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Business, Energy and Industrial Strategy Committee

Carbon capture usage and storage: third time lucky?

Twentieth Report of Session 2017–19

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Business, Energy and Industrial Strategy Committee

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Experts and policymakers agree that carbon capture usage and storage (CCUS) will be necessary to meet the UK's existing climate change targets at least cost, and that the country could not credibly adopt a 'net zero' target, in line with the aspirations of the Paris Agreement, without the technology. The UK is considered to have one of the most favourable environments globally for CCUS, but the technology has suffered from 15 years of turbulent policy support, including the cancellation of two major competitions at a late stage. No commercial-scale plant has yet been constructed in the UK.

Ambitions and least cost decarbonisation

The Government has set an ambition to "have the option to deploy CCUS at scale during the 2030s, subject to costs coming down sufficiently". We welcome the Government's initiatives to retain CCUS as a potential tool to decarbonise the economy, but the lack of specificity in its ambitions does not indicate a commitment commensable with the importance of this technology. CCUS stakeholders are optimistic about the potential for cost reductions, but expect these to arise largely through deployment itself, and the ambition's lack of clarity poses difficulties for investors. We heard widespread concern about the requirement for 'sufficient' reductions, given the technology is already the cheapest—and in some cases only—decarbonisation option for many industries. The Minister provided a more nuanced view of these challenges, stating that there is no cost target on which support is contingent. We recommend that the Government revise the formal aims of its written policy in the light of her position and prioritise the development of clear ambitions to kick-start CCUS. Rather than seeking unspecified cost reductions, the Government should aim to bring forwards projects at least cost.

The scale of deployment targeted in the 2030s is also unclear: the Government's definition is so broad it is meaningless. We recommend that the Government provides ambition and clarity by adopting specific targets in line with the Committee on Climate Change's recommendation.

Industrial opportunities

The UK's expansive geological storage resource and world-class oil and gas supply chains mean that we have a unique opportunity to lead the world in the development of a new CCUS industry. We recommend that the Government prioritise the development of CCUS to benefit from growing international demand for low carbon products and services. We risk losing our early-mover advantage if the UK's slow progress in developing CCUS continues.

CCUS can impose significant costs on industrial processes, and so will require substantial policy support to enable its adoption. However a failure to develop it could force many heavy industries to close in the coming decades, if the UK sticks to its climate change targets. The benefits of CCUS are thought to be poorly understood across Government departments, notably the Treasury. Furthermore, the exclusion of industrial CCUS from the scope of the National Infrastructure Assessment means the full potential of

the technology has not been assessed at the national level. We recommend that such an assessment should be conducted, and that the forthcoming Comprehensive Spending Review should take full account of the benefits, as well as the costs, of CCUS.

Business models and funding

The greatest barriers to the development of CCUS in the UK are commercial, rather than technical. It is inconceivable that CCUS will be developed without government support. Witnesses agreed CCUS costs could be substantially lowered by separating the business model for carbon capture at individual facilities from that for carbon transport and storage infrastructure. We recommend that the Government separates the funding models for these activities, and that BEIS investigates the appropriateness of the Regulated Asset Base model.

Clusters and competition

CCUS could play a significant role in supporting productivity growth outside London and the South East, offering a route to redress some of the regional imbalance evident in the Government's Industrial Strategy. Of the five clusters identified as well-suited to early CCUS deployment, four are in regions with below-average productivity, and witnesses from all five consider CCUS to be critical to future operations. The Government has set a target to commission the first CCUS facility by the mid-2020s. We recommend that this ambition is raised to target the development of first CCUS projects in at least three clusters by 2025, to minimise the risk of further delays to CCUS development in the event that individual projects encounter obstacles, and to ensure that the benefits for productivity accrue to industries across the UK.

The Minister told us that the Government expects to run a third competition to select the first CCUS project. We recommend the Government urgently consults on approaches to allocate funding for CCUS industry clusters, to ensure that the approach selected promotes collaboration and benefits CCUS development across the UK.

1 Introduction

1. Carbon capture usage and storage (CCUS, see Box 1) is necessary to meet national and international climate change targets at least cost.[1] In the UK, failure to deploy CCUS could double the cost of meeting our targets under the Climate Change Act 2008, rising from approximately 1% to 2% of GDP per annum in 2050.[2] It would also mean our country could not credibly adopt a 'net zero emissions' target in line with the Paris Agreement's 1.5°C aspiration.[3] This is a more ambitious policy on which the Government has asked the Committee on Climate Change (CCC) to advise on timing and viability.[4] At the global level, the Intergovernmental Panel on Climate Change (IPCC) has estimated the cost of limiting warming to 2°C would increase by 138% without carbon capture and storage (CCS).[5] Further, the majority[6] of IPCC-assessed pathways to limit warming to 1.5°C are highly dependent on both CCS and carbon dioxide removal technologies, with bioenergy with carbon capture and storage (an evolution of CCS) being one of the two most commonly utilised removal options.[7] The widespread agreement of experts on the necessity of CCUS exists despite the relative immaturity of the technology: worldwide there are only 18 large-scale facilities in commercial operation, with a further five under construction.[8]

Box 1: Definitions

Carbon capture, usage and storage (CCUS) is a set of technologies which can together capture carbon dioxide from waste gases at industrial facilities, and either 'lock up' this carbon dioxide in offshore geological storage sites, where it can be stored indefinitely (carbon capture and *storage*, CCS), or reuse it in industrial processes (carbon capture and *usage*,[9] CCU). CCUS has the potential to help decarbonise many areas of the economy, including power, heating, transport and industry. It can be used to very substantially lower emissions from the combustion of fossil fuels or to produce clean hydrogen from natural gas. Although this report examines CCUS as a whole, we sometimes refer to CCS or CCU individually when points apply only to these particular technologies.

1 Carbon Connect, *Future Electricity Series Part 1: Power from Fossil Fuels* (April 2013); CCC, *An independent assessment of the UK's Clean Growth Strategy From ambition to action* (January 2018); Energy Technologies Institute (ETI), *Targets, technologies, infrastructure and investments – preparing the UK for the energy transition* (2015); IPCC, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (2014); International Energy Agency (IEA), Energy Technology Perspectives 2017* (2017)

2 CCC, *An independent assessment of the UK's Clean Growth Strategy From ambition to action* (January 2018); Energy Technologies Institute (ETI), *Targets, technologies, infrastructure and investments – preparing the UK for the energy transition* (2015)

3 Q4

4 Department for Business, Energy and Industrial Strategy (DBEIS), *UK climate targets: request for advice from the Committee on Climate Change* (15 October 2018)

5 IPCC, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (2014)

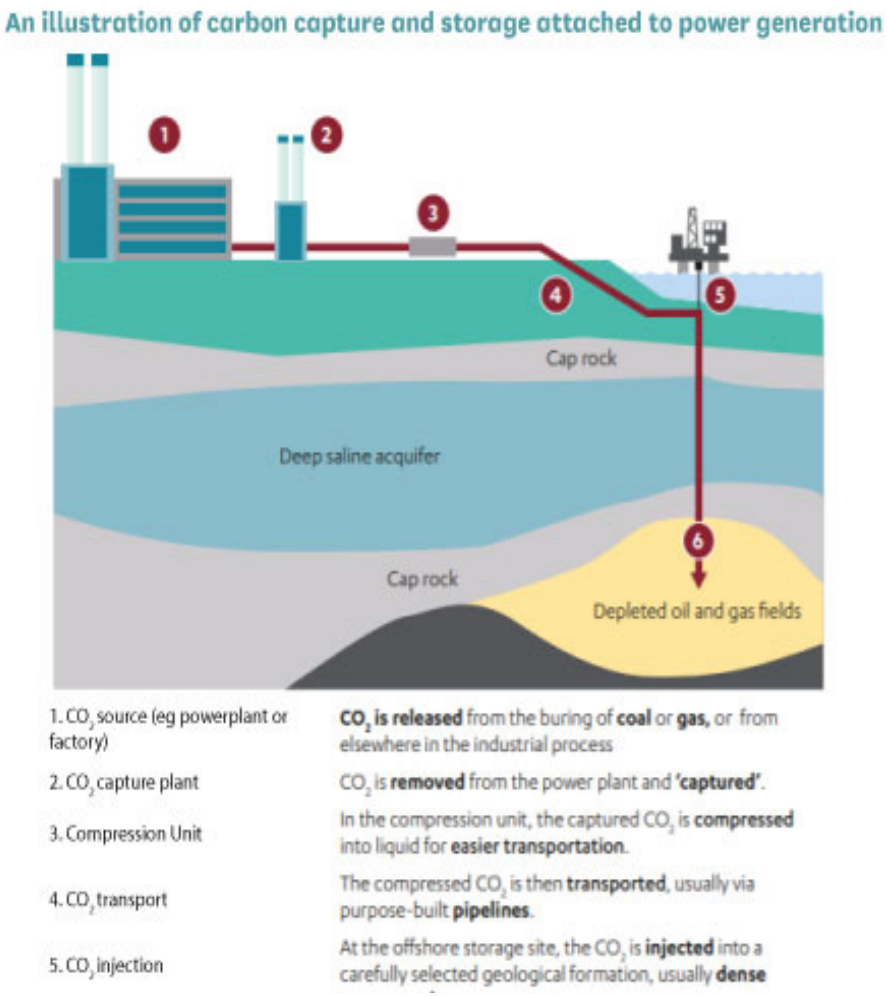
6 A few pathways exclude CCS but require radical reductions in energy demand that would be extremely challenging to achieve.

7 IPCC, *Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development* in *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (2017)

8 Global CCS Institute, *The Global Status of CCS 2018* (2018)

9 For a more detailed discussion of carbon capture and usage, see *Carbon Capture and Usage*, POSTbrief 30, Parliamentary Office of Science and Technology, October 2018.

Figure 1 An illustration of carbon capture and storage.



Source: Adapted from National Infrastructure Commission[10]

Research and Development is underway to combine CCS with other technologies to generate so-called 'negative emissions' which would actively reduce the total amount of carbon dioxide in the atmosphere. These are anticipated to play an important role in meeting the UK's longer-term climate change ambitions, particularly if the UK adopts a 'net zero' target in line with the ambitions of the Paris Agreement. Negative emissions technologies reliant on the development of CCS include bioenergy with CCS (BECCS) and direct air carbon capture and storage (DACCS).

2. The UK is considered to have one of the most favourable environments globally for commercial CCUS, ranking fourth in the Global CCS Institute's CCS Readiness Index.[11] However national interest in the technology was perceived to be only 'average' compared to other countries in 2018.[12] This lack of enthusiasm is symptomatic of CCUS' turbulent

10 National Infrastructure Commission (CCU0625); National Infrastructure Commission, *Congestion, Capacity, Carbon – priorities for national infrastructure* (October 2017)

11 Global CCS Institute, *The Carbon Capture and Storage Readiness Index 2018: Is the world ready for carbon capture and storage?* (2018)

12 As above

history in the UK, and the lack of sustained policy support for the technology, despite a decade of repeated—and increasingly urgent—calls from official bodies and parliamentary inquiries to bring forwards its deployment.[13] CCUS' critical role has been recognised since the 2003 Energy White Paper, with successive Governments aiming to develop large-scale projects.[14] A first CCS demonstration competition was launched in 2007 and was followed in 2009 by a commitment to support up to four CCS demonstrations over the following decade, in order to "enable wide-scale deployment of CCS through the 2020s".[15] These commitments were reiterated by the Coalition Government in 2010.[16] However in 2011 the first demonstration competition was cancelled, because it could not be funded within the £1 billion budget agreed in the 2010 Spending Review.[17] A second £1 billion competition was launched in 2012 but cancelled in 2016, due to concerns about the future costs for consumers.[18] Investigations by the National Audit Office have identified a lack of early cross-Departmental agreement on the budget for the competitions, specifically from the Treasury, as contributing to the cancellations in both cases.[19]

3. The Clean Growth Strategy set out renewed Government interest in CCUS, with an ambition to become an international leader in the technology, and to retain the option of deploying CCUS at scale in the 2030s.[20] This was followed by the establishment of a CCUS Cost Challenge Taskforce in early 2018 to identify routes to reduce deployment costs. The Taskforce's report, published in July 2018, was followed by the Government's CCUS Action Plan in November, and most recently, the creation of an industry-led CCUS Advisory Group in March 2019.[21]

Our inquiry

4. We launched our CCUS inquiry on 29 May 2018, with a specific aim to complement, rather than replicate, the work of the CCUS Cost Challenge Taskforce. We therefore did

13 CCC, *Building a low-carbon economy – the UK's contribution to tackling climate change* (December 2008); CCC, *The Fourth Carbon Budget Review – part 2: the cost effective path to the 2050 target* (December 2013); CCC, *An independent assessment of the UK's Clean Growth Strategy From ambition to action* (January 2018); Energy and Climate Change Committee , Ninth Report of Session 2013–14, *Carbon capture and storage*, HC 742; Environmental Audit Committee, Ninth Report of Session 2007–08, *Carbon capture and storage*, HC 654; HM Treasury, *The Economics of Climate Change: The Stern Review* (2006); Report of the Parliamentary Advisory Group on CCS, *Lowest Cost Decarbonisation for the UK: the Critical Role of CCS*, (2016); Science and Technology Committee, First Report of Session 2005–06, *Meeting UK Energy and Climate Needs: The Role of Carbon Capture and Storage*, HC 578-I

14 Department of Trade and Industry (DTI), *Energy White Paper: Our energy future - creating a low carbon economy*, Cm 5761, February 2003; DTI, *Meeting the Energy Challenge: A White Paper on Energy*, CM 7124, May 2007; *Carbon capture and storage: additional background*, Standard Note SN06136, House of Commons Library, March 2011; *Carbon capture and storage*, Standard Note SN05086, House of Commons Library, July 2014; *Carbon Capture and Storage*, Debate Pack CDP-2017–0188, House of Commons Library, October 2017

15 *Carbon capture and storage: additional background*, Standard Note SN06136, House of Commons Library, March 2011; Department of Energy and Climate Change, *Government Response to the House of Commons Environmental Audit Committee Report: Carbon Capture and Storage (CCS)*, Cm 7605, August 2009, p 8

16 *Carbon capture and storage: additional background*, Standard Note SN06136, House of Commons Library, March 2011

17 National Audit Office (NAO), *Carbon capture and storage: lessons from the competition for the first UK demonstration*, HC 1829, March 2012

18 NAO, *Carbon Capture and Storage: the second competition for government support*, HC 950, January 2017

19 NAO, *Carbon capture and storage: lessons from the competition for the first UK demonstration*, HC 1829, March 2012; NAO, *Carbon Capture and Storage: the second competition for government support*, HC 950, January 2017

20 DBEIS, *The Clean Growth Strategy: Leading the way to a low carbon future*, October 2017

21 CCUS Cost Challenge Taskforce, *Delivering Clean Growth: CCUS Cost Challenge Taskforce Report* , July 2018; DBEIS, *The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan*, November 2018; *"Carbon capture: Shell, BP, Tata Steel, and Drax join £1m UK advisory group, Business Green"*, 22 March 2019

not focus on routes to achieve cost reductions, but instead sought to test the Government's commitment to CCUS technology, and more specifically its stated aim to "ensure that government has the option of deploying CCUS at scale during the 2030s, subject to costs coming down sufficiently". We have also closely investigated the opportunities and challenges of CCUS for local industries, with the aim of identifying appropriate routes forward that can maximise the geographic benefits of the technology, a theme closely linked to our ongoing scrutiny of the Industrial Strategy.[22]

5. During our inquiry we received 52 written submissions in response to our call for evidence, and held three evidence sessions. We also received 17 letters from industry stakeholders, and one from the Minister, in response to specific requests for information. We took the opportunity to visit Teesside to learn about the potential impacts of CCUS first-hand through visits to CF Fertilisers and Wilton International; to hold discussions with local government, businesses, investors and developers; and to take evidence from stakeholders representing all five of the industry clusters seeking to deploy CCUS in the near-term. We are grateful to all those who took the time to contribute to our inquiry.

This report

6. Chapter 2 of this report examines the role of CCUS in delivering least-cost decarbonisation and the adequacy of the Government's targets for deployment. Chapter 3 explores the industrial opportunities and challenges of CCUS, both domestically and for export, while Chapter 4 investigates commercial barriers and options to create viable business models for the technology. Chapter 5 considers the potential role of CCUS in local industry clusters and the challenges associated with selecting the first clusters for deployment. In Chapter 6 we present our overarching conclusions.

22 Business, Energy and Industrial Strategy (BEIS) Committee, Seventeenth Report of Session 2017–19, *Industrial Strategy: Sector Deals*, HC 663; BEIS Committee, Supporting regional investment and growth inquiry, accessed 5 April 2019

2 Ambitions and least cost decarbonisation

CCUS and climate change

7. The vast majority of witnesses to our inquiry emphasised the critical role that CCUS is expected to play in achieving the UK's climate change targets, and doing so cost-effectively, including both Greg Clark MP, Secretary of State for Business, Energy and Industrial Strategy, and Claire Perry MP, Minister of State for Energy and Clean Growth.[23] CCUS is a particularly useful technology in tackling carbon emissions, because it can be applied to many different areas of the economy. It can decarbonise waste gases from power stations and industrial facilities; help to produce clean hydrogen fuel from natural gas; and remove greenhouse gas emissions from the atmosphere via bioenergy with CCS (BECCS) or direct air CCS (DACCS).[24] Whilst CCUS is not necessary to decarbonise all of these economic activities,[25] witnesses to our inquiry could not suggest any routes to decarbonise the entire economy without it. We heard repeatedly from industrial organisations that CCUS is often the least cost, and in some cases only option to decarbonise industrial processes, and as such it is essential to extend the lifetime of heavy industry in the UK.[26] CCUS is also a critical enabling technology for low-carbon hydrogen, which is gaining traction in and outside Government as a potential route to decarbonise heating and parts of the national gas grid (discussed further on page 14).

CCUS targets

8. The Government's current aims for CCUS were set in the 2017 Clean Growth Strategy and reiterated in the CCUS Action Plan in November 2018. They are less ambitious than the aims set by previous Governments (summarised in Chapter 1) and commit:

- "that the UK should have the option to deploy CCUS at scale during the 2030s, subject to the costs coming down sufficiently";

23 Q147; Q157; oral evidence taken on 6 February 2019, HC (2018–19) 604, Q401; Global CCS Institute (CCU0025); Energy Safety Research Institute (CCU0530); Energy Technologies Institute (CCU0244); Grantham Institute, Imperial College London (CCU0358); Professor Jonathan Gibbins (CCU0614); Scottish Carbon Capture & Storage (CCU0499); Tyndall Centre for Climate Change Research (CCU0041); Joint submission by the UCL Institute for Sustainable Resources and the UK Energy Research Centre (CCU0504); Drax Group plc (CCU0464); Peel Environmental (CCU0485); Equinor ASA (CCU0496); Progressive Energy Ltd (CCU0529); Bright Blue (CCU0315); Pale Blue Dot Energy (CCU0029); Pöyry Management Consulting (CCU0051); National Grid, Gas System Operator (CCU0500); Tees Valley Combined Authority (CCU0045); Ian Temperton (CCU0032); Institution of Chemical Engineers (IChemE) (CCU0090); Institution of Mechanical Engineers (CCU0503); The Royal Society and Royal Academy of Engineering (CCU0497); The Geological Society (CCU0492); REA (CCU0502); Carbon Capture and Storage Association (CCU0493); Energy UK (CCU0491); Mineral Products Association (CCU0360); Oil & Gas UK (CCU0489); Anglo American Platinum (CCU0070); Aberdeenshire Council (CCU0050); Carbon Connect (CCU0613); Durham (University) Energy Institute (CCU0600); Pietro Goglio (CCU0136)

24 CCC, *Reducing UK emissions 2018 Progress Report to Parliament* (June 2018)

25 For example, emissions from power can be cut with renewable technologies, nuclear and batteries.

26 National Grid, Gas System Operator (CCU0500); Pale Blue Dot Energy (CCU0029); Mineral Products Association (CCU0360); NP11 (CCU0637); Tees Valley CA (CCU0629), Q1; Q10

- "to enable the development of the first CCUS facility in the UK, commissioning from the mid-2020s".[27] Shortly after the Action Plan's publication, Claire Perry announced additional targets for industrial decarbonisation, which are expected to rely heavily on CCUS:
- To have at least one low-carbon cluster of heavy industry by 2030;
- To have the world's first 'net-zero carbon' cluster of heavy industry by 2040.[28]

Delivering CCUS

9. We welcome the Government's intention to retain CCUS as a potential tool to decarbonise the economy, but the lack of specificity in the ambitions set in the Clean Growth Strategy and the CCUS Action Plan does not indicate a commitment commensurate with the widely-agreed importance of this technology. We heard witnesses' concerns that the lack of clarity on the meanings of 'at scale' deployment and 'sufficient' cost reductions makes it difficult for investors to assess the conditions under which Government might choose to pursue CCUS, and provides leeway should Ministers later decide to withdraw support, even if significant cost reductions have been achieved. This risks a repetition of previous experiences, whereby the Government has set high ambitions for CCUS only to withdraw these after substantial public and private sector investment (discussed in more detail in Chapter 5). We explore the need for more specific targets in the following.

'Sufficient' cost reductions

CCUS costs

10. Arguments against the use of CCUS have often focussed on the expense of the technology—and it is costs concerns that led to the cancellation of the UK's two previous competitions in 2011 and 2016. CCUS imposes additional operational costs on the facilities in which it is adopted. In the case of carbon capture and *storage* this provides a service which—in most cases—is not adequately valued to recoup these additional costs. For example, running CCS processes is estimated to increase the energy consumption of coal and gas power stations by between 11%–40%.[29] It also requires substantial upfront expenditure: the estimated capital required for the preferred projects under the previous competitions was between £1 billion and £2.5 billion to install CCUS at a coal- or gas-fired power station.[30] Cost estimates have fallen in recent years, however, both as result of international deployment and associated economies of learning,[31] and a new focus on applying the technology in industrial settings, which is often cheaper than its application

27 DBEIS, *The Clean Growth Strategy: Leading the way to a low carbon future*, October 2017; DBEIS, *The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan*, November 2018

28 "*World-first carbon 'net-zero' hub of heavy industry to help UK seize global economic opportunities of clean growth*", DBEIS press release, 13 December 2018

29 "*Carbon capture's energy penalty problem*", Reuters, 7 October 2014

30 NAO, *Carbon capture and storage: lessons from the competition for the first UK demonstration*, HC 1829, March 2012; NAO, *Carbon Capture and Storage: the second competition for government support*, HC 950, January 2017

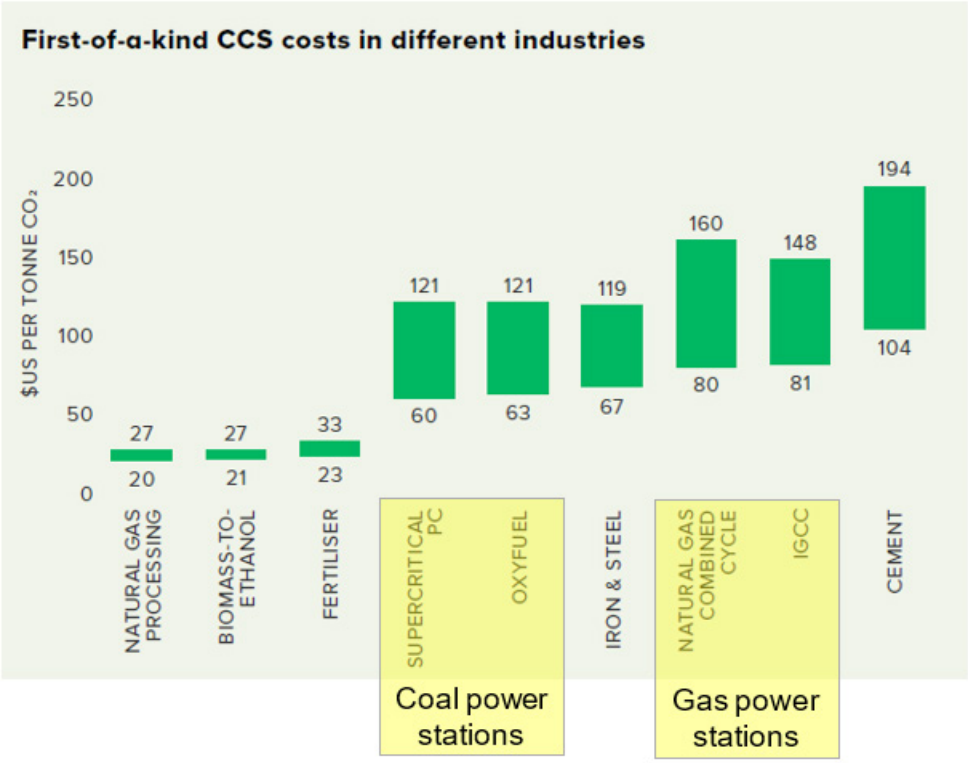
31 Costs to install second-of-kind CCS projects have also fallen substantially, with a follow-up facility to the 2015 Boundary Dam coal power CCS plant expected to be 30% cheaper than the original project, and a follow-up to Shell's 2014 Quest hydrogen CCS plant expected to be 20–30% cheaper. Pöyry Management Consulting (CCU0051); Global CCS Institute (CCU0025)

at a power plant (see Figure 2).[32] CCUS developers told us that UK projects would now be much cheaper than under the previous competitions, with individual project costs well under £500 million.[33]

11. There are different ways of thinking about the costs and benefits of CCUS, and whether the technology offers value for money in its own right. Traditionally CCUS has been envisaged as an appendage to coal and gas power stations, leading to comparisons between the cost of generating electricity at a fossil fuel power station equipped with CCUS and one without, or with generation at other low carbon plant such as renewables and nuclear. For example, the 2012 competition was projected to require a Contracts for Difference 'strike-price' of £170 per megawatt-hour (MWh), substantially more than the £92.50/MWh awarded to Hinkley Point C[34]. More recent estimates have fallen to £80–90/MWh for CCUS at power stations.[35] An alternative approach is to consider CCUS costs and benefits in terms of carbon abatement—a service essential to meeting the UK's climate change targets. Analysis by the Global CCS Institute indicates that CCUS installations at power plants are more expensive than at other industrial facilities, when compared on the basis of carbon savings. First-of-kind CCUS at a gas-fired power station is estimated to cost around £80–160 per tonne of carbon dioxide stored (TCO_2), but much cheaper opportunities are available in industrial activities such as fertiliser production (£23-£33/ TCO_2) and natural gas processing (£20–27/TCO_2) (see Figure 2). **We encourage the Government to view CCUS primarily as a tool for decarbonisation, rather than as an extra cost on power generation. Deployment should be prioritised because CCUS presents an opportunity to reduce the overall cost of meeting the UK's emissions reduction targets.**

32 Q238
33 Q215; Q237; Q240
34 National Audit Office (NAO), *Carbon capture and storage: lessons from the competition for the first UK demonstration*, HC 1829, March 2012
35 Pöyry Management Consulting (CCU0051)

Figure 2: First of kind CCS costs in different industries.



Source: Adapted from Global CCS Institute.[36]

Cost reductions

12. Witnesses were optimistic about the potential for CCUS costs to fall further across all applications, but emphasised that deployment, rather than further R&D, will be critical: according to the Energy Technologies Institute the first three installations of CCS at gas-power stations could drive down costs by as much as 45% owing to increased scale and simplification, whereas technical innovation has the potential to reduce costs by a further 5–10% in the subsequent installations.[37] Additional opportunities for cost reductions include risk-sharing, development of CCUS in clusters (with shared infrastructure), focussing on 'least regrets' projects, R&D, and the creation of market and fiscal incentives to spur uptake and innovation.[38] We discuss cost reduction opportunities further in Chapter 4.

13. Despite the potential to lower costs, witnesses expressed widespread scepticism about the practicality and effectiveness of requiring 'sufficient' cost reductions. Academics, developers, trade and professional bodies emphasised the complexity of setting appropriate and equitable expectations for reductions, due to the large cost disparities across different types of industrial facility, CCUS' existing status as the cheapest carbon abatement

36 Global CCS Institute (CCU0025)

37 CATCH (CCU0640)

38 Centre for Energy Policy, University of Strathclyde (CCU0036); Energy Technologies Institute (CCU0244); Professor Jonathan Gibbins (CCU0614); Joint submission by the UCL Institute for Sustainable Resources and the UK Energy Research Centre (CCU0504); Drax Group plc (CCU0464); Peel Environmental (CCU0485); low (CCU0462); Institution of Chemical Engineers (IChemE) (CCU0090); The Geological Society (CCU0492); Energy UK (CCU0491); Mineral Products Association (CCU0360); Energy Networks Association (CCU0575); Oil & Gas UK (CCU0489); Cambridge Carbon Capture Ltd (CCU0295)

solution in many industries, and the fact that in some industries there are *no* alternative carbon-removal solutions against which costs could be benchmarked.[39] Instead, they called for policy to be designed to encourage developers to bring forwards projects at *least cost*.[40] The Minister was unable to clarify the meaning of 'sufficient' cost reductions in either oral evidence or subsequently in writing, despite us pressing on this point for the benefit of investors.[41] Instead she addressed a different issue, arguing that the demand for cost reductions is "the wrong question" and that there is no cost target on which funding support for CCUS is contingent.[42] She further expressed a willingness to identify price reduction potential through industry dialogue and to agree acceptable project costs on a case-by-case basis.[43] It appears that the Minister has departed from the stated Government policy on this issue, and we welcome her pragmatism. However, the conflict between policy documents[44] and the Minister's explanation of policy creates confusion about the Government's aims and requirements, exacerbating the effects of a decade of ambivalent and volatile policy messaging on CCUS. We question why the Government has departed from its written policy so quickly.

14. **Whilst we strongly support cost minimisation, we disagree with the CCUS Action Plan's stipulation that deployment 'at scale' should be supported only if 'sufficient' cost reductions are achieved. Such vague terminology gives no certainty to investors and does little to ensure that CCUS can contribute to meeting the UK's overarching climate change targets at least cost, given its existing status as the cheapest—or only—decarbonisation option in many industrial applications. *We recommend that Government revise its formal aims in light of the Minister's more nuanced position and prioritise the development of clear ambitions that will bolster its renewed efforts to kick-start CCUS. We further recommend that the Government commits to supporting CCUS where and whilst it remains the cheapest route to decarbonisation, notably in industrial applications. Rather than seeking unspecified cost reductions, the Government should set out plans to ensure that projects are brought forwards at least cost.***

15. Enabling least cost CCUS may require the Government's timetable to be brought forward. The Acorn and HyNet NW projects, in North East Scotland and Merseyside, both intend to make use of redundant oil and gas pipelines and are aiming to be operational as early as 2023.[45] Repurposing assets offers substantial cost savings: Acorn alone is projected to save £548 million by avoiding the cost of constructing new build pipelines.[46] However, these avoided costs depend on swift progress, as many offshore assets are

39 Q235 [Pete Whitton]; Joint submission by the UCL Institute for Sustainable Resources and the UK Energy Research Centre (CCU0504); Scottish Carbon Capture & Storage (CCU0499); Global CCS Institute (CCU0025); Dr Niall Mac Dowell (CCU0480); Professor Jonathan Gibbins (CCU0614); Scottish Carbon Capture & Storage (CCU0499); Tim Kruger (CCU0046); Joint submission by the UCL Institute for Sustainable Resources and the UK Energy Research Centre (CCU0504); Equinor ASA (CCU0496); Progressive Energy Ltd (CCU0529); Pale Blue Dot Energy (CCU0029); Pöyry Management Consulting (CCU0051); Tees Valley Combined Authority (CCU0045); Institution of Chemical Engineers (IChemE) (CCU0090); Carbon Capture and Storage Association (CCU0493); Professor Geoffrey Hammond (CCU0425)

40 Institution of Chemical Engineers (IChemE) (CCU0090); Tim Kruger (CCU0046); Joint submission by the UCL Institute for Sustainable Resources and the UK Energy Research Centre (CCU0504); Pöyry Management Consulting (CCU0051)

41 Qq158–162; Appendix

42 Q160

43 Qq158–162

44 DBEIS, *The Clean Growth Strategy: Leading the way to a low carbon future*, October 2017; DBEIS, *The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan*, November 2018

45 Cadent, HyNet North West, accessed 22/3/19; Qq210–211

46 ACT Acorn, ACT Acorn: A catalyst for low-cost, low-risk clean growth, accessed 5 March 2019

expected to be decommissioned in the early 2020s.[47] The Government has announced it will work with the Oil and Gas Authority, industry and the Crown Estates to identify existing oil and gas infrastructure that could be repurposed for CCUS during 2019.[48] **We welcome this initiative, as well as the Secretary of State's confirmation that he would be willing to bring forward the Government's timeline for deployment of the first CCUS facilities if this enabled delivery at lower cost.**[49] ***We recommend the timetable for policy delivery is accelerated to enable CCUS commissioning from 2023, to avoid the additional cost of recommissioning disused oil and gas pipelines after they have been decommissioned.***

Deployment 'at scale'

16. We have noted that widespread deployment of CCUS is expected to be necessary to keep the UK on track to meet its climate change targets as cheaply as possible. However the Government's intentions for the scale of CCUS roll-out are far from clear. We received advice from the Minister that the current ambition for 'at scale' deployment could mean storing anything between 0.1% of the UK's current carbon dioxide emissions (400,000 tonnes) and 49% (180 million tonnes)—a definition so broad it is meaningless.[50] The Committee on Climate Change has recommended an initial CCS cluster should be operational by 2026, enabling 10 million tonnes of carbon dioxide ($MtCO_2$) to be sequestered each year by 2030, and at least 20 $MtCO_2$ per year by 2035, respectively equivalent to 2.7% and 5.5% of current UK emissions.[51] This is broadly in line with the estimates of necessary scale we received from witnesses, although less ambitious than the Netherlands' target to store 20 $MtCO_2$ every year by 2030.[52] **Our view is that the Government should be both ambitious and clear.** ***We recommend the Government sets a specific target to store 10 million tonnes of carbon by 2030, and 20 million by 2035, to keep the UK on track to meet its 2050 climate change targets, as recommended by the CCC.***

Hydrogen

17. The Clean Growth Strategy identifies hydrogen as a key potential route to meeting the UK's 2050 climate change targets.[53] Use of hydrogen could also enable the UK to achieve greater emissions reductions than without it—an option that will be particularly important if the UK adopts a net zero target.[54] Production of low carbon hydrogen at scale will depend on the deployment of CCUS.[55] The Committee on Climate Change has recommended that "significant volumes" of low carbon hydrogen should be produced at a CCUS industry cluster by 2030.[56]

47 Cadent (CCU0642); Cadent one-pager; Oil & Gas Authority, *Decommissioning Strategy*, 2016
48 DBEIS, *The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan*, November 2018
49 Oral evidence taken on 6 February 2019, HC (2018–19) 604 Q399
50 Percentages calculated from storage figures in tonnes, provided by the Minister, against 2017 UK net emissions of carbon dioxide of 366.9 million tonnes (Mt) as estimated by BEIS. Appendix; DBEIS, *2017 UK Greenhouse Gas Emissions, Provisional Figures*, March 2018.
51 CCC, *Reducing UK emissions 2018 Progress Report to Parliament* (June 2018); percentages calculated against 2017 UK net emissions as above.
52 Q220; Qq222–223; Q225; CATCH (CCU0640); Drax (CCU0638); Bellona Foundation, *New Dutch government puts CO2 capture and storage at forefront in climate plan*, accessed 5 March 2019
53 DBEIS, *The Clean Growth Strategy: Leading the way to a low carbon future*, October 2017
54 CCC, *Hydrogen in a low-carbon economy* (November 2018)
55 As above
56 CCC, *Hydrogen in a low-carbon economy* (November 2018), p 13

18. One major area of interest is the option of injecting hydrogen into the national gas grid. Combined with hydrogen boilers or hybrid heat pumps, this would provide a means to decarbonise heating in buildings connected to the grid.[57] However the scope for trials of this technology is limited by existing law:

- The Gas (Safety Management) Regulations restrict the incorporation of the hydrogen into the gas mix to less than 0.1%. In effect this prevents hydrogen from being injected into the national network, so pilots can only be undertaken on smaller isolated networks.[58]

- The Gas (Control of Thermal Energy) Regulations require all gas sources supplying a geographic "billing zone" to be enriched or deriched to match the prevailing calorific value of gas across the entire zone, and for all customers to be charged according to the zone's average calorific value. These requirements, combined with the large size of the UK's 13 billing zones, prevent the demonstration of hydrogen in smaller areas, e.g. individual cities.[59]

19. The Government is considering options to amend the gas safety regulations, subject to satisfactory safety demonstrations, but witnesses are concerned the necessary changes may not happen quickly enough.[60] The new RIIO-2[61] price controls for gas networks will begin in 2021 and will last until 2026. If gas regulations are not changed beforehand, this could prevent large-scale demonstrations throughout the control period.[62] ***We recommend the Government expedites safety demonstrations, and—assuming these are satisfied—brings forwards amendments to the Gas (Safety Management) Regulations and the Gas (Control of Thermal Energy) Regulations as a matter of urgency to enable large-scale demonstrations of hydrogen injection into the gas grid.***

57 CCC, *Hydrogen in a low-carbon economy* (November 2018); Carbon Connect (CCU0613); The Energy and Utilities Alliance (CCU0044)

58 Qq36–39 [Professor Haszeldine]; Supplementary evidence from Professor Haszeldine, regarding Scottish Carbon Capture and Storage, dated 2 November 2018

59 As above

60 DBEIS, *The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan*, November 2018; Qq36–37; Supplementary evidence from Professor Haszeldine, regarding Scottish Carbon Capture and Storage, dated 2 November 2018

61 RIIO (Revenue = Incentives + Innovation + Outputs) is Ofgem's performance-based framework to set price controls for energy network companies. RIIO-2 is the second phase of RIIO, which will take effect from April 2021 for gas networks. Ofgem has decided that the default length of price controls will reduce from eight years (as currently) to five years, startin with RIIO-2. Ofgem, *RIIO-2 Framework Decision: Our approach to setting price controls for GB gas and electricity networks* (2018)

62 Qq36–39 [Professor Haszeldine]; Supplementary evidence from Professor Haszeldine, regarding Scottish Carbon Capture and Storage, dated 2 November 2018

3 Industrial opportunities

Export potential

20. The UK is uniquely well-placed to develop CCUS. The national geological storage resource is estimated at around 70 billion tonnes of carbon dioxide—equivalent to that of the remaining EU-27 combined—and the supply chains that have grown to service our world-class oil and gas sector provide the capabilities that CCUS deployment demands.[63] Furthermore there are several CCUS projects around the UK that are at an advanced stage of development, and which—with policy support—could commence operations from the early 2020s.[64] In combination, these factors mean that the UK has strong potential to become a world leader in this technology.

21. The Paris Agreement is expected to increase future demand for carbon storage services, assuming that signatories seek to honour their commitments. International Energy Agency projections indicate that the future global CCUS market could be worth over £100 billion per year by 2050, and the Carbon Capture and Storage Association has estimated that UK gross value added resulting from our share in this market could reach between £5bn and £9bn per year by 2030.[65] Despite this potential, CCUS remains a relatively immature technology, with only 18 large-scale facilities operating worldwide.[66] Professor Jon Gibbins, Director of the UK CCS Research Centre, explained that the small size of the current market strengthens the potential for UK leadership:

> "if the UK spent—pick a number—£5 billion on CCS, the world would sit up and take notice and you would have made a very material contribution to progress on climate change because nobody else is doing CCUS… If the UK spent £5 billion on nuclear… [or] on renewables … the world would barely notice."[67]

22. Industry and academic groups are nonetheless concerned that the UK's slow progress in developing this technology could mean that we soon lose any early-mover advantage.[68] Substantial government support has been made available to develop full-chain CCUS projects in several countries, notably Japan, the USA and Canada.[69] Leads taken by competitors in the North Sea region, particularly Norway and the Netherlands, could impinge on the UK's ability to capture potential revenue from CCUS imports (providing storage as service to neighbouring countries).[70] The Port of Rotterdam is aiming to store two million tonnes of carbon dioxide per year from 2021, whilst the Norwegian Government is supporting Equinor to develop the world's first storage site to receive carbon from

63 Q34
64 Cadent, HyNet North West, accessed 22/3/19; Qq210–211; Tees Valley CA (CCU0629)
65 Trades Union Congress and Carbon Capture and Storage Association, *The economic benefits of carbon capture and storage in the UK* (February 2014)
66 Global CCS Institute, *The Global Status of CCS 2018* (2018)
67 Q252
68 Centre for Energy Policy, University of Strathclyde (CCU0036); The National Oceanography Centre (CCU0020); Tees Valley CA (CCU0629)
69 Centre for Energy Policy, University of Strathclyde (CCU0036); The National Oceanography Centre (CCU0020); Global CCS Institute (CCU0025)
70 Centre for Energy Policy, University of Strathclyde (CCU0036); Tees Valley CA (CCU0629)

multiple sources, and is taking on liabilities for carbon dioxide leakage.[71] A failure by the Government to develop CCUS facilities soon could also weaken the competitive edge of UK industry clusters against clusters abroad; for example we heard this would exacerbate already strong competition between Teesside and Rotterdam.[72] **The UK's storage and supply chain resource strengths mean that we have a unique opportunity to lead the world in the development of a new CCUS industry. The Government should not allow the UK to pass this opportunity up.** ***We recommend that the Government prioritise the development of CCUS to benefit from growing international demand for low carbon products and services-building on the UK's existing successes with offshore wind.***

Domestic opportunities and challenges

23. The Committee on Climate Change has advised that industrial emissions must reduce by 25% by 2030, with further reductions required through the 2030s and 2040s to hit national climate change targets. But as the Government's Industrial Decarbonisation Roadmap recognises, there are few options to decarbonise many industrial processes.[73] We heard from industry groups that CCUS will be critical to the future of energy intensive industries, both as a means to produce low-carbon hydrogen for use as a fuel, and to remove carbon directly from their waste streams.[74] It is anticipated that many heavily emitting industries would need to close if the UK sticks to its climate change targets but CCUS fails to materialise.

24. The high costs of CCUS present a major barrier to adoption by industries that will need to remain internationally competitive. The Chemicals Industry Association, Tata Steel and the Northern Powerhouse 11 emphasised the need for substantial policy support to enable industries such as petrochemicals, steel and biofuels to implement CCUS.[75] Peter Quinn, Head of Environmental Policy and Strategy at Tata Steel, cautioned against the unilateral imposition of further costs on UK industry, noting that existing carbon prices already present a "huge" cost on British production of globally-traded materials.[76] Further, we heard in Teesside that the growing internationalisation of industrial facilities, many of which are foreign-owned, means that companies are becoming increasingly mobile and able to (re)locate facilities abroad should UK sites become less commercially attractive. This strengthens the case for developing CCUS industry clusters (to compete against CCUS-equipped clusters abroad), as well as for Government support to ensure that the additional costs do not disadvantage early-moving UK-based industries. The majority of energy technologies have benefited from subsidies in their early years, to reduce the effects of negative externalities and support the move from fledgling technology to commercialisation. **We believe that support for CCUS—an innovative technology expected to be critical to tackling climate change—is also justified on these grounds.**

71 Tees Valley CA (CCU0629); Bellona Foundation, *New Dutch government puts CO2 capture and storage at forefront in climate plan*, accessed 5 March 2019; Global CCS Institute, "CORE2 Facilities Database", access 5 March 2019; Equinor, "Carbon Storage", accessed 5 March 2019

72 Annex; Tees Valley CA (CCU0629)

73 DBEIS, *Industrial Decarbonisation and Energy Efficiency Action Plans: Summary Document*, October 2017

74 National Grid, Gas System Operator (CCU0500); Mineral Products Association (CCU0360); Pale Blue Dot Energy (CCU0029); NP11 (CCU0637); Tees Valley CA (CCU0629), Q1; Q10; Annex

75 Chemical Industries Association (CCU0505); NP11 (CCU0637); Qq215–216

76 Qq241–242

25. Industry and research organisations are frustrated that CCUS policy discussions have historically focussed on costs rather than benefits.[77] They argued that inadequate attention has been paid to the potential to create gross added value in industry clusters, for example through enhanced oil recovery; diversification of North Sea oil and gas industries; construction and operation of cluster hydrogen networks; and development of new low carbon products utilising captured carbon.[78] These are in addition to the benefits of extending the lifetime of heavy industries, and the potential for CCUS exports. Summit Power has estimated that creation of an east-coast CCUS network could create 225,000 jobs and boost the UK economy by over £160 billion by 2060.[79] We heard that although appreciation of benefits is slowly spreading across Government departments, the ongoing focus on costs may be hindering progress in developing CCUS support.[80] Mark Lewis, Technology and Innovation Manager at Tees Valley Combined Authority, explained that in meetings "we have always had to re-educate them [the Treasury] because they did not understand what the benefits of this technology were".[81] ***We recommend that the forthcoming Comprehensive Spending Review take account not only of CCUS' costs, but also its wider benefits-notably to extend the lifetime of heavy industries which will otherwise need to close under the requirements of the Climate Change Act.***

26. One policy area in which the potential benefits of industrial CCUS have clearly been ignored is the National Infrastructure Assessment. Whilst this considered the role of CCUS in decarbonising power and heating (through hydrogen), its potential to decarbonise industrial emissions was out of scope.[82] The result is that no nationwide cost-benefit analysis of industrial CCUS has been conducted. Given that the Committee on Climate Change has identified CCUS as critical future infrastructure for the UK, this omission was a major oversight. It is especially significant since CCUS infrastructure is expected to link up capture plants at a wide range of facilities once built: power, hydrogen and industrial plants could all potentially share the same transport pipelines and storage sites. It is therefore possible that the exclusion of industrial facilities could also have affected the Assessment's cost benefit analysis of CCUS at power and hydrogen facilities, if it was assumed that these would alone shoulder the full cost of transport and storage infrastructure. ***We recommend that the Government tasks the National Instructure Commission—or a third party—to conduct a cost benefit analysis of the potential role of CCUS to decarbonise industrial emissions, taking account of how development of industrial CCUS would affect—and be affected by—the potential development of CCUS for other applications, notably hydrogen and power. The results of this assessment should be taken into account during decision-making on spending for national infrastructure.***

77 Progressive Energy Ltd (CCU0529); Cadent Gas (CCU0569); Centre for Energy Policy, University of Strathclyde (CCU0036); Professor Jonathan Gibbins (CCU0614); Pale Blue Dot Energy (CCU0029); Decarbonised Gas Alliance (CCU0498); Mineral Products Association (CCU0360)Q225 [Pete Whitton] Q235 [Mark Lewis, Pete Whitton]

78 Centre for Energy Policy, University of Strathclyde (CCU0036); Dr Niall Mac Dowell (CCU0480); Scottish Carbon Capture & Storage (CCU0499)Cadent (CCU0642); Anglo American Platinum (CCU0070); The Geological Society (CCU0492); Decarbonised Gas Alliance (CCU0498); Mineral Products Association (CCU0360); Energy Networks Association (CCU0575); Tees Valley CA (CCU0629); Q216

79 Summit Power, *Clean Air, Clean Industry, Clean Growth: How Carbon Capture Will Boost the UK Economy* (October 2017)

80 Q235 [Mark Lewis, Jonathan Briggs]

81 Q235

82 National Infrastructure Commission (CCU0625)

4 Business models and funding

Commercial barriers

27. The greatest barriers to the development of CCUS in the UK are commercial, rather than technical, issues.[83] CCUS has been technologically proven at large-scale facilities abroad, but the very substantial capital requirements and investment risks have so far prevented deployment in the UK. In 2017 the National Audit Office concluded that "[i]t is currently inconceivable that CCS projects will be developed without government support", a view shared by the National Infrastructure Commission.[84] Industry groups, CCUS developers and research institutions all highlighted the lack of a route-to-market for CCUS in the UK at present.[85]

28. This situation points to a need to reduce CCUS risks, since deployment and potential reductions in cost (and capital expenditure) are considered interdependent.[86] The UK CCUS community has been readying itself for demonstration projects since 2007, and the potential to increase efficiencies through R&D is limited without large-scale facilities to evaluate. Professor Stuart Haszeldine, Director of Scottish CCS, explained that universities are "running on the spot… we have done as much as we can" and that "real projects" are needed to enable further progress.[87] This viewpoint was echoed by Ian Temperton, former member of Lord Oxburgh's Parliamentary Advisory Group and the Government's Cost Challenge Taskforce, who emphasised the importance of demonstration projects to enable economies from 'learning by doing'. Further, The Grantham Institute has estimated that moving CCS from a 'high risk' to 'low risk' investment would be twice as effective as halving equipment costs, in terms of its impact on overall cost reductions.[88]

29. Evidence to our inquiry highlighted many areas of risk, and in particular focussed on cross chain default risk (the risk that one part of a project—capture, transport or storage—might fail or be delayed, incurring costs for the remaining parts); liability for the long-term storage of carbon dioxide; political/policy uncertainty; and lack of revenue certainty.[89] Witnesses proposed diverse policy options to alleviate these concerns, such as public-private risk-sharing (e.g. Contracts for Difference, inclusion on the Regulated Asset

83 CCSA, *Lessons Learned: Lessons and evidence derived from UK CCS programmes, 2008–2015,* (June 2016); DBEIS, *The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan*, November 2018; Energy Institute (CCU0462)

84 NAO, *Carbon capture and storage: lessons from the competition for the first UK demonstration*, HC 1829, March 2012; NAO, *Carbon Capture and Storage: the second competition for government support*, HC 950, January 2017

85 Qq5–6; Qq12–13; Q24; Energy UK (CCU0491); Grantham Institute, Imperial College London (CCU0358); Institution of Chemical Engineers (IChemE) (CCU0090); Institution of Mechanical Engineers (CCU0503); Mineral Products Association (CCU0360); Peel Environmental (CCU0485); Tim Kruger (CCU0046)

86 Centre for Energy Policy, University of Strathclyde (CCU0036); Energy Technologies Institute (CCU0244); Grantham Institute, Imperial College London (CCU0358); Professor Jonathan Gibbins (CCU0614); Joint submission by the UCL Institute for Sustainable Resources and the UK Energy Research Centre (CCU0504); Energy Institute (CCU0462); Institution of Chemical Engineers (IChemE) (CCU0090)

87 Q44

88 Grantham Institute, Imperial College London (CCU0358); Pöyry Management Consulting, *A strategic approach for Developing CCS in the UK* (May 2016); Sustainable Gas InstituteGrantham Institute, Imperial College London (CCU0358) Imperial College London, *Can Technology Unlock Unburnable Carbon* (May 2016)

89 Grantham Institute, Imperial College London (CCU0358); Energy Institute (CCU0462); Qq229–230; Q243

Base[90]), fiscal incentives, higher carbon prices (via taxes or trading), capital funding, and the creation of markets for low carbon products (e.g. through certification schemes, or setting requirements on the carbon footprint of homogenous goods such as steel and cement).[91] Many focussed on the need to separate the business model for carbon capture from that for transport and storage, which we explore further below.[92] It should be noted that the great variation between alternative CCUS projects in terms of technology, cost and risk means there is unlikely to be a 'one size fits all' policy solution. For example, we heard that Contracts for Difference could be well suited to CCS at power stations, with potential to replicate cost-reduction successes in offshore wind; a Regulated Asset Base might be appropriate for the transport and storage of carbon dioxide, similar to models used for gas and water pipelines; and that some industries might require capital support to install capture technology, as projected carbon prices will not be sufficient to recoup costs.[93]

Capture, transport and storage

30. The Government's two previous CCS competitions were designed to bring forwards 'full chain' projects, covering the capture, transport and storage of carbon dioxide in a single venture. However, CCUS developers, industry groups and academics agreed CCUS costs could be substantially lowered by separating the business model for capture from that for transport and storage (T&S), due to the stark differences in the investment profile of these two activities.[94]

31. Carbon capture technologies are already deployed in the UK in some industrial processes (e.g. ammonia production), and can involve relatively low additional expenditure.[95] In contrast, the development of T&S infrastructure will entail the construction of long-distance pipelines and the preparation of large geological sites to receive carbon dioxide for long-term storage, in first-of-kind projects for the UK. T&S infrastructure is expensive to build, but once constructed a single facility could receive carbon from multiple capture sites.[96] Steve Murphy, Finance Director of Pale Blue Dot Energy, estimated that T&S costs could reach £100–£150 per tonne of carbon dioxide stored if shouldered by a single capture site, but that this figure could be reduced by 90% if the infrastructure costs were shared across multiple capture points.[97]

90 The Regulated Asset Base (RAB) is an accounting concept which underpins many investments in UK utilities. It was developed during the process of privatisation in the late 20th century, when it represented the value of "past investments, comprising what investors paid for assets when they were originally privatised plus subsequent capital expenditure adjusted for depreciation." RAB is akin to the Net Book Value of an asset. If a company has a large RAB, it has a large asset base against which to borrow money. Ordinarily, the larger a company's asset base, the cheaper the rate at which it can borrow. Recently there have been discussions about using the RAB as a mechanism to help fund new investments in energy infrastructure off the Government balance sheet. SocInvest, "Regulatory Asset Base Model", accessed 29 March 2019.

91 Qq14–15; Q20; Qq240–242; Q257; Mr Denis Hicks (CCU0461)

92 Global CCS Institute (CCU0025); Mineral Products Association (CCU0360); Drax Group plc (CCU0464); Progressive Energy Ltd (CCU0529); Pale Blue Dot Energy (CCU0029); Tees Valley Combined Authority (CCU0045); Institution of Chemical Engineers (IChemE) (CCU0090); Carbon Capture and Storage Association (CCU0493); Energy UK (CCU0491); Scottish Carbon Capture & Storage (CCU0499); Cadent Gas (CCU0569); CCUS Cost Challenge Taskforce, *Delivering Clean Growth: CCUS Cost Challenge Taskforce Report* , July 2018

93 Q252

94 As above

95 Joint submission by the UCL Institute for Sustainable Resources and the UK Energy Research Centre (CCU0504)

96 NAO, *Carbon Capture and Storage: the second competition for government support*, HC 950, January 2017

97 Q244

32. Development of capture and T&S within a single venture is also complicated by the mutual dependence of the two activities, and the impacts of this for managing the risk of delays or failure at either component. Drax Power explained that the interactions between capture and T&S had weakened the business case for the full chain White Rose project, as if either part stopped working it would have had to compensate the other.[98]

33. As well as separating the business models, several CCUS developers and trade bodies argued that T&S should be funded in the same way as other national infrastructure projects and incorporated into the Regulated Asset Base (RAB),[99] in order to minimise returns required by private investors.[100] This model has also been recommended by the CCUS Cost Challenge Taskforce, but we heard that its suitability is not entirely clear, as the investment required by CCUS projects is much smaller (at around £200–£300 million) than other projects that have recently been considered for RAB, such as the Thames Tideway Scheme (£4.2 billion) and the now-suspended nuclear power station at Wylfa (£20 billion).[101] The National Infrastructure Commission has cautioned that whilst RAB would allow CCUS to be supported off the Government balance sheet, it would also effectively require consumers to finance projects at zero interest and to assume at least some of the risks of construction, e.g. liability for cost overruns. The Commission has emphasised the importance of avoiding "any distortion through hidden costs or presentation of costs as artificially lower", which could occur in the absence of adequate consumer protections or insufficient transparency on costs and risks.[102]

34. The Government is investigating whether separating the business models for capture and T&S would reduce risk as part of its Review of Delivery and Investment Frameworks, due for completion by the end of 2019.[103] It is also exploring the potential of a RAB for nuclear power, and "will consider the implications of this work for potential future CCUS power projects", but it has neither provided a timeline for this work, nor confirmed whether it will consider its potential for T&S connected to other (non-power) industrial facilities.[104] ***We recommend that the funding models for carbon capture are separated from those for carbon transport and storage. We welcome BEIS' work to consider RAB's appropriateness for nuclear power, and recommend that this is expanded to consider CCUS, including transport and storage infrastructure to link with industrial carbon emitters.***

98 Q229
99 See footnote 89.
100 Ian Temperton (CCU0032); Drax Group plc (CCU0464); Oil & Gas UK (CCU0489); Cadent (CCU0642); Joint submission by the UCL Institute for Sustainable Resources and the UK Energy Research Centre (CCU0504); Q16 [Luke Warren]; Q229; CCUS Cost Challenge Taskforce, *Delivering Clean Growth: CCUS Cost Challenge Taskforce Report* , July 2018
101 Q245; Tideway, "*Green light for £4.2bn London 'super sewer'*", accessed 4 March 2019; "*Britain on nuclear alert after Hitachi shelves £20bn plant*", Evening Standard, 17 January 2019
102 National Infrastructure Commission (CCU0625); National Infrastructure Commission, *Congestion, Capacity, Carbon – priorities for national infrastructure* (October 2017)
103 DBEIS, *The UK Carbon Capture Usage and Storage deployment pathway: An Action Plan*, November 2018
104 As above

5 Clusters and competition

The potential of CCUS for industry clusters

35. CCUS could play a significant role in supporting productivity growth outside London and the South East, through encouraging innovation, investment and collaboration. The technology is best deployed in areas with a strong industrial base, and from which subsea storage resources can be easily accessed. Four of the five industry clusters identified as well-suited for early CCUS deployment are in regions with below-average productivity (Humberside, Merseyside, South Wales, Teesside), whilst there are plans to link the fifth (North East Scotland) to industries in Grangemouth, another lower-productivity area.[105] As such, CCUS offers a route to redress some of the regional imbalance evident in the Government's Industrial Strategy, and the lack of detailed consideration of 'places' in the majority of sector deals agreed to date. These are issues we considered in our recent report into the Industrial Strategy, and will continue to examine in our forthcoming inquiry into regional growth and investment.[106] CCUS could further serve as a cornerstone in Local Industrial Strategies for the five clusters—and adjacent areas—to help modernise industrial infrastructure and to guard against deindustrialisation.[107]

36. The industry clusters we heard from consider CCUS to be critical to their future operations. Stakeholders in Teesside told us that CCUS, together with the production of hydrogen, will be essential to ensure the longevity of local factories.[108] Local businesses have already taken substantive measures to reduce their environmental impacts, and see limited opportunity to reduce emissions further without the technology. The interactions and interdependencies of the cluster are considered a major strength by investors, but in turn this creates a potential vulnerability, since the internationalisation of heavy industry has made local clusters more sensitive to competition abroad (discussed in Chapter 3). Businesses are concerned that any slowness to develop CCUS infrastructure in the area could lead some parent companies to (re)locate plant elsewhere, potentially undermining the viability of the remaining businesses and the cluster as a whole.[109] Similar concerns have been raised by stakeholders in other regions. For example, Tata Steel has set a target to make its European business carbon neutral by 2050, a goal that is expected to rely on CCUS and/or clean hydrogen.[110]

37. The Government's targets for CCUS, set out in Chapter 2, fall short of the CCUS Cost Challenge Taskforce's recommendation that "at least two CCUS clusters [should] be operational from the mid-2020s".[111] Witnesses to our inquiry were generally supportive of the Taskforce view, although several recommended more ambitious targets, such as an earlier delivery date, three clusters spread around the country, or demonstrations of CCUS

105 DBEIS, *Industrial Strategy: Building a Britain fit for the future* (November 2017), p 218
106 BEIS Committee, Seventeenth Report of Session 2017–19, *Industrial Strategy: Sector Deals*, HC 663; BEIS Committee, Supporting regional investment and growth inquiry, accessed 5 April 2019
107 DBEIS, *Industrial Strategy: Building a Britain fit for the future* (November 2017)
108 Annex
109 Annex; Q256
110 Tata Steel, "Tata Steel's European operations take major step towards becoming carbon neutral", accessed 5 March 2019
111 CCUS Cost Challenge Taskforce, *Delivering Clean Growth: CCUS Cost Challenge Taskforce Report* , July 2018

in a broad range of industrial applications.[112] Progressive Energy and CATCH questioned the viability of delivering the Government's overarching goal of 'at scale' deployment in the 2030s in the event that its near-term target is met with just one cluster operational by 2028, noting that project lead-times are typically between five and seven years.[113]

38. A more ambitious target, involving the development of CCUS clusters in multiple regions, would strengthen the Government's strategy for developing "prosperous communities across the UK".[114] It is likely that benefits from the first clusters will spill-over into neighbouring communities, as development of CCUS infrastructure will de-risk expansion in adjacent areas.[115] In particular, we heard that establishing projects with storage on both the east and west coasts would provide realistic target points for capture facilities on either side of the country to link into. Industry groups anticipate the eventual development of two mega-clusters along each coast, as CCUS facilities link up.[116]

39. Additional benefits of developing several projects include the confidence that a visible project pipeline would provide to investors, developers, and potential actors in the CCUS supply chain, encouraging companies to grow their capacity to deliver subsequent projects and thus putting the UK in a stronger position to deploy CCUS widely in the 2030s.[117] Simultaneous development of multiple clusters would also reduce the risk of the UK's plans being delayed in the event that a given project runs into difficulties.[118] Professor Jon Gibbins called for Government to undertake an assessment of the technology's role across the country. This could help maximise the value of early CCUS deployment by improving understanding of how individual projects can contribute to the technology's development at the national level.[119] **We welcome the Government's recognition of the cluster model for decarbonising industry and delivering industrial CCUS, but the target to deliver only a single first project will limit regional benefits and runs the risk of delaying CCUS development if major obstacles are encountered.** ***We recommend the development and commissioning of first CCUS projects in at least three clusters by 2025 to minimise the risk of a third major delay to the technology's development and to ensure that its benefits for productivity accrue to industries across the UK.***

Selecting clusters

40. The Government's previous attempts to develop CCUS have centred around funding competitions for a first demonstration project. We heard from the Minister that the Government expects to run a third competition, to select the first industrial project in its new drive to deploy CCUS.[120] Whilst we welcome the renewed promise of funding support, we are concerned that the competition model may not necessarily be the best suited to the needs of this emerging sector.

112 Progressive Energy (CCU0634); Q220; Q257 [Peter Quinn]; Decarbonised Gas Alliance (CCU0498); Equinor ASA (CCU0496); Institution of Mechanical Engineers (CCU0503); Pale Blue Dot Energy (CCU0029); Peel Environmental (CCU0485); Joint submission by the UCL Institute for Sustainable Resources and the UK Energy Research Centre (CCU0504)

113 Progressive Energy (CCU0634); Q221 [Geraint Evans]; Q225 [Pete Whitton]

114 DBEIS, *Industrial Strategy: Building a Britain fit for the future* (November 2017) p11

115 Q212; Q225 [Professor Gibbins]; Q254; Tata Steel (CCU0631); Tees Valley CA (CCU0629)

116 Progressive Energy (CCU0633); Q225 [Professor Gibbins]; Q254

117 Q225 [Pete Whitton]

118 Q228; Q252; Tees Valley CA (CCU0629)

119 Q252

120 Q153; Q203

41. We heard strong opposition in Teesside to the prospect of a third competition, mainly owing to the tension between competition and collaboration.[121] Industrial and academic witnesses emphasised that promoting collaboration is essential to achieve cost reductions.[122] Cooperation between first-movers and subsequent projects can de-risk investment, maximise the industry-wide benefits of learning-by-doing, and enable better targeting of R&D to industry needs. The UK CCUS community is considered to have a strong existing culture of collaboration—both within and across the five industry clusters—but we heard that this had been undermined by the previous competitions. These not only pitched projects against one another, but also expressly limited knowledge-sharing beyond project partners, in turn slowing technological progress through R&D.[123] These concerns reflect the findings of our recent *Industrial Strategy: Sector Deals* inquiry. Stakeholders in offshore wind explained that whilst commercial competition can help to drive down prices it also causes fragmentation, creating barriers to the innovation, growth and maturation of burgeoning industries.[124]

42. Witnesses raised additional objections to a third competition on the grounds of historical experiences, imperfect Government knowledge and the necessity of CCUS for emissions reductions:

- During the cancelled competitions industry matched Government spending, investing an estimated £168 million on projects that were ultimately unsuccessful. The history of stop-start support has made it "problematic and challenging" to reengage now-sceptical investors,[125] with political risk ranked very highly, and developers are concerned that the promise of a further competition may be insufficient to bring financiers on board again.[126] Some have restructured their project models specifically to address the tentative nature of Government support;[127]

- The narrow scope of the previous competitions ruled out least-cost opportunities and failed to incentivise cost reductions from learning-by-doing—any future competition would need to be very carefully scoped to avoid similar unintended consequences;[128]

- Industries across at least five regions will require CCUS to allow their continued operation as the UK decarbonises. The technology should therefore be prioritised in the locations where it can generate substantial gross value added, rather than demanding that regions compete for the opportunity to deploy essential low carbon infrastructure.[129]

43. Objection to the competition model was not, however, uniform. Steve Murphy, Finance Director of Pale Blue Dot Energy explained that the design of the previous competitions had been helpful in providing certainty about the revenue model for CCUS

121 Q225 [Professor Gibbins]; Q228; Q253 [Pete Whitton]
122 Qq217–218; Q225 [Professor Gibbins]; Q233; Q253 [Pete Whitton]; Energy Networks Association (CCU0575); Cadent Gas (CCU0569)
123 Qq217–218; Q225 [Professor Gibbins]; Q233; Q253 [Pete Whitton]
124 BEIS Committee, Seventeenth Report of Session 2017–19, *Industrial Strategy: Sector Deals*, HC 663, pp 19–20
125 Q209
126 Q210; Q225 [Professor Gibbins]; Q255
127 Progressive Energy (CCU0633)
128 Q233; Q238
129 Q253 [Pete Whitton]

installations,[130] while Jonathan Briggs, CCS Stakeholder Manager at the Oil and Gas Climate Initiative (OGCI), noted that some sort of assessment will be necessary to ensure that the sequencing of projects is appropriate and supports long-term goals.[131]

44. The CCUS Cost Challenge Taskforce has recommended the use of selection criteria to assess projects and allocate funding-an approach supported by our academic and industry witnesses as a means to better promote collaboration.[132] The Secretary of State told us that he would be willing to consider using an assessment process, rather than a competition, to allocate funding.[133] ***We recommend the Government consults on approaches to allocate funding for CCUS industry clusters, to ensure that the approach selected promotes collaboration and benefits CCUS development across the UK, including those clusters that take longer to get going. It should also seek to ensure that the scope of funding is sufficiently broad to allow consideration of all viable CCUS schemes and avoid excluding particular applications or technology-types. This consultation should be conducted as a matter of urgency and completed by the end 2019, so that there is no delay to the development of projects.***

130 Q230
131 Q228
132 Q20; Qq252–253
133 Oral evidence taken on 6 February 2019, HC (2018–19) 604, Q400

Chapter 6: Conclusions

45. CCUS has been recognised as a priority technology for UK's energy transition for over 15 years. The country is exceptionally well-placed to lead the technology's development, with an expansive geological storage resource and directly-relevant capabilities in our indigenous oil and gas industry. Successive Governments have sought to establish a first demonstration project, but have so far failed in this endeavour, and late cancellations have grown scepticism of the UK's commitment amongst investors. The current Government has made good progress in reinvigorating CCUS interest with a new Action Plan that focuses on industrial applications. This offers potential to develop the technology at substantially lower costs than under the formerly favoured power-sector model, and to provide diversification options that could help guard against future deindustrialisation. During our inquiry we consistently heard praise for the efforts of the Minister, Claire Perry, who is credited with championing the CCUS renaissance during her relatively long-standing tenure as Energy Minister.[134]

46. Despite these positive developments, formal targets for CCUS remain ambiguous, with no clarity on the 'scale' of deployment that Government plans to bring forwards, nor a definitive answer on the apparent precondition that this essential technology must become cheaper before it is widely deployed. The Minister clearly rejected the notion of cost targets in her evidence to us, which begs the question of why this caveat has been written into policy. Given the stop-start history of CCUS in the UK, it would be disastrous if the new direction we have outlined, and which the Government is now setting, is abandoned by a future Government.

47. We are further concerned that not all branches of Government can see the advantages of CCUS as clearly as the Minister. The National Infrastructure Assessment's cost-benefit analysis excluded industrial applications of the technology, and the Treasury has been singled out for its lack of awareness of CCUS' benefits, despite calls from local industries that see it as critical to their future (although early deployment will need policy support to protect UK competitiveness). The two former CCUS competitions were both cancelled at the Treasury's request because of fears surrounding project costs, after substantial industry investment. It is imperative that any future decisions on how and when to fund this technology are taken with a full and thorough understanding of the critical role it is expected to play, not only in decarbonisation across the whole economy, but in extending the life of and modernising UK industry.

134 Q18; Q45; Q233

Conclusions and recommendations

Ambitions and least cost decarbonisation

1. We encourage the Government to view CCUS primarily as a tool for decarbonisation, rather than as an extra cost on power generation. Deployment should be prioritised because CCUS presents an opportunity to reduce the overall cost of meeting the UK's emissions reduction targets. (Paragraph 11)

2. Whilst we strongly support cost minimisation, we disagree with the CCUS Action Plan's stipulation that deployment 'at scale' should be supported only if 'sufficient' cost reductions are achieved. Such vague terminology gives no certainty to investors and does little to ensure that CCUS can contribute to meeting the UK's overarching climate change targets at least cost, given its existing status as the cheapest—or only—decarbonisation option in many industrial applications. *We recommend that Government revise its formal aims in light of the Minister's more nuanced position and prioritise the development of clear ambitions that will bolster its renewed efforts to kick-start CCUS. We further recommend that the Government commits to supporting CCUS where and whilst it remains the cheapest route to decarbonisation, notably in industrial applications. Rather than seeking unspecified cost reductions, the Government should set out plans to ensure that projects are brought forwards at least cost.* (Paragraph 14)

3. We welcome this initiative, as well as the Secretary of State's confirmation that he would be willing to bring forward the Government's timeline for deployment of the first CCUS facilities if this enabled delivery at lower cost. *We recommend the timetable for policy delivery is accelerated to enable CCUS commissioning from 2023, to avoid the additional cost of recommissioning disused oil and gas pipelines after they have been decommissioned.* (Paragraph 15)

4. Our view is that the Government should be both ambitious and clear. *We recommend the Government sets a specific target to store 10 million tonnes of carbon by 2030, and 20 million by 2035, to keep the UK on track to meet its 2050 climate change targets, as recommended by the CCC.* (Paragraph 16)

5. *We recommend the Government expedites safety demonstrations, and—assuming these are satisfied—brings forwards amendments to the Gas (Safety Management) Regulations and the Gas (Control of Thermal Energy) Regulations as a matter of urgency to enable large-scale demonstrations of hydrogen injection into the gas grid.* (Paragraph 19)

Industrial opportunities

6. The UK's storage and supply chain resource strengths mean that we have a unique opportunity to lead the world in the development of a new CCUS industry. The Government should not allow the UK to pass this opportunity up. *We recommend that the Government prioritise the development of CCUS to benefit from growing international demand for low carbon products and services–building on the UK's existing successes with offshore wind.* (Paragraph 22)

7. We believe that support for CCUS—an innovative technology expected to be critical to tackling climate change—is also justified on these grounds. (Paragraph 24)

8. *We recommend that the forthcoming Comprehensive Spending Review take account not only of CCUS' costs, but also its wider benefits–notably to extend the lifetime of heavy industries which will otherwise need to close under the requirements of the Climate Change Act.* (Paragraph 25)

9. *We recommend that the Government tasks the National Instructure Commission—or a third party—to conduct a cost benefit analysis of the potential role of CCUS to decarbonise industrial emissions, taking account of how development of industrial CCUS would affect—and be affected by—the potential development of CCUS for other applications, notably hydrogen and power. The results of this assessment should be taken into account during decision-making on spending for national infrastructure.* (Paragraph 26)

Business models and funding

10. *We recommend that the funding models for carbon capture are separated from those for carbon transport and storage. We welcome BEIS' work to consider RAB's appropriateness for nuclear power, and recommend that this is expanded to consider CCUS, including transport and storage infrastructure to link with industrial carbon emitters.* (Paragraph 34)

Clusters and competition

11. We welcome the Government's recognition of the cluster model for decarbonising industry and delivering industrial CCUS, but the target to deliver only a single first project will limit regional benefits and runs the risk of delaying CCUS development if major obstacles are encountered. *We recommend the development and commissioning of first CCUS projects in at least three clusters by 2025 to minimise the risk of a third major delay to the technology's development and to ensure that its benefits for productivity accrue to industries across the UK.* (Paragraph 39)

12. *We recommend the Government consults on approaches to allocate funding for CCUS industry clusters, to ensure that the approach selected promotes collaboration and benefits CCUS development across the UK, including those clusters that take longer to get going. It should also seek to ensure that the scope of funding is sufficiently broad to allow consideration of all viable CCUS schemes and avoid excluding particular applications or technology-types. This consultation should be conducted as a matter of urgency and completed by the end 2019, so that there is no delay to the development of projects.* (Paragraph 44)

Annex: Notes from visit to Teesside industry cluster

The Teesside Cluster has grown from the Teesside Collective group of energy intensive industrial emitters. This group alone make up over 20% of the UK's industrial emissions. We took a tour of the ammonia and carbon capture facilities at CF Fertilisers in Billingham, and the Wilton International manufacturing site, including Sembcorp power station, in Redcar. We also met with stakeholders from across the cluster. These included: BOC Linde, CF Fertilisers, Lotte Chemicals, North East of England Process Industry Cluster (NEPIC), Redcar and Cleveland Borough Council, SABIC, Sembcorp, South Tees Development Corporation, Tees Valley Combined Authority, and Tees Valley Local Enterprise Partnership.

Subjects discussed:

- plans and ambitions to develop CCUS in Teesside, including the potential of CCUS to increase the cluster's attractiveness to investors and to enable industrial diversification;
- efforts already undertaken to reduce the environmental footprint of Teesside businesses, and the criticality of CCUS to enable further environmental improvements and to extend the lifetime of heavy industry;
- the interdependency of businesses in the cluster, which is seen as a benefit by investors, but could become a vulnerability in the event of deindustrialisation;
- competition with the Rotterdam industry cluster, the substantial support that the Dutch Government is providing to CCUS, and barriers to implementing CCUS in the UK without policy support;
- the increasing foreign ownership of industrial facilities, and ramifications of associated business mobility for future investment in UK clusters and jobs;
- growing scepticism of foreign investors and parent companies regarding the UK's commitment to CCUS;
- the potential for R&D collaboration with universities, and the need for deployment to further progress in CCUS technology;
- the impacts of Brexit on investment and operations;
- the effects of the carbon price support on industrial emitters;
- concerns that selecting new CCUS projects via a third competition may be counter-productive.

Appendix: Letter from Minister on Government ambitions

10 December 2018

Dear Rachel,

Carbon Capture, Usage and Storage (CCUS): BEIS Committee evidence session.

Thank you for your letter of 26 November 2017 on CCUS following the oral evidence session on the 21 November 2018.

Since the evidence session, I have made a number of announcements that underline the Government's support to progressing CCUS in both the UK and globally. This includes, for example, with the Scottish Government, Total and the European Commission, our support for Project Acorn in St Fergus Scotland.[135] I have also co-hosted, with Dr Fatih Birol of the International Energy Agency, the world's first dedicated global CCUS Summit on 28 November 2018 in Edinburgh. This brought together 50 world energy leaders to progress CCUS, confirming its central role in meeting global climate ambitions.

In parallel to the Summit I published '*The UK CCUS Deployment Pathway: An Action Plan*'.[136]

Our Action Plan is designed to enable the development of the first CCUS facility in the UK, commissioning from the mid-2020s. The action plan has been well received by industry, including the Carbon Capture and Storage Association (CCSA) and Energy UK.[137]

You raised four specific questions seeking more information on the Government's ambitions and I have set out a response to each of these below.

1. A clear and specific explanation of what must be achieved in order to satisfy the requirement of "costs coming down sufficiently", including further detail on who is expected to achieve these cost reductions, and the role of Government in supporting investable business models.

Our Action Plan is designed to enable the UK's first CCUS facility being commissioned from the mid-2020s and this is an important step in satisfying our 2030s ambition.

This approach is supported by the Committee on Climate Change, who in response to the Action Plan, stated that "the Action Plan rightly identifies a need and opportunity to proceed at considerably lower cost than expected under the previous UK approach".[138]

135 https://www.gov.uk/government/news/plan-to-enable-first-uk-carbon-capture-project-from-the-mid-2020s-announced-at- world-first-summit

136 https://www.gov.uk/government/publications/the-uk-carbon-capture-usage-and-storage-ccus-deployment-pathway-an-action- plan

137 Energy UK press release, 28 November 2018: https://www.energy-uk.org.uk/media-and-campaigns/press-releases/412- 2018/6930-energy-uk-responds-to-the-government-s-announcement-on-first-uk-carbon-capture-project.html. CCSA press release, 28 November 2018 http://www.ccsassociation.org/index.php/download_file/view/1136/97/

138 https://www.theccc.org.uk/2018/11/28/ccc-welcomes-governments-recommitment-to-carbon-capture-and-storage- technology/

Government, industry, finance, innovators and academia all have a role to play in supporting cost reductions which is why our Action Plan commits us to work with all relevant sectors to explore cost reductions. For example, we will work with stakeholders to identify existing oil and gas infrastructure that could be re-used to support CCUS projects at lower cost and will develop a policy on re-use of infrastructure for the purpose of CCUS.

The UK government has invested over £365 million since 2011 in CCUS since 2011. We continue to support innovation in CCUS. We are investing £45 million in CCUS innovation programmes[139] including:

- a £20 million CCU Demonstration Programme to fund design and construction of CCU demonstration plants in the UK;
- a £15 million CCUS Call for Innovation to fund innovative projects that lead to cost reduction or accelerated deployment; and
- £6.5 million of UK funding to the second international call of the Accelerating Carbon Technologies (ACT) research programme, a €30 million fund supporting CCUS research across 11 countries that can lead to safe and cost-effective development of CCUS technology.

Establishing market-based investment frameworks will be important to enabling cost reductions. This is why we are currently completing a Review of Delivery and Investment Frameworks which is considering investable business models for CCUS, across power, industry, and transport and storage, as well as assessing the relative roles of Government and industry. In parallel to this, we will be undertaking detailed engagement with industry on the critical challenges to delivering CCUS in the UK, including risk sharing and cost structures. We will consult on the findings of this review and publish the outcome next year.

2. An explanation of how the Action Plan addresses our concern that the requirement for sufficient cost reductions will impede deployment of CCUS in a timely fashion.

As I outlined during the evidence session, we are committed to supporting the development of CCUS in the UK, recognising its potential important role in meeting our 2050 emissions reduction target. That is why we are investing £45 million in CCUS innovation to March 2021, to support technological development to drive cost reductions.

Our Action Plan is designed to enable the UK's first CCUS facility to be operational from the mid-2020s. The Action Plan introduces a staged approach to allow Government, industry and finance to develop and test commercial and regulatory concepts during the 2020s.

This approach has been welcomed by industry, for instance Luke Warren, Chief Executive of the CCSA, said: "the Government's announcement in Edinburgh recognises the need for urgent action, with a commendable commitment to develop the first project by the mid-2020s as a first step towards having the ability to deploy CCUS at scale"[140]

139 https://www.gov.uk/guidance/funding-for-low-carbon-industry
140 CCSA press release, 28 November 2018 http://www.ccsassociation.org/index.php/download_file/view/1136/97/

We will, in 2019, work with industry to develop a shared understanding of the cost structures and risk sharing arrangements. This will allow the development and testing of commercial and regulatory concepts incrementally during the 2020s, including enabling initial deployment from the mid-2020s.

3. A clear explanation of what the Government means by deployment of CCUS "at scale", and how this differs from deployment of initial industry clusters.

The definition of "scale" varies and the range of "at scale" deployment that might be required between 2030 and 2050 similarly varies. For the example, the Committee on Climate Change states that the scale of CCUS required by 2050 may be between 60–180MtCO2/year,[141] whilst modelling by the Energy Systems Catapult shows capacity of approximately 80MtCO2/year by 2045.[142]

At an individual facility level, according to the Global CCS Institute, a large-scale facility is defined as "involving the capture, transport and storage of carbon dioxide at a scale of at least 400,000 tonnes of CO2 annually".[143]

With regard to CCUS clusters, we will examine the opportunity that industrial clusters – regional groupings of multiple CCUS facilities connected to a shared transport and storage infrastructure – can offer.

4. Confirmation of whether the Government's ambition is to deploy CCUS "at scale" during the 2030s or by the mid-2020s.

Our ambition is for the UK to have the option to deploy CCUS at scale during the 2030s, subject to the costs coming down sufficiently. To help realise this ambition, our Action Plan is designed to enable the development of the first CCUS facility in the UK, commissioning from the mid-2020s.

I hope you find this information helpful.

Yours ever,

THE RT HON CLAIRE PERRY MP

Minister of State

141 Upper limit of 180 MtCO2 per year by 2050: Committee on Climate Change, 2018, pers.comm. to the Cost Challenge Task Force, 29 June.

142 Options, Choices, Actions Report: 2018 Update. https://es.catapult.org.uk/publications/options-choices-actions-how-could- the-uk-be-low-carbon-by-2050/

143 The Global Carbon Capture and Storage Institute define large-scale as integrated facilities involving both capture and storage at a scale of: at least 800,000 tonnes of CO2 annually for a coal–based power plant, or at least 400,000 tonnes of CO2 annually for other emissions–intensive industrial facilities.

Formal minutes

Wednesday 3 April 2019

Members present:

Rachel Reeves, in the Chair

Vernon Coaker	Albert Owen
Stephen Kerr	Mark Pawsey
Peter Kyle	Antoinette Sandbach
Ian Liddell-Grainger	

Draft Report (*Carbon Capture Usage and Storage*), proposed by the Chair, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 47 read and agreed to.

Summary agreed to.

Annex agreed to.

Appendix agreed to.

Resolved, That the Report be the Twentieth Report of the Committee to the House.

Ordered, That the Chair make the Report to the House.

Ordered, That embargoed copies of the Report be made available, in accordance with the provisions of Standing Order No. 134.

[Adjourned till Wednesday 24 April at 9.45 am

Witnesses

The following witnesses gave evidence. Transcripts can be viewed on the inquiry publications page of the Committee's website.

Tuesday 6 November 2018

Luke Warren, Chief Executive, The Carbon Capture & Storage Association, **Professor Stuart Haszeldine**, Director, Scottish Carbon Capture and Storage, **Kristofer Hetland**, Senior Adviser, Project Management, Equinor, **Nick Sturgeon**, Energy and Competitiveness Director, Chemicals Industry Association — Q1–45

Wednesday 21 November 2018

Claire Perry MP, Minister of State for Climate Change and Industry, Department for Business, Energy and Industrial Strategy, **Ashley Ibbett**, Director for Clean Electricity, Department for Business, Energy and Industrial Strategy, **Tim Lord**, Director for Clean Growth, Department for Business, Energy and Industrial Strategy — Q46–209

Thursday 17 January 2019

Andy Lewis, Future Role of Gas Innovation Manager, Cadent Gas, **Dr Geraint Evans**, CATCH Advisor, CATCH, **Jonathan Briggs**, CCS Stakeholder Manager, Oil & Gas Climate Initiative, **Steve Murphy**, Finance Director, Pale Blue Dot Energy, **Pete Whitton**, Managing Director, Progressive Energy, **Peter Quinn**, Head of Environmental Policy and Strategy, Tata Steel, **Mark Lewis**, Technology & Innovation Manager, Teesside, **Prof Jon Gibbins**, Director, UK CCS Research Centre, **Andy Koss**, CEO, Drax and **Lord Haskins**, Joint Lead for Energy, Northern Powerhouse 11 — Q210–257

Published written evidence

The following written evidence was received and can be viewed on the inquiry publications page of the Committee's website.

CCU numbers are generated by the evidence processing system and so may not be complete.

1 Aberdeenshire Council (CCU0050)

2 Anglo American Platinum (CCU0070)

3 Bright Blue (CCU0315)

4 Cadent Gas (CCU0569)

5 Cambridge Carbon Capture Ltd (CCU0295)

6 Carbon Capture and Storage Association (CCU0493)

7 Carbon Connect (CCU0613)

8 Centre for Energy Policy, University of Strathclyde (CCU0036)

9 Chemical Industries Association (CCU0505)

10 Decarbonised Gas Alliance (CCU0498)

11 Department for Business, Energy and Industrial Strategy (CCU0543)

12 Drax Group plc (CCU0464)

13 Durham (University) Energy Institute (CCU0600)

14 The Energy and Utilities Alliance (CCU0044)

15 Energy Institute (CCU0462)

16 Energy Networks Association (CCU0575)

17 Energy Safety Research Institute (CCU0530)

18 Energy Technologies Institute (CCU0244)

19 Energy UK (CCU0491)

20 Equinor ASA (CCU0496)

21 The Geological Society (CCU0492)

22 Gibbins, Professor Jonathan (CCU0614)

23 Global CCS Institute (CCU0025)

24 Goglio, Pietro (CCU0136)

25 Grantham Institute, Imperial College London (CCU0358)

26 Hammond, Professor Geoffrey (CCU0425)

27 Hicks, Mr Denis (CCU0461)

28 Institution of Chemical Engineers (IChemE) (CCU0090)

29 Institution of Mechanical Engineers (CCU0503)

30 Joint submission by the UCL Institute for Sustainable Resources and the UK Energy Research Centre (CCU0504)

31 Kruger, Tim (CCU0046)

32 Mac Dowell, Dr Niall (CCU0480)

33 Mineral Products Association (CCU0360)

34 National Grid, Gas System Operator (CCU0500)
35 National Infrastructure Commission (CCU0625)
36 The National Oceanography Centre (CCU0020)
37 Natural Resources Defense Council (CCU0528)
38 Nuclear Industry Association (CCU0490)
39 Oil & Gas UK (CCU0489)
40 Pale Blue Dot Energy (CCU0029)
41 Peel Environmental (CCU0485)
42 Penultimate Power UK Limited (CCU0440)
43 Progressive Energy Ltd (CCU0529)
44 Pöyry Management Consulting (CCU0051)
45 REA (CCU0502)
46 The Royal Society (CCU0028)
47 The Royal Society and Royal Academy of Engineering (CCU0497)
48 Scottish Carbon Capture & Storage (CCU0499)
49 Southern Environmental Law Center (CCU0387)
50 Tees Valley Combined Authority (CCU0045)
51 Temperton, Ian (CCU0032)
52 Tyndall Centre for Climate Change Research (CCU0041)

List of Reports from the Committee during the current Parliament

All publications from the Committee are available on the publications page of the Committee's website. The reference number of the Government's response to each Report is printed in brackets after the HC printing number.

Session 2017–19

First Report	A framework for modern employment	HC 352 (HC 966)
Second Report	Leaving the EU: implications for the civil nuclear sector	HC 378 (HC 881)
Third Report	The safety of Electrical Goods in the UK	HC 503 (HC 920)
Fourth Report	Pre-legislative scrutiny of the draft Domestic Gas and Electricity (Tariff Cap) Bill	HC 517 (HC 865)
Fifth Report	The impact of Brexit on the automotive sector	HC 379 (HC 1018)
Sixth Report	The impact of Brexit on the aerospace sector	HC 380 (HC 1049)
Seventh Report	The impact of Brexit on the processed food and drink sector	HC 381
Eighth Report	Pre-appointment hearing with the Government's preferred candidate for Chair of the Competition and Markets Authority	HC 985
Ninth Report	The impact of Brexit on the pharmaceutical sector	HC 382
Tenth Report	Carillion	HC 769
Eleventh Report	Pre-appointment hearing with the Government's preferred candidate for Chair of Ofgem	HC 1353
Twelfth Report	Draft National Policy Statement for Geological Disposal Infrastructure	HC 1092
Thirteenth Report	Gender pay gap reporting	HC 928
Fourteenth Report	Electric vehicles: driving the transition	HC 383
Fifteenth Report	Small businesses and productivity	HC 807
Sixteenth Report	The response from business to the Withdrawal Agreement and Political Declaration	HC 384
Seventeenth Report	Industrial Strategy: Sector Deals	HC 663
Eighteenth Report	Executive Rewards: paying for success	HC 2018
Nineteenth Report	Future of Audit	HC 1718

First Special Report	Industrial Strategy: First Review: Government Response to the Committee's Second Report of Session 2016–17	HC 337
Second Special Report	Corporate governance: Government Response to the Committee's Third Report of Session 2016–17	HC 338
Third Special Report	Apprenticeships: Government Response to the Second Joint Report of Session 2016–17	HC 450
Fourth Special Report	Leaving the EU: negotiation priorities for energy and climate change policy: Government Response to the Committee's Fourth Report of Session 2016–17	HC 550
Fifth Special Report	Pre-legislative scrutiny of the draft Domestic Gas and Electricity (Tariff Cap) Bill: Government Response to the Committee's Fourth Report	HC 865
Sixth Special Report	Leaving the EU: implications for the civil nuclear sector: Government response to the Committee's Second Report	HC 881
Seventh Special Report	The safety of Electrical Goods in the UK Government Response to the Committee's Third Report	HC 920
Eighth Special Report	A framework for modern employment: Government response to the Second Report of the Work and Pensions Committee and First Report of the Business, Energy and Industrial Strategy Committee of Session 2017–19	HC 966
Ninth Special Report	The impact of Brexit on the automotive sector: Government Response to the Committee's Fifth Report	HC 1018
Tenth Special Report	The impact of Brexit on the aerospace sector: Government Response to the Committee's Sixth Report	HC 1049
Eleventh Special Report	The impact of Brexit on the pharmaceutical sector: Government Response to the Committee's Ninth Report	HC 1426
Twelfth Special Report	Carillion: Responses from Interested Parties to the Committee's Tenth Report	HC 1392
Thirteenth Special Report	Carillion: Government response to the Committee's Tenth Report	HC 1456
Fourteenth Special Report	The impact of Brexit on the processed food and drink sector: Government Response to the Committee's Seventh Report	HC 1461
Fifteenth Special Report	Electric vehicles: driving the transition: Government Response to the Committee's Fourteenth Report	HC 1881

Sixteenth Special Report	Gender pay gap reporting: Government Response to the Committee's Thirteenth Report	HC 1895