish Funding Council (SFC) and the Scottish Government.

Our mission is to enable CO_2 emissions reduction through CCS research and knowledge exchange.

SCCS researchers and the supporting delivery team work with academics, business, industry, the public, regulators and policymakers worldwide to undertake research and facilitate dialogue towards CO_2 emissions reduction. A recognised centre of excellence, SCCS provides independent and trusted advice to address the global challenge of climate change through economically robust CCS solutions.

Our comments on the National Infrastructure Commission (NIC) report relate only to issues relevant to CCS. We would be pleased to provide the National Infrastructure Commission with any further information that they might need, and to work with them to explore these issues further.

3 Role of CCS in the UK economy

The NIC report discusses CCS almost entirely in the context of electricity generation. We would argue that this is both outdated and lacking in vision. CCS has a much bigger role to play in the wider economy: it is currently the only way to decarbonise many industries (those that rely on fossil fuels for a high heat demand, or that generate CO_2 as part of their industrial process), and it can be combined with steam methane reforming to produce hydrogen, which can be used to deliver low-carbon commercial and domestic heat and transport.

The industrial Sector Plans developed with industry bodies and published by the UK Government in 2017 highlight the importance of CCS in retaining skilled jobs by making high-emitting industries less carbon-intensive, and thus future-proofing them against future measures to reduce global emissions. The plans for cement, oil refining and chemicals industries include actions to facilitate the delivery of carbon capture, utilisation and storage (CCUS): between these three industrial sectors, the plans estimate that CCUS could reduce the UK's emissions by nearly 50 million tonnes per year by 2050.[2]

In addition to the role that CCS can play in reducing direct emissions from industrial processes, further emissions reductions can be achieved by replacing fossil fuels with hydrogen: hydrogen is a low emitter of greenhouse gases at the point of combustion, making it suitable to decarbonise

[2] The seven Industrial decarbonisation and energy efficiency action plans can be downloaded at https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-action-plans

dispersed emissions sources, such as heating and transport. Producing hydrogen through SMR generates CO_2 but, if combined with CCS, that CO_2 can be efficiently and cost-effectively captured at the point of production. Where industries with high heat demand are connected to hydrogen production facilities, they could use hydrogen as their fuel source, avoiding the need to install carbon capture plant on their own operations. A key point here is that a CO_2 removal network needs to be planned for, providing a service for users towards the greater public good. As stated in the Oxburgh report, it is extremely unlikely that individual CO_2 capture projects will be large enough, or have adequate finances, to shoulder the entire burden of network development. CO_2 removal networks are an archetypal case where the state must enable the creation of a network, with a network operator who can also create a market. This would provide a service to multiple small-scale users – a related example is the growth of the UK natural gas distribution network, which grew out of a state-funded distribution spine and was later privatised.

The NIC report appears to discount hydrogen as a decarbonisation option, because CCS is not currently operational in the UK.[3] This is a circular argument and could be viewed as an excuse for inaction. If the NIC identifies the lack of CCS in the UK as a barrier to developing a low-carbon industry with a significant role to play in reducing hard-to-treat emissions, that demonstrates the importance of additional investment in, and support for, CCS. It is clear from the United Nations Environment Programme that CCS is not optional, it is an imperative if we are to keep global warming to safe levels.[4] The government's own advisory body, the Committee on Climate Change, has stated that the Fifth Carbon Budget (2028-32) will be very difficult to achieve without CCS.[5] Studies show the essential contribution of CCS to cost-effective UK decarbonisation[6] and point to the heavy cost penalties that will be imposed on UK consumers by a failure to enact an effective CCS policy.[7] These penalties can be expected to start during the early 2020s due to the intended rise in the European carbon price, following re-structuring of the EU Emissions Trading System. Whether the UK is inside or outside markets at that point is irrelevant as the UK is likely to shadow or go higher than European prices.

A 2017 study into the value of CCS for the UK found that its development around an East Coast infrastructure network of pipelines and shipping could lead to the creation and/or retention of 225,600 jobs, and £54 billion in gross value added (GVA) cumulatively by 2060 (the date conservatively assumed to be the end of the asset life for the infrastructure). The study noted the UK's significant potential for storing CO_2 from other countries as well as benefits from the import and export of CCS-related goods and services as potential up-sides for the UK, but made no direct calculation of that value, partly because of missing infrastructure.

This East Coast study considered the impacts of delaying deployment of fully operational CCS infrastructure by ten years to 2035. It found that such a delay would result in 75,000 fewer jobs, and £21bn less GVA, as well as reductions in health and wellbeing benefits.

An option, being considered by government, to capture CO_2 at UK sites then transport it for storage by another country (e.g. Norway), would lead to costs around three times greater than developing our own storage in the UK. It would also retain the high costs of capture and transport but lose the job creation and wealth associated with CCS deployment.[8]

---

[3] Page 115
[4] *The Emissions Gap Report 2017*. UNEP 2017, https://wedocs.unep.org/bitstream/handle/20.500.11822/22070/EGR_2017.pdf?sequence=1&isAllowed=y
[5] *Meeting Carbon Budgets: Closing the policy gap*. Committee on Climate Change, 2016. https://www.theccc.org.uk/wp-content/uploads/2017/06/2017-Report-to-Parliament-Meeting-Carbon-Budgets-Closing-the-policy-gap.pdf
[6] http://www.ccsassociation.org/news-and-events/reports-and-publications/parliamentary-advisory-group-on-ccs-report/
[7] *Carbon Capture and Storage: Potential for CCS in the UK*. Energy Technologies Institute, 2014. https://s3-eu-west-1.amazonaws.com/assets.eti.co.uk/legacyUploads/2014/03/ETI_CCS_Insights_Report.pdf
[8] *Clean Air - Clean Industry - Clean Growth: How carbon capture will boost the UK economy*. Summit Power, 2017. http://www.ccsassociation.org/news-and-events/reports-and-publications/clean-air-clean-industry-clean-growth/

4 Corrections to figures in Congestion, Capacity, Carbon

4.1 Table 4.1 (page 120)

We would dispute the cost estimates given in this table for gas with CCS:

- The cost of CCS on power in the UK is calculated by the Cost Reduction Task Force (2013) to decrease to £80-90 per MWhr, based on shared infrastructure efficiency rather than any new process invention.[9]
- Poyry reporting to UK Government (2016) confirmed a CCS system cost of £80-90 per tonne for a system with shared infrastructure.[10]
- The Global CCS Institute estimates a levelised cost of energy for gas power with CCS in the USA of 79-90 USD/MWh (2014 dollars)[11] - £58-67 per MWh.[12]
- Costs for CCS are shown in the ETI report by Pale Blue Dot Energy on offshore storage – where new-build pipeline and storage sites range from £10 to £20 per tonne of CO_2, providing enough storage capacity for the UK in 2030.[13]
- The cost of CO_2 capture, combined with transport and storage, is shown for industry by the Teesside project illustrations – depending on the industrial process, this is £50-£200 per tonne of CO_2 transported and stored.[14]

We would dispute the emissions ranges given in the table for gas with CCS: the CCS Cost Reduction Task Force report suggests an emissions range of 30-70 g-CO_2/kwh.[15]

4.2 "What is carbon capture and storage?" (page 127)

This explanatory section contains some elementary errors and should be re-worked. We would be happy to assist with this.

A 90% capture rate is what is normally considered as typical, and a reasonable balance between cost and capability, but the capture rate can be higher or lower depending on the objectives and economics of a particular project.

The introductory paragraph should replace "salt caverns" with "saline aquifers": salt caverns are commercially useful for methane gas storage and hydrogen storage, and may be useful for temporary buffer storage (for days or weeks) of CO_2 destined for re-use in a carbon utilisation system, but not for permanent CO_2 storage. The well-researched options for CO_2 storage at the tens of millions of tonnes per year required by the UK until the end of the century, are deep offshore aquifers filled with saline water. Those have been studied in detail, costed and publicly reported with open access by SCCS,[16] the Energy Technologies Institute[17] and industry.[18]

[9] https://www.gov.uk/government/groups/ccs-cost-reduction-task-force
[10] https://www.theccc.org.uk/wp-content/uploads/2016/07/Poyry_-_A_Strategic_Approach_For_Developing_CCS_in_the_UK.pdf
[11] https://www.globalccsinstitute.com/insights/authors/LawrenceIrlam/2015/07/24/levelised-costs-electricity-ccs
[12] source for currency conversion: xe.com, 11 January 2018
[13] http://www.eti.co.uk/programmes/carbon-capture-storage/strategic-uk-ccs-storage-appraisal
[14] http://www.eti.co.uk/programmes/carbon-capture-storage/strategic-uk-ccs-storage-appraisal
[15] See Table 1.1 in https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/198823/ccsa_ctrf_interim_report.pdf
[16] http://www.sccs.org.uk/expertise/reports/co2multistore-joint-industry-project; http://sccs.org.uk/news/394-brine-production-can-greatly-enhance-co-storage-potential-of-north-sea-aquifers-new-study-finds; http://sccs.org.uk/images/expertise/reports/progressing-scotlands-co2/ProgressingScotlandCO2Opps.pdf
[17] CO_2Stored website and database, www.co2stored.co.uk; Strategic UK CCS Storage Appraisal: http://www.eti.co.uk/programmes/carbon-capture-storage/strategic-uk-ccs-storage-appraisal

In the legend to Figure 4.5, we recommend that the word "dense" is deleted from point 5, and that the word "up" is deleted from point 6.

In relation to the paragraph which follows this, we would point out that, although there are 17 large-scale CCS projects in operation, there are numerous smaller scale projects and those that use one or more of the suite of CCS technologies but do not constitute a full-chain CCS system.

The penultimate paragraph in this section should be amended to state that it is carbon dioxide (not carbon) that is used in enhanced oil recovery (EOR). Although current practice of EOR is generally carried out with the aim of producing oil rather than sequestering carbon, a high proportion of the CO_2 used in the process *is* stored indefinitely. It is possible to manage EOR in a way that sequesters much higher amounts of the CO_2 used in the process,[19] as well as allowing for additional CO_2 to be stored once oil recovery is complete. If CO_2-EOR were to be used in the UK, we would advocate for this more stringent management approach to ensure that the process delivered a genuine reduction in CO_2 over the lifecycle of the operation.

The paragraph should also be amended to reflect the fact that CCS can also be applied to industrial processes: either those that have a high fossil fuel demand (such as steel manufacture) or those that have high CO_2 emissions as a result of the process (such as cement production).

5 Consultation question 17

What are the critical decision factors for determining the role of carbon capture and storage in the UK in scenarios where electricity either does, or does not, play a major role in the decarbonisation of heat? What would be the most cost-effective way to bring it forward?

This question assumes that the only role for CCS is in decarbonising fossil-fuel electricity generation, whereas, as stated above, CCS has a crucial role to play in the decarbonisation of industry and, potentially, in decarbonising heat and transport using hydrogen.

We recommend that the NIC revisit its assumptions about hydrogen in the energy mix as well as the role of CCS in the economy to ensure that all options are adequately assessed and accounted for in future work.

CO_2 can be transported for geological storage under the North Sea by either ship or pipeline. The UK is well served with existing oil and gas pipelines, which can be assessed for repurposing to transport CO_2, with considerable potential savings over constructing new pipelines. There is a tension between the possibility of leaving pipelines *in situ* for future potential use (incurring maintenance and leasing fees for the owner) and the drive to decommission quickly and at lowest cost. Several pipelines[*] have been identified as key for CO_2 transport to support lowest-cost CCS, but their retention has not yet been developed into an economically viable proposition, so they are still in the frame to be decommissioned in the near future. In the interests of delivering lowest cost decarbonisation through CCS, we urge the NIC to use its influence to safeguard them from immediate decommissioning, and look into how they might be retained for potential future re-use: this may require a public (or other) body to take on their ownership and liabilities.

[18] CCS Cost Reduction Task Force: https://www.gov.uk/government/groups/ccs-cost-reduction-task-force; Lord Oxburgh Report: http://www.ccsassociation.org/news-and-events/reports-and-publications/parliamentary-advisory-group-on-ccs-report/

19 See CO_2-EOR Joint Industry Project (http://www.sccs.org.uk/expertise/reports/co2eor-joint-industry-project#co₂-management-and-environmental-impacts), particularly Stewart RJ & Haszeldine RS, *Carbon Accounting for Carbon Dioxide Enhanced Oil Recovery*, November 2014 (http://www.sccs.org.uk/images/expertise/misc/SCCS-CO2-EOR-JIP-Carbon-Balance.pdf)

[*] Initial priorities are Atlantic and Cromarty, Miller and Goldeneye

The CO_2 transport and storage elements of CCS should be considered as infrastructure to support decarbonisation of carbon-intensive industries. By its nature, this infrastructure will have an investment profile that is unattractive to private investors: high up-front costs and risks, with a long return period (but also a long asset lifetime). The Oxburgh report recommends that this infrastructure is therefore provided by the state in the first instance, through a CCS Delivery Company, including a transport and storage company, that can later be privatised.

Electrification is one possibility for decarbonising heat, although it would require significant disruption to domestic and non-domestic buildings and would be likely to require flexible operation of thermal generation with CCS to address the intermittency of renewable generation. An alternative is to repurpose the recently renovated natural gas distribution network and use it to supply hydrogen to domestic heating and cooking appliances and industrial users. A switch to hydrogen has the advantage that the seasonal peak heat demand can be met by hydrogen, which has been stored through the year and hence without further material change to the distribution network.

A key to this is the utilisation of a pervasive, existing modernised distribution network and a safe and strengthened infrastructure to store and distribute the hydrogen, as found feasible by the H21 Leeds City Gate project.[20] Hydrogen supply to industry for heat at even less cost is found feasible by the Liverpool-Manchester Hydrogen Clusters project.[21] Both of these require CO_2 removal services. In evidence to the Scottish Parliament Economy, Jobs and Fair Work Committee, SCCS concluded that "the substantial conversion of heating to hydrogen is feasible in the 15-year timescale being considered. But it is ambitious and would need rigorous planning."[22]

5.1 Options for low-cost start-up of CO_2 removal infrastructure

A smart way to develop CO_2 removal infrastructure is to link initial networks onto sites with industrial emitters, rather than seek to initiate CCS by developing high-cost capture on power plant in the face of competition from low-cost renewables. For example, in Scotland, the Acorn project, undergoing feasibility studies, can re-use legacy pipeline and CO_2 separation infrastructure on natural gas production to build and operate CCS, at small scale by 2022.[23] Once the initial system is operating, it can then be built out and linked to very low-cost capture sites at industries in Central Scotland, again using legacy pipelines.

5.2 CO_2-EOR: profitable development of infrastructure

It is possible to make a profit from captured CO_2 by using it for CO_2-EOR at mature oil fields. This offers the opportunity to extend the life of offshore infrastructure and defer decommissioning costs to HM Treasury of multiple billions of pounds.[24] The option of CO_2-EOR is so well established that Norwegian company, Statoil, is seeking to develop such opportunities in the North Sea but is waiting for a reliable CO_2 supplier.

If regulated effectively, CO_2-EOR can store tens of millions of tonnes of CO_2 per year at no cost to the taxpayer and can be followed by CO_2 disposal. That will also enable the full life-cycle of the project to be strongly negative, i.e. a net CO_2 store even including the carbon footprint of the additional oil extracted.[25]

---

[20] https://www.northerngasnetworks.co.uk/wp-content/uploads/2017/04/H21-Report-Interactive-PDF-July-2016.compressed.pdf
[21] https://cadentgas.com/About-us/Innovation/Projects/Liverpool-Manchester-Hydrogen-Cluster
[22] *Supplementary evidence to the Scottish Parliamentary Committee on Economy, Jobs and Fair Work: CCS and heat.* SCCS, 2017. http://www.sccs.org.uk/images/expertise/reports/working-papers/WP_SCCS_2017_01_CCS_and_Heat.pdf
[23] http://www.actacorn.eu/about-act-acorn
[24] CO_2-EOR Joint Industry Project http://www.sccs.org.uk/expertise/reports/co2eor-joint-industry-project
[25] CO_2-EOR Joint Industry Project andStewart, RJ & Haszeldine, RS 2015, *Can producing oil store carbon? greenhouse gas footprint of CO_2-EOR, offshore North Sea*, Environmental Science and Technology, vol 49, no. 9, pp. 5788-5795. DOI: 10.1021/es504600q

5.3 Infrastructure: role with coal?

We note the recent policy statement by the Department for Business, Energy & Industrial Strategy concerning the phase-out of unabated coal use for electricity generation in the UK by 2025. This imposes an instantaneous emission standard of 450g CO_2 per kilowatt hour of electricity, which would continue to permit electricity generation using coal if a power plant was fitted with at least 50% CCS. Although SCCS does not advocate a continuing role for coal in the UK's energy mix, we recognise that it remains a low-cost fuel to supply, and has advantages of stockpiling for energy storage. However, the lack of CCS infrastructure means that any commercial valuation of the options for coal would not stack up. In the case of power generation, this is not a problem because of the availability of other lower carbon options for generating electricity. But it does illustrate the way that the lack of a CO_2 removal service is already affecting forward planning by the UK for industry, heat and power.