National Audit Office

Report
by the Comptroller
and Auditor General

Department for Business, Energy & Industrial Strategy

Carbon capture and storage: the second competition for government support

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Department for Business, Energy & Industrial Strategy

Carbon capture and storage: the second competition for government support

Report by the Comptroller and Auditor General

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This report examines how the Department of Business, Energy & Industrial Strategy designed and ran the second competition for government support of carbon capture and storage before its cancellation in January 2016.

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Contents

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Key facts

£1bn

capital support available to bidders in the government's second competition for supporting carbon capture and storage

£100m

cost to government of the second competition prior to its cancellation

£8.9bn

upper limit of the Department's range of expected cost to consumers over a 15-year period once the two competition projects started generating electricity

16	examples of operational large-scale carbon capture and storage (CCS) projects worldwide at January 2017
0	examples of large-scale CCS in the UK
2007–2011	years the government ran its first competition for support to build CCS
2012–2015	years the government ran its second competition for support to build CCS
2	preferred bidders that undertook design and engineering stage research and development during the second competition
75%	percentage of the bidders' design and engineering costs that the government planned to meet
£168 million	amount the Department of Business, Energy & Industrial Strategy (the Department) has spent (2015-16 prices) on the two CCS competitions
£30 billion	the Department's 2015 estimate of the cost to meet the UK's 2050 decarbonisation target without CCS in the power sector

Summary

1 The Department for Business, Energy & Industrial Strategy (the Department) has lead responsibility for solving the UK's energy 'trilemma': ensuring a secure supply of energy that is affordable for consumers and helps the UK to meet its decarbonisation target to reduce carbon dioxide emissions in 2050 by 80% compared to 1990 levels.[1] In 2012, the Department launched its Electricity Market Reform strategy, which set out how it would secure investment in new generating capacity to achieve this target while meeting the challenge posed by increasing demand for electricity and closures of existing capacity in the 2020s and beyond.

2 Carbon capture and storage (CCS) formed an important part of the Department's plans to reduce carbon dioxide emissions. The Department expected CCS to enable existing and new fossil-fuelled power stations to produce low-carbon electricity. In 2015, the Department estimated that it would cost the UK £30 billion more to meet the 2050 target without CCS in the power sector because a more expensive mix of low-carbon technologies would be required. Once established, CCS could also potentially help to decarbonise the industrial sector and domestic heating systems.

3 CCS is a process to avoid the release of carbon dioxide (CO_2) into the atmosphere. It involves capturing CO_2 from sources such as power stations and energy-intensive industries, transporting it through pipes and storing it, usually underground. Globally, there are 16 examples of large-scale CCS operating with 22 more being developed. Most aspects of the transport and storage technology are well established in the oil and gas sector. However, only two of the 16 examples operating globally are at a large power station and the commercial viability of designs for capturing CO_2 from power stations has not been fully established.

4 Like other low-carbon power technologies, CCS is currently too expensive in the UK to be commercially viable for private developers without public support. CCS faces additional investment barriers due to a lack of supporting infrastructure and the risks involved in being the 'first-of-a-kind' in this country. The government has twice tried to help developers overcome these barriers. The Department launched its first competition for the government to support the development of the first CCS projects in 2007, but cancelled it in 2011 before awarding funding.

1 On 14 July 2016, the government announced that the Department of Energy & Climate Change (DECC) would close and its responsibilities for energy markets and climate change would transfer to a new department, the Department for Business, Energy & Industrial Strategy (BEIS). References to 'the Department' throughout this report that relate to events prior to July 2016 are referring to the then DECC.

5 In 2012, it launched a new CCS programme, with an objective to enable developers to invest in CCS in the early 2020s with government support that is comparable to other low-carbon generating technologies. The second competition was the start of this plan, with the Department hoping it would demonstrate the commercial and technical viability of deploying CCS in the UK.

6 In its 2015 Spending Review, the government announced the £1 billion capital funding allocated to the second competition was no longer available. This decision led to the two competition bidders, Shell and Capture Power Limited, cancelling their projects. It came shortly before the Department was due to receive their bids and decide whether either would receive support. In July 2016, we reported on the Spending Review process that led to HM Treasury, which runs spending reviews, withdrawing funding for the second competition.[2] We found HM Treasury considered:

- the costs to consumers through contracts for difference (the consumer-funded mechanism for supporting projects once up-and-running) would be high and regressive;
- the competition was aiming to deliver CCS before it was cost-efficient to do so;
- the competition would not guarantee the further investment required to expand CCS; and
- there were better uses for the £1 billion.

7 Had the competition been successful, the Department expected it to enable further CCS projects, with gradually reducing deployment costs and a decreasing requirement for government support. Given its potential to decarbonise different sectors, many stakeholders still regard CCS as being critically important to the UK achieving its decarbonisation target. It is currently inconceivable that CCS projects will be developed without government support. This may change, particularly if the price generators are required to pay for emitting CO_2 increases. Additionally, CCS may need to play less of a role in decarbonising the power sector if there are developments in storage, demand-side or nuclear technologies, which mean other forms of low-carbon generation become better suited to meeting the country's low-carbon energy needs affordably. The Department will indicate in due course what role, if any, CCS will play in meeting the 2050 target, or whether it now expects to reduce CO_2 emissions through other means.

2 National Audit Office, *Briefing: Sustainability in the Spending Review*, July 2016.

Scope of our report

8 This report assesses how the Department ran the second competition before its cancellation. It builds on the recommendations we made in our 2012 report on the first competition and makes new recommendations relating to the Department's future CCS plans.[3] The report:

- gives an overview of the CCS technology and its challenges (Part One);
- describes the government's efforts to support CCS through the competitions, the costs it has incurred and assesses the value that the competitions have generated (Part Two);
- assesses how the Department designed the second competition (Part Three); and
- evaluates how the Department planned to fund the competition projects (Part Four).

We do not assess whether withdrawing funding for the competition, leading to its cancellation, was the correct decision, but do identify ways in which the Department's running of the competition contributed to this outcome.

9 We evaluate the Department's performance according to: its objectives for the competition; the recommendations in our 2012 report; and good practice we have identified in assessing other government projects. We set out our audit approach in Appendix One and our evidence base in Appendix Two.

Key findings

The role of CCS

10 CCS could make a significant contribution to decarbonising the economy, but there are challenges which increase the costs to deploy it in the UK. CCS has the potential to contribute to the decarbonisation of the power, industrial, transport and heating sectors. Together these make up around 83% of the UK's CO_2 emissions. At present, there are no working commercial-scale examples of CCS in the UK, which makes it more expensive because investors in the first projects require a higher return in line with the greater risk. CCS also requires investment in new transport and storage infrastructure, which creates additional costs. The Department has stated that the costs to deploy CCS must come down for it to fulfil its potential in contributing to decarbonisation (paragraphs 1.4 to 1.13).

3 Comptroller and Auditor General, *Carbon capture and storage: lessons from the competition for the first UK demonstration*, Session 2011-12, HC 1829, National Audit Office, March 2012.

Costs and benefits of the competitions

11 The government has spent £168 million on its two CCS competitions. The Department spent £100 million on the second competition, in line with its budget for the stage it had reached. The Department spent £68 million on developing the first competition, which it cancelled in 2011. Cancelling the second competition has impacted on investors' confidence and means they may demand better conditions to engage with the government again, such as being required to bear less risk (paragraphs 2.7 and 2.8).

12 The value of the Department's spending on the second competition will depend on how it takes forward CCS. The competition achieved some benefits. It improved the Department's and bidders' understanding of the risks and technical and commercial challenges involved in deploying CCS in the UK. The two short-listed developers have produced a set of publicly accessible 'key knowledge deliverables', which set out learning about the projects' design, construction and commissioning. The Department expects developers to use these in any future CCS projects. Some of this learning could apply to other projects, such as appraisals of two potential storage sites and learning about commercial risk-sharing. But other learning could be lost, as project teams disband, or because it was specific to the projects being developed (paragraphs 2.9 to 2.13).

Competition design

13 The Department opted for a two-phase outcome-based competition because the commercial and technical uncertainties were too great to set a more detailed specification at the outset. In early 2012, the Department considered 21 different options for deploying CCS, of which it assessed five in detail. The Department concluded that the commercial, technical and cost uncertainties around CCS meant it could not identify which option would best meet its objective to reduce costs of future projects. Rather than specifying the technical details of the projects it wanted, the Department opted to start a two-phase outcome-based competition. In the first phase, it would shortlist two developers to undertake work that would reduce the uncertainties, before deciding whether to award contracts to either project to build their facility in the second phase (paragraphs 3.3 and 3.4).

14 The Department designed the competition so it could withdraw from supporting its preferred bidders without incurring cancellation costs. We have reported on many government projects to design, build and operate infrastructure or IT systems. We have found that, in many cases, departments awarded contracts where the commercial arrangements did not give them sufficient flexibility to manage uncertainties from the outset. In this case, the Department was not contractually obligated to the preferred bidders beyond the first phase. This limited its liability when it cancelled the process before deciding whether to contract either developer to build their facilities (paragraphs 3.5 to 3.7).

15 However, the terms of the competition contributed to one of the shortlisted projects being unlikely to reach the construction phase. The Department required projects to cover the 'full CCS chain' – from generation to storage – or have access to a full chain. Capture Power Limited, a consortium of companies looking to obtain external investment in the project, accepted this condition. However, it was struggling to allocate risks between the parties covering the different elements of the CCS chain in a way that would enable it to secure external investment. The project also could not find a partner to manage the storage facility. On this basis, this project would not have been able to present a final proposal fully in line with the Department's specifications (paragraphs 3.8 to 3.13).

16 The other competition project was more commercially viable but had less potential to reduce the costs of subsequent CCS projects. Shell took responsibility for the full chain of its project, meaning it did not face the same challenges as Capture Power Limited. This meant it was more able to submit a bid in line with the Department's specification. However, its location meant there would be fewer subsequent projects that could share its infrastructure. The Department noted this in its scoring of the project bid at the outset of the competition. It considered having a full-chain project operating in the UK would increase subsequent investors' confidence sufficiently to outweigh the disadvantages of its location. But HM Treasury withdrew funding partly because it concluded that the competition projects would not enable the CCS sector to expand without significant further costs to consumers (paragraphs 3.14 and 3.15).

17 Many stakeholders think the government needs to carry more risk to make CCS more affordable to consumers. The Department's approach to allocating risk was in line with wider energy policy that the private sector should, as far as possible, bear the construction and operating risks of new generating capacity. The Department received bids on this basis, which it took as evidence of the CCS sector's acceptance. But it is now clear that, of the two shortlisted projects, only Shell's appeared able to comply in full with the risk allocation. Many in the CCS sector do not consider it likely that certain conditions around Shell's project can be replicated and therefore think the government should bear more risks, particularly over stored CO_2, for CCS to be built in the UK. Government taking a greater share of the risk could reduce delivery costs, as developers and investors require lower returns when they carry less risk, but would expose taxpayers to losses in the event of risks materialising (paragraphs 3.16 and 3.17).

Funding the competition projects

18 The Department began the competition without agreeing with HM Treasury on the amount of financial support available over the lifetime of the projects. In our report following the first competition, we recommended that the Department and HM Treasury should be clear about the funding available across the life of the programme. For the second competition, the £1 billion capital towards construction was clear from the outset. There was less clarity on the revenue support that would be available through consumer-funded contracts for difference (CfDs), which fix the 'strike price' that developers receive for each unit of electricity they sell. When it launched the competition, the Department was uncertain about how much it would cost consumers and expected their contribution would be between £2 billion and £6 billion. But the Department did not agree with HM Treasury an overall budget for the total cost of the projects from the outset, which would have enabled it to tailor its approach to the competition within known affordability constraints (paragraphs 4.2 to 4.5).

19 The Department expected the unit costs of electricity from the competition projects would be higher than for subsequent CCS projects and other low-carbon technologies. Building the first CCS projects is made more expensive than established technologies by the risks inherent with being the 'first-of-a-kind' in this country, but the Department's competition design added additional costs to the first projects. The Department's long-term CCS programme plan required the competition projects to build and pay for the transport and storage infrastructure, reducing the costs of subsequent projects that could share it. The Department's allocation of most risks to bidders also increased the return the developers required on their investment, over and above the higher return already required for developing 'first-of-a-kind' projects. Additionally, the terms of the competition limited the size of generating plant that could take part, which reduced unit cost savings achievable through economies of scale. The Department established a Cost Reduction Task Force, which set out in 2013 how the costs of deploying CCS would reduce in subsequent projects. The competition projects' expected costs were in line with the task force's predictions (paragraphs 4.6 and 4.7).

20 The expected costs to consumers of the competition projects contributed to HM Treasury's decision to withdraw its support. By the time of the 2015 Spending Review, when it knew more about the competition projects through its negotiations, the Department had increased its estimate of the costs to consumers to between £3.9 billion and £8.9 billion. HM Treasury had sight of the Department's estimates during the competition through the CCS programme board. But during the 2015 Spending Review, HM Treasury noted the projects' CfD strike prices were expected to be around £170 per megawatt hour (MWh) compared with the wholesale market price of around £45, meaning costs to consumers of the projects would be high and regressive. It also concluded that reducing subsequent projects' costs further would require significant additional consumer support through CfDs. Following the competition, the Department identified the importance of clearly articulating, particularly within government, why the programme was necessary and why the competition projects were more expensive than mature and extensively deployed low-carbon technologies (paragraph 4.8).

CCS in the Levy Control Framework

21 Flaws in the design and implementation of the Levy Control Framework impacted on CCS investors' confidence. The Department would have included the costs of CfDs for CCS in its Levy Control Framework (the Framework), which caps the costs of certain consumer-funded policies up to 2020-21. We recently reported how the Framework has not met its potential to support investor confidence because of poor forecasting, a lack of transparency and its short and reducing time frame.[4] In April 2015, the Department forecast it would breach the Framework limit, leading it to reduce support for low-carbon technologies other than CCS. Developers of CCS projects outside the competition found these reductions in support caused them to have concerns that the government would also not provide further support for CCS beyond the competition, even before it was cancelled. During the Spending Review, the Department set out to HM Treasury its intention to provide support through CfDs for up to two future CCS projects. It could not make decisions about the nature and amount of this until the Spending Review and the competition had concluded (paragraphs 4.9 to 4.11).

Conclusion on value for money

22 The Department's plan to use a competition to develop and deploy carbon capture and storage was ambitious but, ultimately, unsuccessful. Achieving this goal was challenging because the untried nature of the technology in this country meant the costs and benefit of the proposed projects were inherently uncertain. Given the level of challenge, it was an achievement for the Department to sustain negotiations with the preferred bidders so that it gained valuable technical and commercial knowledge about how to deploy the competition projects. But the Department did not agree a funding limit with HM Treasury for the cost of contracts for difference to ensure it could manage the competition within the bounds of agreed affordability constraints. HM Treasury then withdrew its funding, partly because it concluded the proposed projects were too expensive and would not provide strategic benefits to warrant the impact they would have on consumers' bills.

23 We conclude that the Department has not achieved value for money from the £100 million it spent on the competition. Any value that could be gained is contingent on the Department and the CCS industry applying the lessons they learnt as a result of the competition. The Department should take some credit for designing the competition in a way that enabled withdrawal from proceedings without significant additional financial consequences.

4 Comptroller and Auditor General, *Controlling the consumer-funded cost of energy policies: The Levy Control Framework*, Session 2015-16, HC 725, National Audit Office, October 2016.

Recommendations

24 In developing its next phase of supporting CCS, the Department should:

a **Maximise the potential value from the competition by incorporating the lessons it and the key stakeholders have learned into any new CCS strategy.** The Department will be more likely to achieve this if it limits the dissipation of skills, knowledge and experience where possible, both within government and the wider CCS industry.

b **Ensure it understands, from the outset, the position of CCS developers and their ability or willingness to carry certain risks and applies this in its approach.** This should, for example, dictate which strategy is feasible and what delivery model is appropriate. In particular, it should consider how it will allocate storage risk, and learn from the challenges of sharing risks between participants in a project that are responsible for separate elements of the CCS process.

c **Assess options for how it can make early projects more affordable to taxpayers and consumers.** Experience from the competition has indicated that affordability considerations are as important as the long-term benefits of each option.

d **Agree early with HM Treasury any affordability constraints.** Crucially, this needs to take into account the costs of both capital support and any subsequent operational support, be that through CfDs or an alternative mechanism.

25 More generally, the Department should:

e **Work with HM Treasury to establish and use a consistent way of measuring the value of investments in different generating technologies that enable meaningful comparisons.** HM Treasury sets out guidance for departments in its Green Book on evaluating the costs and benefits of different programmes and projects. Some metrics that can be used to compare energy generation projects, such as the strike price, are not appropriate for comparing the costs and benefits of technologies at different stages of development and with different characteristics. Compared to established technologies such as wind power, CCS requires additional spending to build supporting infrastructure but could provide additional benefits, such as availability of power when it is needed.

f **Regularly revisit its commercial strategy and the value-for-money case in light of the evolving understanding of the delivery environment and market conditions.** This includes working with stakeholders to re-evaluate benefits and emerging challenges of its programmes at regular intervals. These should be clearly communicated across government and to wider stakeholders.

g **Consider the possible consequences of, and its risk appetite for, scenarios that are outside its central forecast or expectation when it develops a new project or programme.** The Department launched the competition with the intention of enabling construction of the first CCS projects without fully considering the negative impacts on investor confidence that would occur if it could not achieve this objective.

Part One

Carbon capture and storage technology

1.1 In this part we explain:

- how carbon capture and storage (CCS) works;
- its potential importance in contributing to the UK's decarbonisation target; and
- the main challenges to deploying CCS.

How CCS works

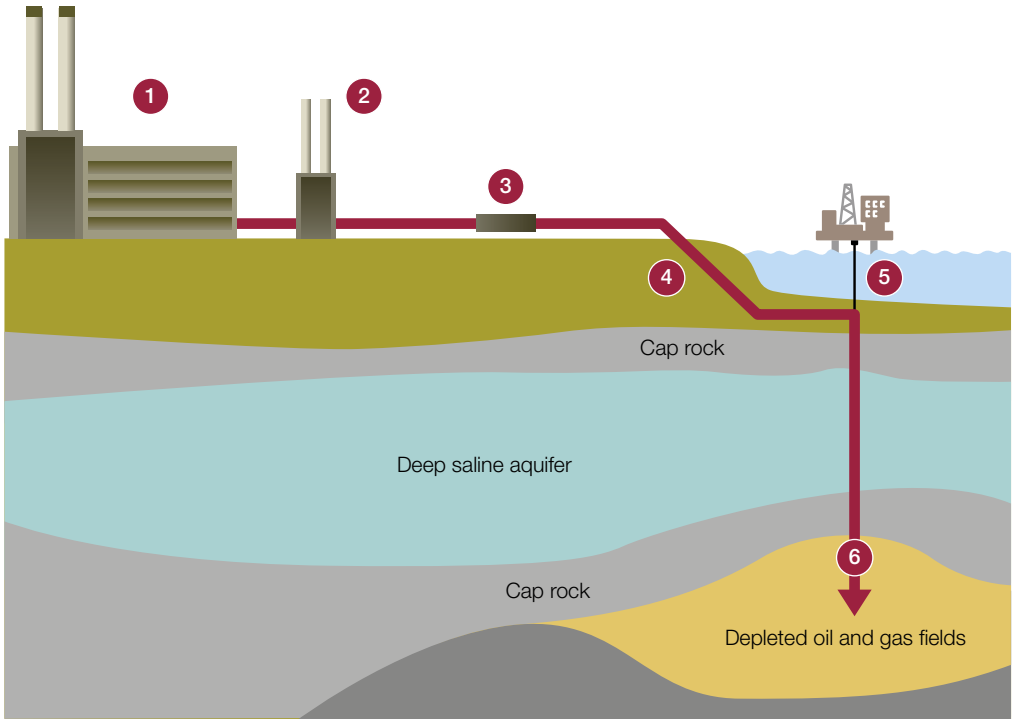
1.2 CCS collects carbon dioxide (CO_2) before it is released into the atmosphere. It can be used on any emitter of large amounts of CO_2, such as power stations or energy-intensive industries. CCS has three stages: capture, transport and storage (**Figure 1** overleaf).

a **Capture** – A capture plant removes CO_2 before, during or after the combustion of substances containing carbon, such as coal and gas. Current technologies are designed to capture around 90% of the CO_2 emitted, but require large amounts of energy to work.

b **Transport** – Once contained and compressed, the CO_2 is transported through a pipeline to a storage site.

c **Storage** – CO_2 is injected into storage locations underground or under the seabed. Depleted oil and gas reservoirs or deep saline rock formations are ideal locations because their surrounding rocks would prevent CO_2 escaping, in the same way that they contained oil and gas for millions of years. Storage sites must store the CO_2 indefinitely because if it is released into the atmosphere or water it could have severe environmental effects.

Figure 1
CCS process



1	**CO_2 source (eg power plant)**	**CO_2 is released** from the burning of **coal** or **gas**, or from elsewhere in the industrial process.
2	**CO_2 capture plant**	The CO_2 is **removed** from the power plant and '**captured**'.
3	**Compression unit**	In the compression unit, the captured CO_2 is **compressed** into liquid form for **easier transportation**.
4	**CO_2 transport**	The compressed CO_2 is then **transported**, usually via purpose-built **pipelines**.
5	**CO_2 injection**	At the **offshore storage site**, the CO_2 is **injected** into a carefully selected geological formation, usually **dense porous rock**.
6	**CO_2 storage**	After injection, the CO_2 moves up through the storage site until it reaches the **impermeable layer** of rock above the storage site. This layer of rock acts as a '**seal**', preventing CO_2 from escaping.

Source: National Audit Office

1.3 Most existing CCS projects are in the oil and gas sector, which means large parts of the technology are well established. For example, gas production companies upgrade fuels such as natural gas by extracting CO_2 so that it matches market requirements. According to the Global CCS Institute, there are 16 large-scale CCS facilities operating in the world. Only two of these are at a power station.[5] Applying CCS in the power sector is challenging as the design of the capture stage needs to be tailored to the emitting source. The 16 established facilities have the capacity to capture 30 million tonnes of CO_2 every year, equivalent to 0.08% of global CO_2 emission in 2015.[6] There are 22 more facilities under construction or in planning. North America has the most CCS projects, with 15 sites that are operational or under construction.

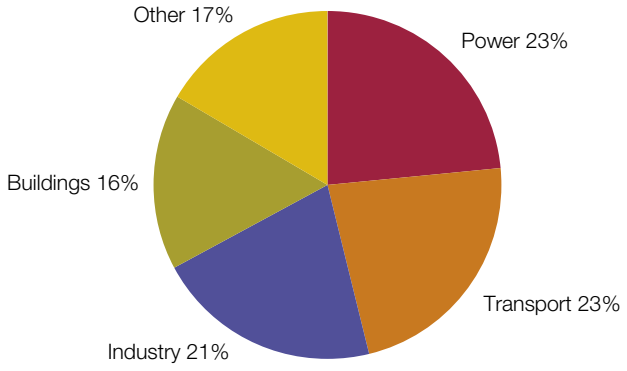
CCS in the UK

1.4 CCS has the potential to contribute to the decarbonising of power, industrial, transport and heating sectors. Altogether, these sectors make up around 83% of the UK's CO_2 emissions (**Figure 2**). In power, CCS can be applied to coal and gas power stations, or combined with biomass. The latter combination removes CO_2 from the atmosphere instead of just avoiding its release. CCS is also the only technology available that reduces emissions from heavy industry, such as iron and steel manufacturing. If it is combined with CCS, coal and gas could be used as a low-carbon means of producing hydrogen. This can potentially be used as a way of heating industrial furnaces, powering vehicles and as the main heating fuel in homes and businesses. Some cities in the UK are exploring the potential to replace their heating systems' natural gas with hydrogen.[7]

Figure 2

UK emissions of greenhouse gases, million metric tons of carbon dioxide equivalent ($MtCO_2e$), 2014

The power, transport, industry and building sector accounts for more than three-quarters of UK emissions



Source: Committee on Climate Change, *The fifth carbon budget – the next step towards a low-carbon economy*, November 2015

5 The others are five industrial carbon capture and storage (CCS) projects and nine natural gas projects.
6 Figures for operational plants and plant in construction are from the Global carbon capture storage Institute and are available at: www.globalccsinstitute.com/projects/large-scale-ccs-projects (accessed January 2017).
7 KPMG, *Energising the North*, A report for Northern Gas Networks, April 2016.

1.5 CCS could make a significant contribution to the UK achieving its objectives to reduce CO_2 emissions. The Climate Change Act 2008 commits the UK to reducing its CO_2 emissions by 80% in 2050 compared with 1990 levels. According to the Committee on Climate Change, CCS is necessary to meet the 2050 target at the lowest cost.[8] The International Energy Agency (IEA) estimates that CCS must deliver a 12% cut in global emissions to help limit average global warming to two degrees by 2050.[9] The IEA estimates that CCS can contribute a 20% cut in industrial carbon emissions with 29,000 $MtCO_2$ captured from cement, steel and chemical industries to 2050.[10]

1.6 In 2012, the Department of Energy & Climate Change (the Department)[11] launched the Electricity Market Reform strategy. This set out how it would secure investment in new generating capacity to achieve the 2050 target while meeting the challenge posed by increasing demand and plant closures in the 2020s and beyond. Along with renewables and nuclear power, CCS formed an important part of the Department's plans. In 2015, the Department estimated that meeting the 2050 target without CCS could cost up to £30 billion more in the power sector alone, although it says that this figure was subject to some uncertainty.[12]

1.7 Having CCS in the power supply mix could generate additional strategic benefits in ensuring a secure supply of low-carbon electricity. Generators pays for their carbon emissions through the European emissions trading scheme and the UK carbon price support mechanism. Many stakeholders expect this price will increase, potentially making fossil fuel power plants economically unviable without CCS. Applying CCS to the power sector would mean flexible coal- and gas-fired power plants could be part of a low-carbon generating mix. The main alternatives to CCS – renewable energy and nuclear power – are either intermittent, requiring excess capacity to be built, or inflexible, and therefore not well suited to meet short-term and seasonal surges in demand.

1.8 There may be alternatives, such as interconnection, smart technologies and storage that would mean CCS has a smaller role in achieving the UK's decarbonisation target. The National Infrastructure Commission reported in March 2016 that there could be an increased role for these technologies in a decarbonised electricity sector.[13] The Department is updating its modelling of pathways to the 2050 target as part of work on the government's emissions reduction plan.

8 Committee on Climate Change, *The fifth carbon budget – the next step towards a low-carbon economy*, November 2015.
9 International Energy Agency, *Energy Technology Perspectives – Executive Summary*, 2016.
10 International Energy Agency, *20 Years of Carbon Capture and Storage*, 2016.
11 On 14 July 2016, the government announced that the Department of Energy & Climate Change (DECC) would close and its responsibilities for energy markets and climate change would transfer to a new department, the Department for Business, Energy & Industrial Strategy (BEIS). References to 'the Department' throughout this report that relate to events prior to July 2016 are referring to the then DECC.
12 Net present value at 2012 prices.
13 National Infrastructure Commission, *Smart Power*, March 2016.

Challenges of CCS

1.9 There are several generic challenges to developing CCS, which increase the risks and therefore the costs for investors. These include:

- **Storage risk:** there are working examples of offshore CO_2 storage outside UK, which have proven reliable so far. However, storage is the most challenging element of investing in CCS because its risks have to be managed over the long term.
- **Infrastructure costs:** CCS transport and storage infrastructure is expensive. It is better value to build large capacity so multiple CO_2 emitters can share the pipelines and storage.
- **Operating costs:** CCS is expensive to operate because capturing, transporting and injecting CO_2 into storage requires energy. For example, running CCS on a power station could require between 16% and 32% of additional fuel input, increasing operating costs.[14]
- **Building a 'full chain':** all of the different elements of CCS have been proven to work, such as capturing CO_2 or injecting it into wells. Linking the elements together in one system is less developed. Most full CCS 'chains', from capture to storage, will involve different entities owning or operating the CO_2 emitter (for example a power station), pipeline and store. Successfully building and operating a full chain requires complex commercial arrangements between these entities to allocate and manage risks, for which no standard framework exists.

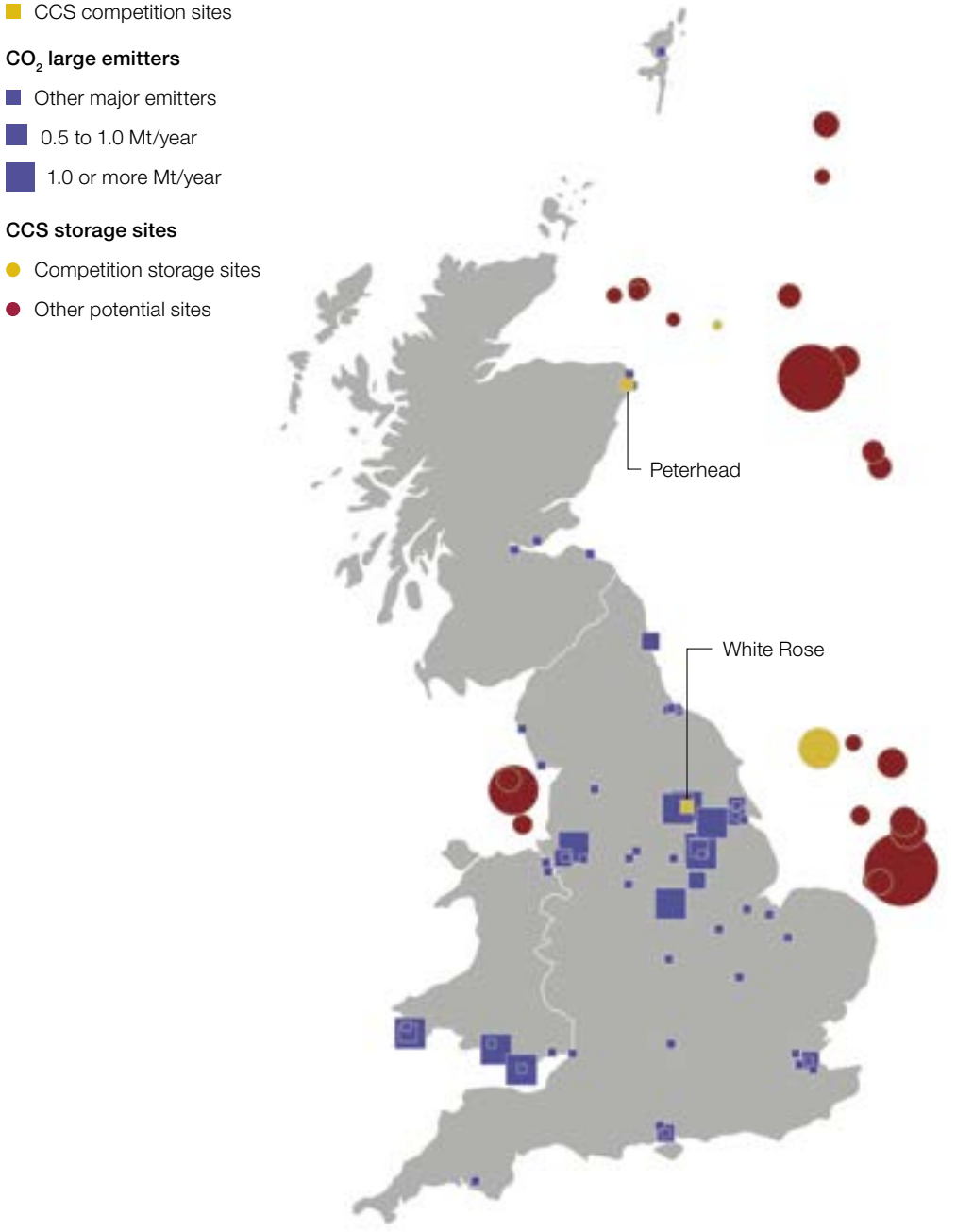
1.10 There are additional challenges for CCS in the UK, which increase developers' risks even further. While there are examples of CCS working globally, much of the risk to investors stems from setting up commercial arrangements. Arrangements in other countries cannot be replicated easily and must be adapted and tested to demonstrate how they can work in the UK's regulatory framework. Additionally, compared with North America, where most existing CCS projects are located, CO_2 storage in the UK is more difficult as most sites are offshore and CCS is less commercially viable as the UK does not have a market for re-using CO_2. For example, in some places CO_2 is injected into wells to recover more oil, or used in some chemical and manufacturing industrial plants. Being able to sell CO_2 for this purpose often means transport and storage infrastructure is already in place. In the UK, the transport and storage infrastructure still has to be developed, which increases the cost of establishing the technology.

1.11 On the other hand, the UK has some advantages for CCS development. It has an abundance of oil and gas fields and saline aquifers which could store CO_2. Many potential storage sites are near the coast, not far from many of the UK's largest industrial clusters, such as in Eastern England and the North West of England (**Figure 3** overleaf). CCS would also extend the life of some oil and gas assets in the North Sea, by converting oil platforms to injection sites and reusing pipelines. This would offer economic opportunities to the oil and gas industry, as skills are highly transferable.

14 Representative values for different capture technologies included in Rubin et al., 'The cost of CO_2 capture and storage', *International Journal of Greenhouse Gas Control*, issue 40, July 2015.

Figure 3

UK storage and large CO_2 point sources



Notes

1 Capacity of storage sites shown ranges from 30 Mt–1691 Mt.

2 The competition storage sites have estimated capacities of 30 Mt for Peterhead and 520 Mt for White Rose.

3 The storage sites shown on this map represent those which have been assessed by Energy Technologies Institute (ETI) to be the most promising. There are many other potential storage sites details of which are shown in the CO_2 Stored project data, available at: www.co2stored.co.uk

Source: National Audit Office analysis of Energy Technologies Institute and National Atmospheric Emissions Inventory data

1.12 The challenges illustrated above mean that the cost of implementing CCS in the UK in the short term are high, compared with other low-carbon generating technologies. The Department has estimated different costs of the initial CCS projects using its levelised cost measure, which includes all capital and operating expenditure during the lifetime of the project. These estimates are very uncertain and dependent on a number of factors, such risk-sharing arrangements; capacity deployed; and whether transport and storage costs are included. For example, in 2012 the Department expected the lifetime costs of the first CCS projects to range between £113 and £145 per megawatt hour (MWh) of electricity, including the costs of transport and storage infrastructure.[15] The Department now forecasts costs of between £102 and £172 per MWh for projects commissioning in 2025.[16] The levelised cost measure also provides an incomplete picture as it does not reflect the potential strategic benefits of CCS over intermittent renewables (paragraph 1.7).

1.13 It is also uncertain how the costs to deploy CCS will evolve over time. The Cost Reduction Task Force, which the Department set up in 2012, estimates third-generation projects could cost 40% less than a first-of-kind project per MWh.[17] But in 2016, the Parliamentary Advisory Group on Carbon Capture and Storage suggested a large enough programme can bring cost down to £85/MWh from the outset, making CCS comparable with the expected cost of more established low-carbon technologies in 2025.[18] Since the end of its second competition, the Department has stated that the costs of deploying CCS need to come down for it to contribute to decarbonising the UK's economy.

15 Department of Energy & Climate Change, *Carbon Capture and Storage Delivery Programme Outline Business Case*, January 2012, unpublished. Figures are for a first-of-a-kind project commissioned in 2011 and have been converted to 2015 prices.

16 Department of Business, Energy & industrial Strategy, *Electricity Generation Costs*, November 2016. Figures for a first-of-a-kind project converted to 2015 prices.

17 Carbon Capture and Storage Cost Reduction Task Force, *Final report: The Potential For Reducing The Costs of CCS in The UK*, May 2013.

18 Parliamentary Advisory Group on Carbon Capture and Storage, *Lowest Cost Decarbonisation for the UK: The critical role of CCS*, September 2016.

Part Two

Government support for carbon capture and storage

2.1 The challenges of deploying carbon capture and storage (CCS) in the UK mean that it is not commercially viable and government intervention is required for it to become an established technology. Given the potential importance of CCS for meeting decarbonisation targets, the government has implemented a series of measures to support it, including a programme to establish the first CCS projects and grants for research and development. In this part we:

- describe the government's various actions to support CCS since 2007 (**Figure 4**);
- report the costs the Department for Energy & Climate Change (the Department)[19] incurred in running the competitions; and
- assess the second competition's value.

The first competition

2.2 In November 2007, the then Department for Business, Enterprise and Regulatory Reform (BERR, the Department's predecessor) launched a competition for capital funding to design, construct and operate the UK's first CCS demonstration project. BERR planned to meet the entire cost of building the project (at an existing coal-fired power station), expected to be operative by 2014. On 19 October 2011, the Department withdrew from negotiations with the remaining bidder in the competition, as it could not agree a deal that would represent value for money. The Department spent £64 million[20] on the competition from November 2007 to October 2011, including £40 million awarded to two bidders in engineering and design contracts. We reported on the first competition in March 2012 and made recommendations for the Department to incorporate into the second competition.[21]

19 On 14 July 2016, the government announced that the Department of Energy & Climate Change (DECC) would close and its responsibilities for energy markets and climate change would transfer to a new department, the Department for Business, Energy & Industrial Strategy (BEIS). References to 'the Department' throughout this report that relate to events prior to July 2016 are referring to the then DECC.

20 2012 real prices.

21 Comptroller and Auditor General, *Carbon capture and storage: lessons from the competition for the first UK demonstration*, Session 2011-12, HC 1829, National Audit Office, March 2012.

Figure 4
Timeline of events

Nov	2007	The Department for Business, Enterprise and Regulatory Reform (the Department's predecessor) launches a competition to design, construct and operate the UK's first commercial-scale carbon capture and storage demonstration project
May	2010	Coalition Agreement sets out plans to invest in the technology at four coal-fired power stations (subsequently amended to include gas-fired power stations)
Oct		Spending Review makes £1 billion available for the CCS demonstration project
Oct	2011	Government announces it is withdrawing from negotiations
Apr	2012	The Department launches the new CCS strategy and the second CCS commercialisation competition
Jul		Developers submit eight bids
Sep		The Department shortlists four projects
Mar	2013	White Rose (Capture Power Limited) and Peterhead (Shell) selected as the two preferred CCS projects. The Department and bidders begin negotiating the Front End Engineering Design (FEED) contracts
May		Cost Reduction Task Force publishes its final report
Dec		White Rose FEED contract signed
Feb	2014	Peterhead FEED contract signed
Jun		White Rose awarded €300 million of European Union funds
Nov	2015	HM Treasury withdraws the £1 billion one month before bids for support to build their facilities were due. Both bidders announce that they will not progress with their projects
Jan	2016	The Department formally closes the competition

Source: National Audit Office

The second competition

2.3 In April 2012, the Department launched a second competition as the first major part of its new long-term CCS programme. The Department's desired outcome for its CCS programme was that developers should be able to build CCS-equipped fossil fuel power stations in the early-2020s without capital subsidy from the government, at a price competitive with other low-carbon generation technologies. The Department published a 'CCS roadmap', which set out five strands of government support to achieve this objective, of which the competition was the main one.[22] The Department expected its programme would enable generators to install between 10GW and 30GW of CCS by 2030 – equivalent to between 10% and 30% of current generating capacity, subject to the technology demonstrating its cost-competitiveness.[23]

22 The five strands are: the commercialisation competition; research and development; international collaboration; addressing barriers to deployment; and the Electricity Market Reform.

23 Subsequent departmental publications assumed lower deployment of CCS. For example, the Department presents a central case of 5GW deployed by 2030 in Department of Energy & Climate Change, *Electricity Market Reform Delivery Plan*, December 2013.

2.4 The Department wanted the competition to result in the construction of CCS projects that demonstrated the commercial operability of CCS in the UK and build the transport and storage infrastructure for subsequent facilities to share. Confidence in the commercial model and having the infrastructure in place would bring down costs for subsequent projects, eventually leading to CCS becoming an established technology. Developers would build and operate new projects competing with other low-carbon technologies, for government support through contracts for difference (CfDs), but not capital support (**Figure 5** on pages 24 and 25).

2.5 The Department identified two preferred projects that it awarded contracts to cover 75% of the pre-development costs (£84.1 million out of £112 million). It expected this to enable the developers to present full proposals to the Department for financial support to build their facilities (**Figure 6** on page 26). Successful projects would receive financial support in two ways:

- A **capital grant** to support a proportion of construction costs. The Department had £1 billion available and budgeted £100 million of this to pay for 75% of the projects' front-end engineering design (FEED) study costs. It would then allocate the remaining £900 million according to whether either or both projects brought forward proposals that satisfied its value-for-money criteria (see Figure 8).
- **CfDs.** CfDs guarantee a 'strike price' that a generator receives for each unit of low-carbon electricity it sells. Generators receive top-ups if the wholesale price is lower than the guaranteed price, which electricity consumers ultimately pay for. Conversely, payments flow in the opposite direction when wholesale prices rise above the strike price. Before it closed the competition, the Department was negotiating the terms of the CfDs in parallel to the project contracts. The CfD would last 15 years from the point that the CCS project began generating electricity and storing CO_2 and included a clause to index the strike price to fossil fuel prices.

Cancellation

2.6 The Department closed the competition in January 2016, prior to receiving the full project proposals. This was because HM Treasury had withdrawn the £1 billion capital funding previously available for successful bids during its Spending Review the previous November. We reported on this decision in July 2016 and found that HM Treasury withdrew the money because:

- the costs to consumers through CfDs would be high and regressive;
- the competition was aiming to deliver CCS before it was cost-efficient to do so;
- the competition would not guarantee the further investment required to expand CCS; and
- there were better uses for the £1 billion.[24]

24 National Audit Office, *Briefing: Sustainability in the Spending Review*, July 2016.

Both of the competition bidders confirmed that their projects would not be able to proceed as a result of the capital support no longer being available.

Costs

2.7 When HM Treasury withdrew the £1 billion capital funding, the Department expected both developers to submit bids within weeks. Both had incurred most of the costs allowed in their development contracts. Overall, the Department spent £100 million[25] running the competition, including:

- £20 million in legal, technical and financial advisory costs;
- £29 million to fund 75% of the cost Shell incurred for its FEED design; and
- £52 million to Capture Power Limited. This includes £1.3 million additional costs, that Capture Power was contractually entitled to claim due to the early closure of the competition.

The Department paid the two preferred bidders a total £81 million to complete engineering designs. This is below the contracted amount (£84 million) because, at the time of the closure of the competition, the White Rose project had not completed its work.

2.8 The Department and its predecessors have spent £168 million on the two CCS competitions.[26] There remains no CCS project in operation in the UK.

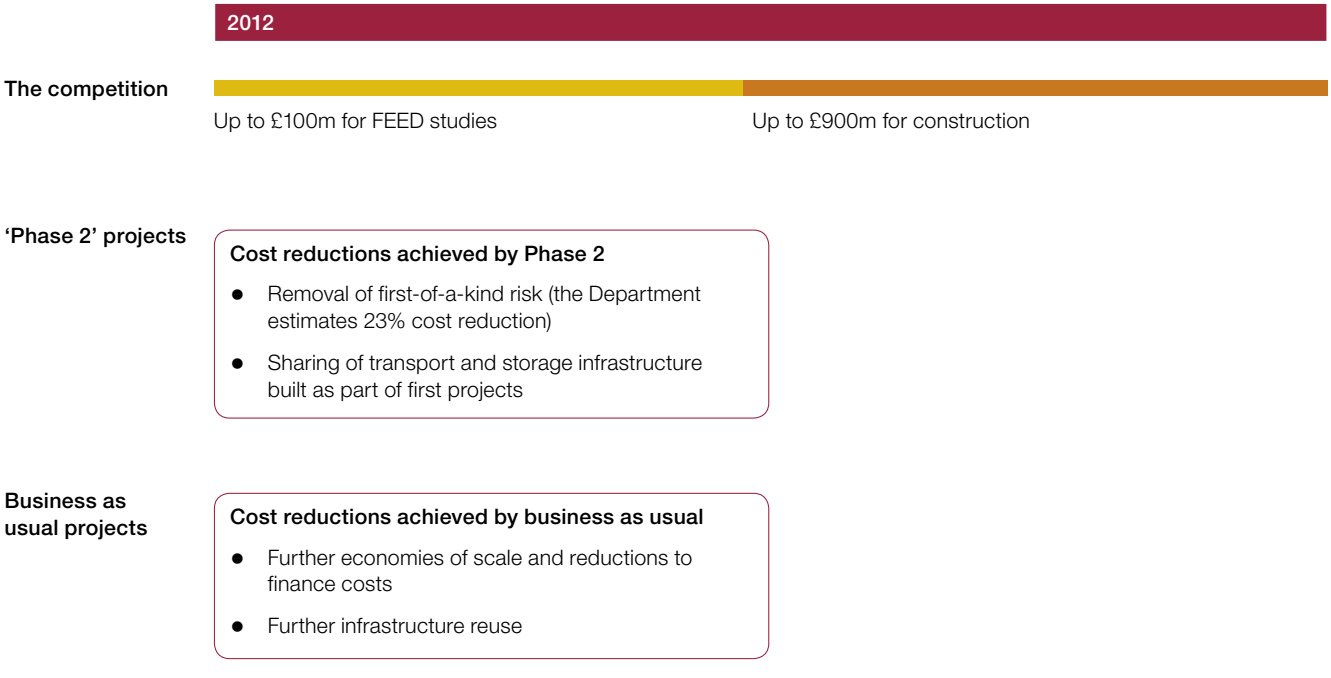
Benefits

2.9 The Department put conditions in the FEED contracts to ensure that learning could be derived from the competition even without it having reached completion. The Department required each of the bidders to produce 'key knowledge deliverables' (KKDs), which are publicly available and set out learning about the projects' design, construction, operation and decommissioning. It wants these to provide learning to the CCS supply chain, prospective developers, financiers and insurers, and policy-makers, both in the UK and overseas. In addition, both projects appraised potential geological storage sites, including their capacity and development costs, which could be useful for any future projects wanting to use the same sites.

25 Real 2015-16 prices. Total is lower than the sum of costs due to rounding.
26 Real 2015-16 prices.

Figure 5
The CCS programme

The programme would offer decreasing support as the technology reaches commercial maturity



Note

1 Strike prices are an indicative trajectory.

Source: National Audit Office analysis

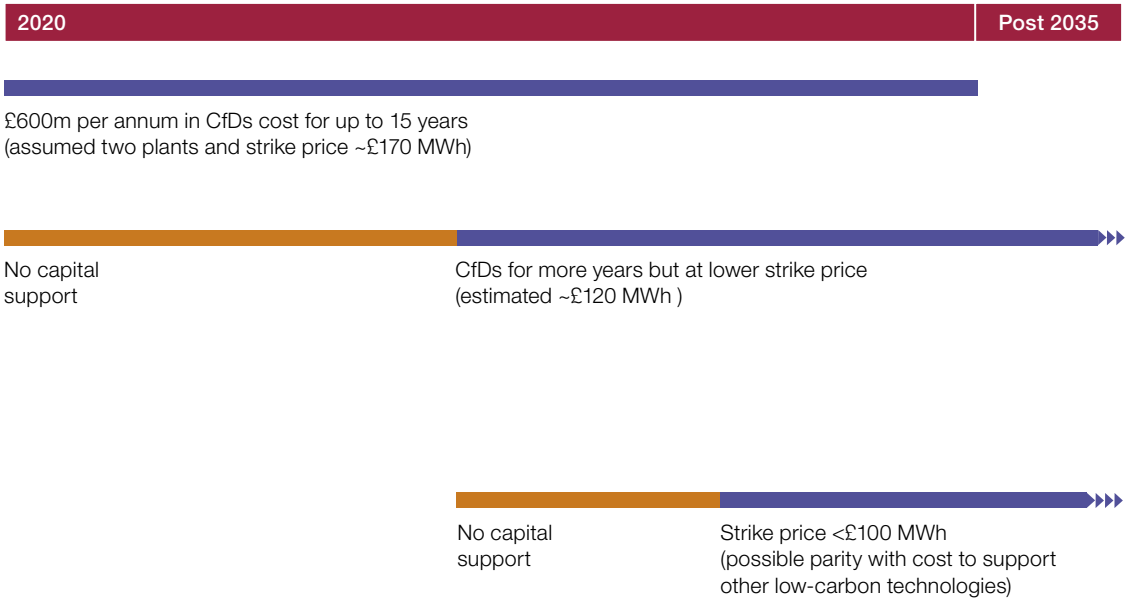

2020
Post 2035
£600m per annum in CfDs cost for up to 15 years
(assumed two plants and strike price ~£170 MWh)
No capital
support
CfDs for more years but at lower strike price
(estimated ~£120 MWh)
No capital
support
Strike price <£100 MWh
(possible parity with cost to support
other low-carbon technologies)

Figure 6
The Department's preferred projects

Name	Peterhead	White Rose
Developer	Shell	Capture Power Limited (a consortium of Alstom Power,[1] Drax and BOC) in partnership with National Grid
Location	Peterhead, Aberdeenshire	Selby, North Yorkshire
Technology	Post-combustion retrofit to an existing SSE-operated gas plant	Oxyfuel combustion in a purpose-built supercritical coal plant
Capacity	385 MW gross	448 MW gross
Annual CO_2 capture	1 Mt	2 Mt
Transport and storage construction details	Shell to convert an existing gas pipeline and the Goldeneye Platform in the North Sea. The project requires 102 km of pipelines. CO_2 to be stored in an exhausted gas field	National Grid to build pipes and run the injection platform in the North Sea. The project would require 165 km of pipeline. CO_2 to be stored in a saline formation to be newly developed
Expected project construction cost (indicative)	£1 billion	£2 billion to £2.5 billion
Expected commissioning date	2019	2020
FEED contract[2] (front-end engineering design)	75% of costs incurred (up to £28.6 million)	75% of costs incurred (up to £55.5 million)

Notes

1 General Electric acquired Alstom Power in November 2015.

2 Sums that bidders were contractually entitled to claim from the Department (real prices 2015-16). White Rose received only £52 million because at the competition closure date it had not completed its work.

Source: National Audit Office

2.10 Since the Department cancelled the competition, many stakeholders have drawn lessons for the future of CCS. Beyond the KKDs, the Department did its own lessons learned exercise, as has the Carbon Capture and Storage Association, which represents the CCS industry. The Committee on Climate Change observed that if these lessons are appropriately accounted for, CCS could be developed at a lower overall cost to consumers and taxpayers compared to the current approach.[27] In September 2016, a cross-party committee made recommendations on the government's future CCS strategy, largely based on experiences from the competition. The Department is considering the recommendations as it develops its new CCS strategy.

2.11 There are some recurring lessons. These include:

- the significant challenge for the market to bear storage risk;
- the challenges for a consortium to develop full-chain CCS, due to the difficulty of establishing cross-chain risk-sharing arrangements;
- that the technological risks of constructing CCS are well understood, meaning most reductions in cost will come from economies of scale, improvements in manufacturing techniques and reduced financing costs; and
- that potential CCS investors need signals that there is a long-term policy and regulatory certainty to reduce their required rate of return.

2.12 The value that the Department can derive from the competition will depend on whether it incorporates the lessons learned into its new approach, and how quickly it acts. Many of the benefits will be short-lived, as the people who have established skills and knowledge through the competition – developers, in the wider supply chain and within the Department – move on, particularly if no new projects come forward. Additionally, some of the competition's assessments and planning were project-specific and will only be re-usable if those projects are resurrected.

2.13 The Department will need to revive the CCS sector's willingness to engage with government on future projects to generate any value from the competition learning. The sense of disappointment and impact on investors' confidence following its cancellation may mean that additional support will be required for them to engage with the government again. The Energy and Climate Change Committee produced two reports that concluded government's decision to end the competition damaged investors' confidence.[28] There is also now less time to develop CCS in time to meet the 2050 target, which, according to the Energy Technologies Institute, could significantly increase the cost of meeting it.[29]

27 Committee on Climate Change, *A strategic approach to Carbon Capture and Storage*, Letter to the Secretary of State for Energy and Climate Change, 6 July 2016. Available at: www.theccc.org.uk/wp-content/uploads/2016/07/Letter-to-Rt-Hon-Amber-Rudd-CCS.pdf

28 Energy and Climate Change Committee, *Future of carbon capture and storage in the UK*, Second Report of Session 2015-16, HC 692, February 2016 and Energy and Climate Change Committee, *Investor confidence in the UK energy sector*, Third Report of Session 2015-16, HC 542, March 2016.

29 Energy Technologies Institute, Letter to the Chair of the Energy and Climate Change Committee, January 2016. Available at: www.parliament.uk/documents/commons-committees/energy-and-climate-change/ETI-letter-to-Chair-on-Future-of-CCS.pdf

Part Three

Designing the competition

3.1 In this part we evaluate how the Department of Energy & Climate Change (the Department)[30] designed the second competition, including:

- a description of its options appraisal process; and
- an assessment of the competition design given the delivery environment, including how it planned to allocate risks between government and the developers.

3.2 We have based our evaluation of the Department's competition design on recommendations that we made in our report on the first competition and through comparisons to best practice identified during our previous work on government contracting with commercial bidders to develop infrastructure. Key success factors include selecting a delivery model that:

- is aligned to wider objectives;
- takes account of the delivery environment, such as market conditions; and
- allocates risks between government and commercial partners based on investors' capacity and willingness to bear and manage risk.

Where any of these factors are uncertain, the delivery model should be flexible to allow changes in response to new information.

Options appraisal

3.3 In our report on the first competition, we found that the Department opted to run a competition without considering alternative options. This time, the Department initially appraised 21 project options to determine the best one for meeting its objective. It narrowed down the options to the five highest-scoring projects according to criteria including whether the option:

- could be adjusted during delivery;
- demonstrated the feasibility of UK regulatory, legal and licensing frameworks; and
- would advance the understanding of carbon capture and storage (CCS).

30 On 14 July 2016, the government announced that the Department of Energy & Climate Change (DECC) would close and its responsibilities for energy markets and climate change would transfer to a new department, the Department for Business, Energy & Industrial Strategy (BEIS). References to 'the Department' throughout this report that relate to events prior to July 2016 are referring to the then DECC.

3.4 The Department analysed costs and benefits of five highest-scoring project options based on their contribution to its aim of reducing technology costs and increasing investor confidence for subsequent projects (**Figure 7**). It concluded that the technical and commercial uncertainties around CCS at that time meant that it could not estimate the projects' costs and benefits with great confidence. Therefore, it opted instead for an outcome-based competition, which would keep its options open and begin to address the uncertainties.[31] Our experience from assessing government's support for infrastructure construction projects is that clarity over the cost and deliverables is required from the outset to maximise the chance of a successful outcome.[32] But this clarity was not possible at the start of the competition, in the context of commercial and technical uncertainties about CCS.

Figure 7
Steps to select the competition model

Year	Source	Delivery model selection stage
Aug 2011	Strategic business case	High-level analysis of 21 options
Jan 2012	Outline business case (annex)	Further analysis of the 21 options
	Outline business case	Summary analysis of 13 options (from the list of 21) Five options shortlisted for cost:benefit analysis: • Any UK project in receipt of EU funds and other projects overseas • One UK large-scale gas project following further research • One UK large-scale coal project following further research • One UK gas project and further projects overseas • Transport and storage infrastructure with small capture plant Conclusion: due to uncertainties around costs and benefits, none of the five options offer a clear advantage compared with the others. An outcome-based competition would allow selecting the project at a later stage

Source: National Audit Office

31 An output or outcome-based specification focuses on the desired outputs of a service in business terms, rather than a detailed technical specification of how the service is to be provided. This allows providers scope to propose innovative solutions.

32 National Audit Office, NAO guide, *Initiating successful projects*, December 2011.

Competition format

3.5 The Department designed the competition so that it had two stages. This would allow it to explore project options in more detail, with further funding agreed only if their costs and feasibility were clearer.

- **Stage 1:** The Department would provide pre-development support to projects that met its selection criteria, through 'front-end engineering design' (FEED) contracts. The FEED phase aimed to increase the Department's and developers' confidence that the projects could be delivered affordably. The Department made £100 million available for this phase.

- **Stage 2:** When the FEED contracts ended, the Department would decide which projects would receive capital support for construction and a contract for difference (CfD). This could be one, both or neither project, depending on whether they met its value-for-money criteria (**Figure 8**). There was up to £900 million available for capital support, while the total funding available through CfDs was unclear.

3.6 The Department shortlisted two projects for FEED contracts, having started with eight proposals. It chose its preferred projects based on their potential contribution to its objective to reduce the costs of deploying CCS in the 2020s. It applied criteria including location, deliverability and learning that could be gained from the specific technology (for example, generation type) and commercial arrangements (**Figure 9** on page 32). The Department was constrained by the budget it allocated to the FEED stage to shortlisting only two projects.

3.7 The phased approach enabled the Department to limit the financial impact of withdrawing from the competition. The Department had only committed £100 million allocated to the FEED studies rather than the whole £1 billion funding available for the competition. This contrasts with other government projects, where the commercial arrangements have not given departments sufficient flexibility to manage uncertainties from the outset. For example, our report *E-borders and successor programmes* found that the Home Office required more control over the programme than the commercial arrangement involving a fixed price and deadline was able to bear. We found that a two-stage contract that separated the design and build phases, like those commonly used in construction, may have been more appropriate in these circumstances.[33]

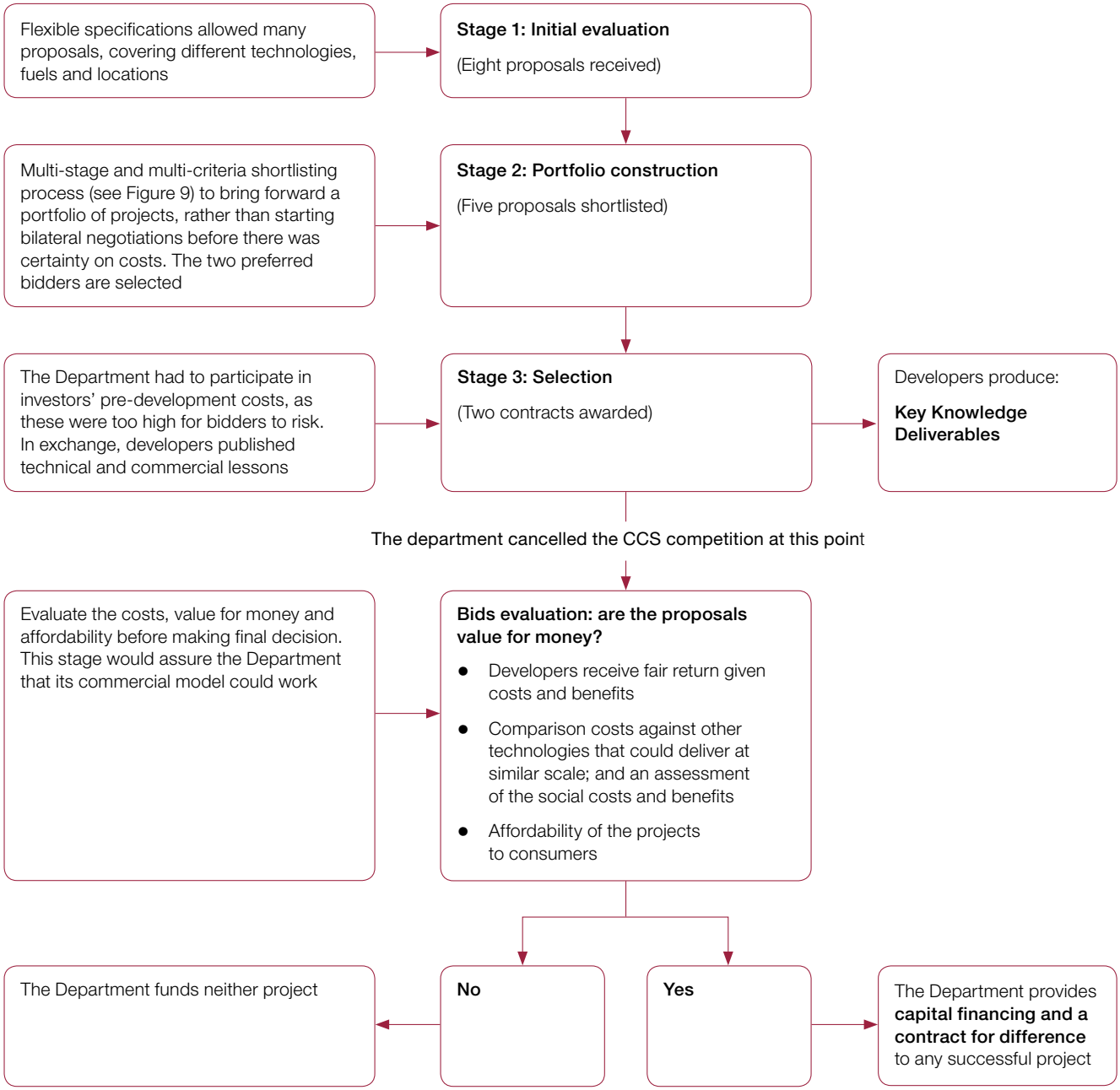
Risk allocation

3.8 In our assessment of the first competition, we found that the Department had not done enough to understand the commercial risks involved in CCS projects. In the second competition, the Department developed a risk-allocation matrix. This identifies risks and allocates them between government and developers.

33 Comptroller and Auditor General, *E-borders and successor programmes*, Session 2015-16, HC 608, National Audit Office, December 2015.

Figure 8
The competition process

The CCS competition process was stopped just before the evaluation phase was due to start



National Audit Office

Figure 9
Project selection process

Stage	Participants	Notes
Stage 1: Initial evaluation	Eight bids received	Three bids rejected because: • failed to meet eligibility test; • major concerns emerged during evaluation (two bids); and • the three bids were for part-chain.
Stage 2: Portfolio construction	Five bids	Five bidders proposed a total of 19 options. These were to be evaluated (score 1 to 5) in three stages according to a set of weighted criteria.
	Five bids – Stage 2.1	• An individual evaluation of each option. **Criteria include:** technical, commercial and financial feasibility.
	Five bids – Stage 2.2	• Assessment of each option's contribution to the CCS commercialisation outcome. **Criteria include:** part of or access to a full chain, location relative to other potential CCS projects, technology feasibility. • Project attractiveness scores and capital requirements. **Criteria:** Project attractiveness, FEED funding requirement, expected capital grant and annual CfD required, length of CfD period.
	Five bids – Stage 2.3	• Portfolio development. Combines individual project assessment to create a portfolio. • Evaluation scores: calculates project attractiveness per government pound invested for each portfolio.
Stage 3: Selection	Two + Two bids	• Projects are ranked according to evaluation score. • Affordability constraints (to be agreed) would set where to draw the line: best projects affordable for the budget. • Two projects selected for FEED contracts. • Two projects selected as 'reserve projects'. These would step in if any of the two first choices withdrew from the process.

Source: National Audit Office

3.9 The Department's risk-allocation matrix distinguished between CCS-specific risks and business-as-usual risks:

- CCS-specific risks are those risks that arise directly as a result of the design, construction, installation, operation or decommissioning of the CCS. The Department intended to share CCS-specific risks with the developers. The exact risk-sharing arrangements would be agreed with each developer during the FEED phase, such as setting a liability cap for the bidders, over which the liability to pay for the financial consequences of a risk materialising would fall to government.
- Business-as-usual risks are remaining risks associated with the day-to-day running of the project. The Department allocated all business-as-usual risks to the project developers rather than government.

3.10 The Department consulted on these risks with stakeholders. In 2011, before it launched the competition, the Department held an 'Industry Day', followed by a questionnaire, to gather feedback from prospective participants. Stakeholders highlighted the main challenges for industry to manage without government support (**Figure 10**).

3.11 The Department received eight bids on the basis of its proposed risk allocations, which it took as a sign that the sector accepted them. Both Shell and Capture Power Limited agreed to work with the Department to define and share the CCS-specific risks when they signed the FEED contracts, including which risks would be covered by any liability cap.

Figure 10
Challenges highlighted by stakeholders at the start of the competition

Challenge	Department's mitigation
Stranded asset risk: an element of the CCS chain is unavailable, meaning the other elements lose income. This is particularly an issue where a group of organisations operates a project, with each responsible for a different part of the chain (for example, capture, transport, storage). Each organisation within the chain would not be willing to take the risk that other parts of the chain might fail: they would need to arrange compensation clauses in their contracts.	None – allocated to bidders as a business-as-usual risk.
Uncapped liability risks: in particular related to stored CO_2 leaking. While the risk of CO_2 leaks is very low, any leak would have to be paid for with EU Emissions Trading Scheme permits. The future cost of these permits is uncertain, meaning the storage risk is unquantifiable. Investors' required rate of return increases where risks cannot be quantified, increasing overall project costs.	Risk shared – the Department planned to negotiate a liability cap with each of the developers, where the government would assume costs over a certain level. This would only apply to costs due to unforeseen events stemming from the untested nature of CCS. The Department was negotiating what would fall under this definition when the competition ended.

Source: National Audit Office

3.12 The risk allocation became the main difficulty in progressing the White Rose project through the FEED phase. The consortium said that had it reached the stage of presenting its bid to the Department, it would not have been on the basis of the initial allocation of risks:

- It did not have a partner willing to take on the storage risks. There are many long-term risks and associated costs that private developers are not able to accept, such as EU rules requiring storage operators to make financial arrangements to cover leakage risk and storage monitoring costs.[34]
- It was struggling to deal with the stranded asset risk, which the Department regarded as a business-as-usual risk. This required the partners in the project to allocate risks between them and external investors. The partners found it would have significantly increased the cost of their insurance to be able to cover liabilities to the other partners if they were responsible for an outage in the chain. The partners had not reached agreement on how this would work by the time the Department terminated the competition.

3.13 During negotiations, White Rose reaffirmed to the Department that it was committed to trying to finance its project on the basis of the proposed risk allocation. But it could not find lenders or institutional investors ready to accept some risks the Department defined business-as-usual risks, such as cross-chain default. Investors were also concerned about the potential for uncapped liabilities stemming from storage issues that are not deemed to be caused by a CCS-specific risk.

3.14 Shell was better placed to manage the risks the Department had allocated, primarily because it was backing the whole project rather than being part of a consortium. Accepting these risks did nevertheless push up its project costs. It also found that some risks were uninsurable, including the risk that stored CO_2 may leak in the future. The Department was negotiating a liability cap with Shell at the time the competition ended.

3.15 Shell's project may have been more commercially viable, but it was strategically weaker:

- Its location meant there would be fewer potential projects that could share its infrastructure. The Department noted this in its scoring of the project bid at the outset of the competition. It considered the project would still reduce investors' risks of investing in other CCS projects by demonstrating operability within the UK's commercial and regulatory framework. But one of HM Treasury's reservations about the competition was that the competition projects would not enable the CCS sector to grow without significant further costs to consumers.

34 European Union Carbon Capture and Storage Directive on Financial Securities and the Financial Mechanism.

- The conditions of the Shell project are unlikely to be replicated in future CCS projects. Shell led on the project, underpinning all elements of the CCS 'chain', meaning it did not have the challenges of dealing with cross-chain risk-sharing. It also had sufficient financial capacity to fund the project through equity rather than seeking investors in the project and had good knowledge of CCS from its involvement in the first CCS competition.[35]

3.16 The competition model meant that the Department could not easily amend the allocation of risk once it had awarded the FEED contracts as it could have faced legal challenge from unsuccessful bidders. Both preferred developers told us they had tried to amend risk allocations as part of the negotiations, such as treating the stranded asset risk as a CCS-specific risk, but that the Department was inflexible to changing it. The Department has stated that the bidders could have amended the risk allocation in their bids for capital funding and that it would have examined whether transferring more risk to the government would have been value for money.

3.17 Following the competition, many stakeholders have concluded that the government needs to carry more of the project risk if it is to deploy CCS affordably in the future. The Parliamentary Advisory Group on Carbon Capture and Storage has recently recommended that the government should take full ownership and bear all of the risk in developing CCS.[36] It recommends that the Department should establish a CCS delivery company to finance the first power plant with capture technology, as well as the transport and storage infrastructure, carrying the cross-chain risk and storage liability.

3.18 Government taking a greater share of the risk could reduce delivery costs but would expose taxpayers to losses in the event of risks materialising. Investors' required return reflects the level of risk they are exposed to; if the government carried more of the risk, investors would require lower returns, potentially reducing the costs to build the first CCS facilities. The downside of this approach is that the government, and therefore taxpayers, would be exposed if risks materialised. When designing the competition, the Department ruled out the option of government carrying more risk through ownership or part-ownership of projects at the first stage of its options appraisal, as this conflicted with government policy that the private sector should lead on investment in new energy infrastructure and bear the majority of risk.

35 Carbon Capture and Storage Association, *Lessons Learned – Lessons and Evidence Derived from UK CCS Programmes, 2008–2015*, June 2016.

36 Parliamentary Advisory Group on Carbon Capture and Storage, *Lowest Cost Decarbonisation for the UK: The critical role of CCS*, Report to the Secretary of State for Business, Energy and Industrial Strategy, September 2016.

Part Four

Funding the competition projects

4.1 This part of the report evaluates how the Department of Energy & Climate Change (the Department)[37] planned to fund the competition. The Department would have contributed to the projects' construction costs through a capital grant and contracts for difference (CfDs), which would have guaranteed the price the developers received for each unit of electricity they sold. In this part we:

- assess how clear the funding available was from the outset; and
- consider the impact on the carbon capture and storage (CCS) programme of the inclusion of the competition in the Department's Levy Control Framework (the Framework).

Funding clarity

4.2 Our report on the first competition found that the Department established funding for the project's capital costs three years after it launched the competition. It did not reach agreement with HM Treasury on the funding for operating costs. The lack of clarity on the government funding for the project delayed the early stages of that competition and added to the bidders' commercial risks. We recommended that the Department and HM Treasury should be clear about the capital investment available, both in total and across the length of the programme. Our previous reports on government projects have demonstrated that clarity of funding available is required from the outset to maximise the chance of achieving successful outcomes.[38]

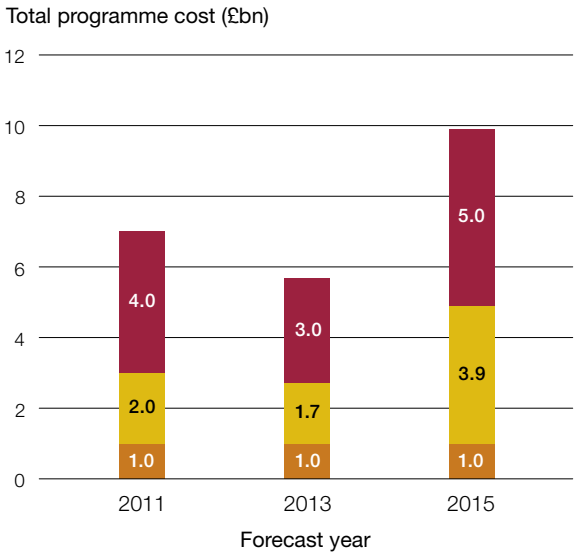
4.3 While the Department obtained assurances from HM Treasury at the outset that the £1 billion capital grant was available for the competition, it was less certain about the funds available for supporting the projects once operational. The Department made broad estimates about the level of support that the competition projects would require before it launched the competition. Its outline business case (January 2012) estimated supporting the CCS projects once operational would cost in the region of £2 billion to £6 billion, but would be dependent on the nature of projects chosen. This increased to between £3.9 and £8.9 billion by the time of the 2015 Spending Review, when it knew more about the costs of the two competition projects having conducted most of the front-end engineering design (FEED) stage (**Figure 11**).

37 On 14 July 2016, the government announced that the Department of Energy & Climate Change (DECC) would close and its responsibilities for energy markets and climate change would transfer to a new department, the Department for Business, Energy & Industrial Strategy (BEIS). References to 'the Department' throughout this report that relate to events prior to July 2016 are referring to the then DECC

38 National Audit Office, NAO guide, *Initiating successful projects*, December 2011.

Figure 11
Total expected cost of the programme

Expected programme costs increased between 2013 and 2015



Notes

1 The Department estimated the 2011 figure before it set out details of the CfD funding mechanism and of the competition. The Department told us it expected a total cost for the programme of up to £7 billion, but this was only an indicative figure.

2 Figures are in nominal terms.

Source: National Audit Office analysis

4.4 The Department and HM Treasury did not agree on a limit to the amount of support that could be provided to the CCS projects through CfDs. While there was agreement that the Department should negotiate a maximum funding amount for each project, consisting of both the capital grant and the CfD, there was no indication what this amount should be. The Department planned to agree this with the bidders once the competition was completed and it had more clarity over the costs of the projects and the support they required. The lack of agreement between the Department and HM Treasury on a limit to the support through CfDs meant the Department could not tailor its approach to the competition in a way that matched an agreed affordability constraint.

4.5 The Major Projects Authority repeatedly found in its reviews a lack of agreement between the Department and HM Treasury over the affordability constraints for the CfDs. As late as February 2015, it reported that the Department and HM Treasury were presenting different assessments of the affordability of operational support. It warned this presented a significant risk as it could indicate to the bidders a lack of long-term government commitment to CCS.

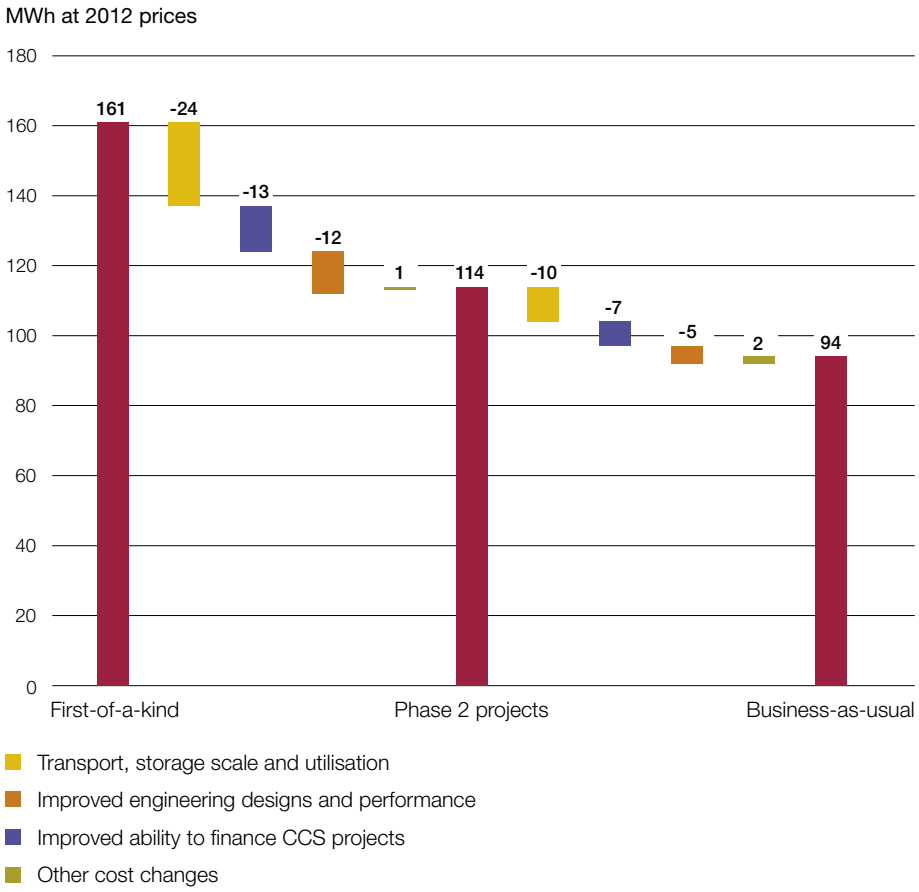
4.6 There were aspects of the Department's approach to the competition that made the unit cost of electricity produced by the first projects higher:

- bidders required higher returns, which would have been reflected in the CfD strike price, to reflect the risks they were bearing;
- the competition's terms limited the size of the plant that could earn support. Larger plants or clusters of plants generate economies of scale that would reduce the unit cost. However, larger plants sell more electricity, which could increase the amount of consumer-funded support for the completition projects through CfD top-up payments;
- the projects would finance and build oversized transport and storage infrastructure that subsequent CCS projects could share. National Grid Carbon estimated that transport and storage costs would have dropped by 60% to 80% for any Phase 2 projects that used the infrastructure put in place by the White Rose project; and
- the Department could only shortlist two projects for the design phase, reducing the competitive tension between bidders that could drive down costs. The Department mitigated this risk by being clear with the bidders that it was possible for neither project to receive support if they did not meet its value-for-money criteria.

4.7 The Department hoped the projects would achieve value for money in the long term by bringing down costs of subsequent projects. It established a Cost Reduction Task Force to set out a plan for reducing the costs of CCS over time. In 2013, it estimated that the first project would have a lifetime cost of £161 per megawatt hour (MWh) of electricity, and that this would reduce to £94 per MWh by the late 2020s (**Figure 12**). This would be due to a combination of sharing infrastructure, improved technical performance and greater access to lower-cost financing.

Figure 12
CCS cost reduction trajectory

The CCS Cost Reduction Task Force set out how the cost of CCS would reduce over time



Note

1 Indicative cost for an average of different technologies.

Source: CCS Cost Reduction Task Force, *Final report: The potential for reducing the costs of CCS in the UK*, May 2013

4.8 HM Treasury partly based its decision to withdraw funding for the competition on the expected cost to consumers. This drew on estimated strike prices of the competition projects of around £170 per MWh. It also expected strike prices for subsequent projects to be higher than for other low-carbon technologies even after significant additional consumer support. For the CfD contracts already awarded, strike prices for offshore wind farms range from £114 to £150 per MWh. The CfD for the Hinkley Point C nuclear power station is £92.50 per MWh (2012 prices). After the competition, the Department reflected in its lessons learned exercise on the importance of articulating and quantifying the long-term benefits of the competition projects and why they were expensive compared to more mature and extensively deployed low-carbon technologies, particularly within government.

CCS and the Levy Control Framework

4.9 The Department had earmarked funding for the CCS CfDs as part of its Levy Control Framework forecasts. The Framework is the Department's mechanism for controlling the impact of the government's low-carbon electricity policies on consumer bills up to 2020-21. The Department expected the Framework to allow funding for up to two of the competition projects and it earmarked £600 million in 2020-21 for CCS CfDs. HM Treasury had sight of these estimates through its role on the CCS programme board, although the Levy Control Board, set up to give the Department and HM Treasury joint oversight of all Framework forecasts, did not meet between November 2013 and July 2015.[39] The total amount available for CCS projects beyond the competition was yet to be determined as the Framework was only planned as far as 2020-21.

4.10 The Department was reducing support for other low-carbon electricity schemes it includes in the Framework in the run-up to it planning to agree CfDs for the competition projects. We recently reported how, in 2015, the Department reduced the cost of two other schemes when its revised forecasts showed that the Framework cap would be breached, due to falls in wholesale prices and changes to its assumptions of deployment and load factors. Poor governance of the Framework contributed to the delay in the Department discovering that its forecasts needed updating.[40] This put pressure on the availability of CfDs for CCS. In July 2015, four months before the Spending Review, HM Treasury indicated to the Department that the support available to CCS projects through CfDs could need to reduce because of forecast overspends in the Levy Control Framework.

39 Comptroller and Auditor General, *Controlling the consumer-funded cost of energy policies: The Levy Control Framework*, Session 2015-16, HC 725, National Audit Office, October 2016.
40 See footnote 39.

4.11 Our recent report on the Framework found that it had not met its potential to support investors' confidence. This has been particularly the case in the CCS sector. The Framework reduced investors' confidence due to its short time frame compared to the life of projects it supports, the Department's late forecasts of overspends and a lack of transparency.[41] Developers of CCS projects outside the competition had concerns that the government would not provide further support for the technology after the competition, particularly once the Department reduced support for other schemes in the Framework. During the 2015 Spending Review, the Department set out to HM Treasury its intention to provide support through CfDs for up to two future CCS projects. However, it could not decide about the nature and amount of this until the end of the competition and the conclusion of the Spending Review.

41 See footnote 39.

Appendix One

Our audit approach

1 This study examined the Department of Energy & Climate Change's (the Department's) design and implementation of its second competition for government support for Carbon Capture and Storage (CCS) projects. We reviewed:

- the case for government's support for CCS;
- how the Department decided a competition was the best way to provide support;
- how the Department and HM Treasury decided to fund the competition;
- how the Department ran the competition, including its interactions with commercial bidders; and
- how much the competition cost the Department and what value it has generated.

2 We followed up on recommendations that we made in our report on how the Department ran the first CCS competition.[42] We applied analytical frameworks that consider best practice in government contracting and negotiations with commercial bidders. We also applied best practice in initiating and managing successful projects.

3 We established the costs the Department and commercial bidders incurred during the competition.

4 We assessed the progress made in deploying CCS in the UK as a result of the competition, including reductions in commercial and technical uncertainties that have been achieved.

5 Our audit approach is summarised in **Figure 13**. Our evidence base is described in Appendix Two.

42 Comptroller and Auditor General, *Carbon capture and storage: lessons from the competition for the first UK demonstration*, Session 2011-12, HC 1829, National Audit Office, March 2012.

Figure 13
Our audit approach

The objective of government

Carbon capture and storage (CCS) is a technology with the potential to decarbonise the power and heavy industry sectors. However, there are several barriers to its deployment, including the costs to build infrastructure and high investor risk stemming from it being a new technology. The government wanted to provide support that would begin lowering these costs so they are comparable with those for other low-carbon technologies by the 2020s.

How this was to be achieved

In 2012, the Department of Energy & Climate Change (the Department) launched a competition to award up to £1 billion in capital support to build the first CCS plants. It expected that once the first plants were in place, successive ones could be built at much lower costs, because of lower investment costs and the potential to share the use of infrastructure.

Our study

Our study examines how effectively the Department ran the competition. It follows up on recommendations we made in a report on a previous CCS competition, which the government cancelled in 2011.

Our evaluative criteria

Did the Department remain within its budget and generate value from the competition?

Did the chosen delivery model:

- align to wider objectives?
- take account of the delivery environment?
- allocate risk appropriately?

Has the Department acted on the basis of our previous recommendations?

Did the Department and HM Treasury agree on an appropriate financing structure to support the competition?

Our evidence
(see Appendix Two for details)

We reviewed how the Department ran the competition by:

- interviewing industry and academic experts; and
- quantitative analysis of the cost of the competition.

We reviewed the Department's choice of delivery model by:

- reviewing its business case documents;
- interviewing departmental officials and representatives from the commercial bidders; and
- applying National Audit Office frameworks.

We reviewed the choice of financing model by:

- reviewing business case documents; and
- interviewing departmental officials from the Department and HM Treasury.

Our conclusions

The Department's plan to use a competition to develop and deploy CSS was ambitious but, ultimately, unsuccessful. Achieving this goal was challenging because the untried nature of the technology in this country meant the costs and benefit of the proposed projects were inherently uncertain. Given the level of challenge, it was an achievement for the Department to sustain negotiations with the preferred bidders so that it gained valuable technical and commercial knowledge about how to deploy the competition projects. But the Department did not agree a funding limit with HM Treasury for the cost of contracts for difference to ensure it could manage the competition within the bounds of agreed affordability constraints. HM Treasury then withdrew its funding, partly because it concluded the proposed projects were too expensive and would not provide strategic benefits to warrant the impact they would have on consumers' bills.

We conclude that the Department has not achieved value for money from the £100 million it spent on the competition. Any value that could be gained is contingent on the Department and the CCS industry applying the lessons they learnt as a result of the competition. The Department should take some credit for designing the competition in a way that enabled withdrawal from proceedings without significant additional financial consequences.

Appendix Two

Our evidence base

1 We reached our conclusions on whether the Department of Energy & Climate Change (the Department) achieved value for money with its second competition for government support for carbon capture and storage (CCS) projects following our analysis of evidence collected between March 2016 and January 2017.

2 We applied analytical frameworks with evaluative criteria, which consider what arrangements for dealing with commercial bidders and managing a major project would be optimal. Our audit approach is outlined in Appendix One.

3 We reviewed the Department's choice of delivery model at the outset of the competition.

- We reviewed departmental documents produced at the outset of the competition, including its outline business case and its strategic business case.
- We interviewed departmental officials to understand the motivations behind opting for the competition model.
- We interviewed participants in the competition to get their perspectives on the strengths and challenges of aiming to deploy CCS through a competition.

4 We assessed the Department's and HM Treasury's selected funding model for the competition.

- We reviewed departmental documents produced at the outset of the competition, including its outline business case and its strategic business case.
- We interviewed departmental officials to understand the reasons for the choice of funding model.
- We reviewed Major Project Authority reports to understand the impact of the funding model choice on the success of the competition.

5 We assessed how the Department ran the competition.

- We drew on the recommendations from our report on the first CCS competition to direct our analysis of how the Department ran the second competition.
- We reviewed departmental documents to understand its approach to allocating risks, its procurement specifications and its efforts to ensure the project team had the necessary skills and capacity.
- We interviewed participants in the competition to hear their perspectives on how the Department selected preferred projects and handled the negotiations.
- We reviewed the Department's financial information to assess how much the competition cost.

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