SCCS WP 2018-05

Climate Change (Emissions Reduction Targets) (Scotland) Bill

SCCS evidence to Environment, Climate Change and Land Reform Committee

August 2018

Authors:

Rebecca Bell, Policy & Research Officer,

Dr Peter Brownsort, Scientific Research Officer,

Dr Philippa Parmiter, SCCS Project Manager,

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

Evidence on the Climate Change (Emissions Reduction Targets) (Scotland) Bill

1 Key points

- Carbon capture and storage (CCS) will have a key role to play in meeting Scotland's new greenhouse gas emissions target
- Meeting the Paris Agreement ambitions will require negative emissions technologies, such as capturing and storing carbon dioxide (CO_2) from biogenic sources
- Scotland is in a strong position to begin deploying CCS, and is at the forefront of CCS research
- We urge the Scottish Government to continue working closely with the UK Government to develop a deployment pathway for CCS that enables Scotland to make the most of its potential

2 Introduction

Scottish Carbon Capture & Storage (SCCS) is a research partnership of the British Geological Survey, Heriot-Watt University, University of Aberdeen, the University of Edinburgh and the University of Strathclyde with associate member the University of St Andrews. SCCS researchers are engaged in innovative applied research and joint projects with industry and government to support the development and commercialisation of carbon capture and storage as a climate change mitigation technology.

2.1 Scottish Government consultation

SCCS responded to the Scottish Government's 2017 consultation on a Scottish Climate Change Bill[1], and some of our comments are restated elsewhere in this evidence. Both Committee on Climate Change Scenarios – Central and High Ambition – show the vital role of carbon capture and storage, including in conjunction with bioenergy.

SCCS does not have a view on when to set a net-zero greenhouse gas emissions target year, but we do believe it would be appropriate at the present time to set a **net zero CO_2** emissions target for 2050.

[1] Available at: http://www.sccs.org.uk/images/expertise/reports/working-papers/WP_SCCS_2017_06_consultation_Scottish_Climate_Change_Bill_SCCS_response.pdf

3 Provisions to set a Net Zero Emissions target in the future

We believe it would be appropriate at the present time to set a net zero CO_2 emissions target for 2050, as set out in the Committee on Climate Change's advice[2] as "Option 2", and that this distinction between GHG and CO_2 targets should be made clear.

It is important to differentiate between GHG targets, which may be expressed as carbon dioxide equivalent (CO_2-e) targets but include other gases, and actual CO_2 targets – and to use the correct terms. Equally important is to recognise that a 90% GHG reduction target may encompass, indeed is likely to require, a near-zero, net-zero or below-zero level of CO_2 emission.

Provided CO_2 emissions from industrial processes and fossil fuel use are reduced in line with the proposed 90% reduction target by 2050, through all the measures currently envisaged (including energy efficiency, fuel switching, renewables, gas grid decarbonisation with hydrogen and CCS), there is a real potential for Scotland to achieve a net zero CO_2 balance in this timescale. This achievement would be sustainable, as required by the 2015 Paris Agreement, and would strengthen Scotland's place amongst the leading nations in GHG emissions reduction.

4 Challenges associated with implementation of the Bill

CCS will be essential for meeting Scottish targets; furthermore, CCS combined with bioenergy is a front-running 'negative emissions' technology and so is expected to be crucial for meeting the Paris Agreement ambition to limit warming to below 1.5°C.

Therefore, CCS deployment will be essential to meeting a 90% or more greenhouse gas emissions reduction target. As well as allowing deep emission reductions from industry,[3] it allows the bulk production of hydrogen, when combined with steam methane reforming, which can be used as a zero-CO_2 fuel in heating and transport, areas which are otherwise hard to decarbonise and make up around 50% of Scotland's annual emissions[4].

However, there are some persistent myths that are hampering efforts to deploy CCS. Some of these are addressed below:

4.1 Technology readiness

"The technology is extremely uncertain."[5]

SCCS categorically rejects the suggestion that CCS technology is uncertain.

The Scottish Government's briefing, *When to set a net-zero greenhouse gas emissions target year*[6], discusses CCS in a section entitled "Making legally binding commitment that are dependent on as yet undeveloped technological advancement and cannot be properly scrutinised". This gives a

[2] Available at: https://www.theccc.org.uk/wp-content/uploads/2017/03/Advice-to-Scottish-Government-on-Scottish-Climate-Change-Bill-Committee-on-Climate-Change-March-2017.pdf
[3] SCCS (2016), *Scottish CO_2 Hub: A unique opportunity for the United Kingdom*. Available at: http://www.sccs.org.uk/images/expertise/reports/working-papers/WP_SCCS_2016_01_Scottish_CO2_hub.pdf
[4] National Atmospheric emissions Inventory (2018) *Report: Greenhouse Gas inventories for England, Scotland, Wales & Northern Ireland: 1990-2016*. Available at http://naei.beis.gov.uk/reports/reports?report_id=958
[5] Russon, T, Scottish Government, evidence to ECCLR Committee, 19 June 2018. Official report available at: http://www.parliament.scot/parliamentarybusiness/report.aspx?r=11612
[6] Available at: https://www.gov.scot/Publications/2018/05/3939/0

misleading impression of the technical feasibility of CCS, which is operating all over the world[7], including more than 20 years of offshore geological CO_2 storage in the Sleipner field[8], in Norwegian waters, which uses the same rock formations as CCS storage sites identified in waters held in the Scottish Crown Estate[9]. Furthermore, CO_2 has been captured in Scotland for decades as part of the gas sweetening process at St Fergus gas terminal; however, that CO_2 has always been vented to atmosphere rather than securely stored.

Research at Scottish universities includes developing more efficient CO_2 capture materials and process; improving our understanding of CO_2 storage and how CO_2 behaves in the subsurface; and monitoring safety and security[10].

4.2 Scotland's ability to deploy CCS

CCS and BECCS "are big technologies that will be developed and deployed effectively only on a multinational scale. They are simply beyond the scope of what a small country can do unilaterally […] We are limited, to an extent, by the pace of development internationally"[11]

CCS is an area in which Scotland is at the forefront of research and understanding. Scottish Carbon Capture and Storage[12] is the UK's largest CCS research group in the UK and has a strong track record of high-level research into all aspects of CCS. Our researchers and their work support industry, regulators and government. We have led on several reports commissioned by the Scottish Government, and undertaken projects with international partners in, for example, the US, South Korea and Norway, and with the Global CCS Institute. We have forged strategic links with industry, and more than 60 business partners have been involved in our projects to date. We have also managed a number of Joint Industry Projects (JIPs) with leading companies including: CO_2MultiStore[13]; CO_2-EOR (CO_2-Enhanced Oil Recovery for the North Sea)[14]; CO_2 Impurities[15]; Phase Behaviour & Properties of CO_2-Oil Systems[16].

Despite the importance of international projects, deployment of CCS will always be specific to local circumstances: local decisions on the appropriate CO_2 capture process to a particular operation; local decisions on appropriate CO_2 transport infrastructure – particularly taking into account local opportunities to reuse existing pipelines; and detailed understanding of a country's unique CO_2 storage resources.

Scotland has two CCS projects for which feasibility studies have been, or are being carried out[17], and a wealth of information on CO_2 storage resources; this places Scotland in an advantageous position compared to most of the rest of Europe. Furthermore, it has a combination of onshore and offshore pipeline assets that could be repurposed for CO_2 transport, and a cluster of high emitting industries that are ideally placed to take advantage of this infrastructure and reduce deployment costs.

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[7] See SCCS's Global CCS Map, available at: http://www.sccs.org.uk/expertise/global-ccs-map
[8] See https://www.bgs.ac.uk/science/CO2/home.html
[9] http://www.co2stored.co.uk/home/index
[10] See http://www.sccs.org.uk/expertise/reports, http://www.sccs.org.uk/expertise/reports/working-papers, http://www.sccs.org.uk/expertise/publications
[11] Russon, T, Scottish Government, evidence to ECCLR Committee, 19 June 2018. Official report available at: http://www.parliament.scot/parliamentarybusiness/report.aspx?r=11612
[12] SCCS has five member institutions: University of Edinburgh, British Geological Survey, Heriot-Watt University, University of Aberdeen and University of Strathclyde. More information here: www.sccs.org.uk
[13] http://www.sccs.org.uk/expertise/reports/co2multistore-joint-industry-project
[14] http://www.sccs.org.uk/expertise/reports/co2multistore-joint-industry-project?id=237
[15] http://www.sccs.org.uk/images/expertise/projects/co2-impurities/JIP-CO2-Impurities.pdf
[16] http://www.sccs.org.uk/images/expertise/projects/co2-oil-systems/JIP-CO2-Oil-Systems.pdf
[17] Acorn (https://pale-blu.com/acorn/ and the Caledonia Clean Energy Project (https://summitpower.com/wp-content/uploads/2018/06/CCEP-Feasibilility-Final-Report-MAY-2018-SUMMARY-VERSION.pdf). There is also a wealth of published information and expertise developed during the cancelled Peterhead CCS project: https://www.gov.uk/government/collections/carbon-capture-and-storage-knowledge-sharing

4.3 Readiness to deploy bioenergy with CCS (BECCS)

A project is underway to demonstrate bioenergy with carbon capture and storage (BECCS) at Drax power station in Yorkshire. BECCS is usually described – as it is in the Scottish Government briefing - as purpose-grown crops that are then combusted to provide power (and/or heat), with the CO_2 captured and stored. However, the briefing was incorrect in linking food-source biomass to combustion: ("Biomass, such as maize or rapeseed, is grown as an input the combustion process"[18]). This does not occur to any extent in Scotland. Indeed, maize is not generally grown in Scotland, and rapeseed is predominantly used for foodstuff; in countries where maize and rapeseed are used for energy it is for bioethanol and biodiesel respectively, both of which are used for transport, which could not realistically be combined with CCS.

The stored CO_2 from the BECCS process is considered to be a negative emission due to the 'renewable' nature of biomass and the fact that emissions from biomass combustion are not routinely counted in greenhouse gas inventories. However, BECCS could also apply to the combustion of biogas and biomethane from anaerobic digestion (AD), as well as to the CO_2 co-produced as part of the AD process. Further unaccounted-for biogenic CO_2 emissions are also produced by fermentation processes such as distilling and brewing, and indeed some CO_2 capture is already happening in this industry: North British distillery has been capturing fermentation CO_2 for over 30 years, and supplying it for use elsewhere in the food and drink industry.

Unpublished research by SCCS estimated the potential for near-term deployment of BECCS in Scotland based on estimates of current biogenic CO_2 emissions, and the options for CO_2 transport, including the potential to re-use existing pipeline infrastructure. The main findings of the report are:

- The total emission in Scotland of biogenic CO_2 from the sectors considered is estimated to be in the order of 3.5 million tonnes of CO_2 per year (Mt-CO2 /yr) in recent years.
- From biomass combustion (for heat only or for CHP) emissions are estimated at 2.44 Mt-CO_2/yr.
- From AD processes of all types (landfill, sewage treatment, wet-waste and crop residue) emissions are estimated at 0.56 Mt-CO_2/yr, mostly from landfill gas operations.
- From fermentation to produce alcohol (beer, grain spirit, malt whisky) emissions are estimated at 0.47 Mt-CO_2/yr.
- Around 60% of the total biogenic emission (2.1 Mt-CO_2/yr) is from 32 facilities at 29 locations, each with biogenic CO_2 emission ranging from over 10,000 t-CO_2/yr to over 400,000 t-CO_2/yr.
- Available CO_2 capture and liquefaction equipment suitable for these scales has been identified from a number of suppliers; it is available at scales smaller than the 10,000 t-CO_2/yr threshold chosen in this study.
- Of the 32 facilities, most are in Scotland's Central Belt and 23 are within 40 km of the Feeder 10 pipeline, identified as potentially forming a trunk route for a developing CO_2 transport infrastructure in Scotland.

[18] https://www.gov.scot/Publications/2018/05/3939/0 page 7

- Technical options for CO_2 transport are available for all identified emitters; by road transport for smaller-scale emitters, possibly by rail for medium to larger-scale emitters, which are not close to other emitters or to Feeder 10, or by a pipeline collection network.

- A CO_2 transport consolidation hub could be located in Grangemouth, or west or northwest of Falkirk. The ideal location would depend on the involvement of other major industries and on the long-term trunk transport method, which could potentially be by onshore or offshore pipeline or by shipping.[19]

Capture and storage of biogenic CO_2 from bioenergy or from fermentation industries is an area where Scotland could take a global lead by investing to develop such opportunities and can be used to offset difficult to control emissions of other greenhouse gases from elsewhere in the economy.

4.4 Cost of CCS

"The costs involved in such technologies are very large"[20]

It is true that the costs of CCS are high, but the impact CCS can have on greenhouse gas emissions is also high: CCS is currently the only way to decarbonise many industries, and it offers the opportunity to produce low-carbon hydrogen which can be used in other hard-to-decarbonise areas of the economy such as heat and transport. The Lord Oxburgh[21] report found that CCS is the most cost-effective route to decarbonisation: the aim now must be to create the policy and legislative environment that will drive uptake of CCS. The CCUS Cost Challenge Task Force, set up by the UK Government, has recently reported its recommendations to reduce the cost of deploying CCS, and the Government is expected to announce a deployment pathway by the end of 2018. This is expected to include funding opportunities to decarbonise industrial clusters.

The Scottish Government's briefing paper presents costs for CCS that are based on out-of-date figures – for example a 2007 report for the cost of CCS on a refinery. The costs also do not take into account the value of maintaining industry in Scotland, and the lack of alternative decarbonisation options for industries with process CO_2 emissions (unavoidable CO2 emissions resulting from the process, not related to energy use), or high heat demand that is difficult to meet without fossil fuels.

More recent studies by the Teesside Collective suggest a cost of £58/tCO_2[22] for industrial carbon capture – significantly lower than the £330/tCO_2 suggested in the briefing paper. Furthermore, discussion of CCS on a power station comparable to Peterhead is unlikely to be relevant as Scotland shifts the bulk of its generation to renewable energy sources. Fossil fuel power may be needed to provide peaking and balancing services to the grid, but this is likely to be smaller and more demand-responsive[23].

The briefing paper states that "As the volume of emissions captured increases, more expensive processes need to be deployed, with removing the remaining emissions becoming more technically challenging." It is true that CO_2 capture is easier, and therefore less expensive, the more concentrated the stream CO_2: so fermentation emissions (almost pure CO_2) are significantly easier to capture than emissions from a gas power plant (where the CO_2 is mixed with nitrogen and excess oxygen from combustion air). However, it is also the case that deployment of CCS technology –

[19] Brownsort, P, report awaiting publication
[20] Russon, T, Scottish Government, evidence to ECCLR Committee, 19 June 2018. Official report available at: http://www.parliament.scot/parliamentarybusiness/report.aspx?r=11612
[21] Parliamentary Advisory Group on Carbon Capture and Storage (2016), Lowest Cost Decarbonisation for the UK: The critical role of CCS. Available at http://www.ccsassociation.org/news-and-events/reports-and-publications/parliamentary-advisory-group-on-ccs-report/ report
[22] Teesside Collective (2017) *A Proposition for an Industrial Carbon Capture & Storage (CCS) Pilot*. Available at: http://www.teessidecollective.co.uk/wp-content/uploads/2017/02/Teesside-Collective-—-a-proposition.pdf
[23] https://summitpower.com/wp-content/uploads/2018/06/CCEP-Feasibilility-Final-Report-MAY-2018-SUMMARY-VERSION.pdf

learning by doing – will bring down the unit cost as lessons learned from one project are carried over into the next; likewise, as the scale of CO_2 capture plant increases, the cost per unit of CO_2 captured will reduce.

5 Actions that will be required of organisations if Scotland is to meet more ambitious climate change targets

SCCS has demonstrated in a number of working papers the opportunities for Scotland, including A Scottish CO_2 Hub: A Unique Opportunity for the United Kingdom[24], and Scotland's Energy Strategy: The role of carbon dioxide capture and permanent storage[25].

The CCUS Cost Challenge Task Force report had four key messages which support SCCS's position:

- We need to recognise the CCUS opportunity and the urgency of acting now in order to deliver CCUS at scale, at lowest cost.
- CCUS can unlock value across the economy.
- We need viable business models
- We believe that CCUS can already be deployed in clusters at a competitive cost[26]

It also made 16 recommendations to government to unlock industry action on CCS, and we urge the ECCLR committee to ensure that Scottish Government continues to work closely with the UK Government Department for Business, Energy and Industrial Strategy (BEIS) to ensure that Scotland fully benefits from both the emissions reduction and the economic opportunities that this offers. This includes taking urgent action to identify and preserve North Sea oil and gas infrastructure at risk of being decommissioned in the next 5-10 years which could be maintained as "strategic assets" for CCUS use in the future.

CCS can enable deep reductions in emissions across the whole economy. In combination with hydrogen production at large scale by steam methane reforming, CCS can enable deep decarbonisation of domestic and commercial heating, using hydrogen in place of natural gas in the upgraded gas distribution network, thereby preserving the value of the investment made in this network. Widespread availability of "low-carbon" hydrogen may also enable decarbonisation of transport, leading to business opportunities in developing and deploying fuel-cell electric vehicles and in other parts of the transport sector, particularly heavy vehicles. Hydrogen-powered vehicles are already operating in the UK and in several other countries; infrastructure costs for hydrogen as transport fuel may be significantly lower than large-scale upgrading of electrical grid supplies for transport use.

The availability of CCS infrastructure to manage emissions can help protect energy-intensive industries from the effects of carbon pricing and so help retain these industries in Scotland. Such industries, including chemicals, petrochemicals, cement, glass, pulp and paper, and their supply chains, are valued employers and generate significant economic value in Scotland. CCS is the most promising option for large reductions in emissions from these industries and many of them are located in areas that can be serviced by CCS infrastructure. Such areas can develop as low-carbon industry zones, attracting new business growth without increasing emissions.

[24] http://www.sccs.org.uk/images/expertise/reports/working-papers/WP_SCCS_2016_01_Scottish_CO2_hub.pdf
[25] http://www.sccs.org.uk/images/expertise/reports/working-papers/WP_SCCS_2016-07_Scotlands_Energy_Strategy_role_of_CO2_capture_storage.pdf
[26] CCUS Cost Challenge Task Force (2018) Delivering Clean Growth. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727040/CCUS_Cost_Challenge_Taskforce_Report.pdf

Underlying these and other specific business opportunities that will arise from the establishment of a large-scale CCS infrastructure using offshore storage in the North Sea, the development of CO_2 transport and storage facilities opens two significant new business opportunities. One is by extending the productive lifetime of oil fields through CO_2-enhanced oil recovery; the other is by offering CO_2 management and storage services to other states around the North Sea basin.[27] While there are undoubtedly challenges and costs in establishing such infrastructure, there is potential to deliver substantial and long-term revenue streams through sustaining oil production and through service charges for CO_2 storage[28]. This new North Sea CO_2 management industry would complement and progressively replace the waning hydrocarbon production industry, needing much of the same technology and so preserving expertise, maintaining employment and delivering continued economic value to Scotland.

[27] Scottish Carbon Capture & Storage, 2016: http://www.sccs.org.uk/images/expertise/reports/working-papers/WP_SCCS_2016_01_Scottish_CO2_hub.pdf

[28] *Clean Air, Clean industry, Clean Growth: How carbon capture will boost the UK economy* http://www.ccsassociation.org/news-and-events/reports-and-publications/clean-air-clean-industry-clean-growth/