



LESSONS LEARNED

LESSONS AND EVIDENCE DERIVED FROM
UK CCS PROGRAMMES, 2008 - 2015



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The Carbon Capture and Storage Association (CCSA) exists to represent the interests of its members in promoting the business of Carbon Capture and Storage (CCS) and to assist policy developments in the UK, EU and internationally towards a long-term regulatory framework for CCS as a means of abating carbon dioxide (CO₂) emissions.

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Front cover image: the envisioned CO₂ storage system at the oxyfuel CCS plant in Schwarze pumpe. Image copyright Vattenfall

EXECUTIVE SUMMARY

Following the decision of the UK Government (HMG) to cancel the UK CCS Commercialisation Programme in November 2015, it became clear that there was a need to identify and collate the key lessons learned by those who have sought to develop CCS.

It is hoped that making these lessons available will help to inform the future development and deployment of CCS in the UK. This exercise was led by Patrick Dixon (Director, CCSA) and the Carbon Capture and Storage Association (CCSA). Interviews were conducted with CCS project developers and a selection of other CCS stakeholders between January and April 2016. Views were sought on the recent UK CCS Commercialisation Programme (2012 – 2015); and more generally around experiences with developing CCS projects in the UK and Europe over the last decade.

This exercise was evidence-based. The document identifies 36 key lessons based on evidence provided by participants. This document aims to avoid advocacy, and does not provide any specific recommendations; however readers should be able to draw a number of important conclusions from the evidence.

DELIVERABILITY OF THE CCS COMPETITION PROJECTS AND THE CCS BUSINESS MODEL

The UK CCS Commercialisation Programme sought to achieve the “Outcome” that

“private sector electricity companies can take investment decisions to build CCS equipped fossil fuel power stations, in the early 2020s, without Government capital subsidies, at an agreed Contract for Difference (CfD) Strike Price that is competitive with the strike prices for other low carbon generation technologies”

To achieve this, the Invitation to Participate in Discussions (ITPD) published by DECC in April 2012 outlined a high level structure and set of terms that would enable project developers to share some of the costs and consequences of “CCS risks” in the first CCS projects.

Following a lengthy period of project negotiations it became clear that, *subject to a UK Government assessment of affordability and value for money, a full-chain CCS project could have been delivered at Peterhead, using the Goldeneye store, within the structure, risk allocation and terms of the Commercialisation Programme, albeit with some amendments.* After lengthy and detailed exploration with the potential providers of both equity and debt finance to the White Rose project, it became clear that delivery of *a CCS full-chain project developed on the Drax site by Capture Power Ltd. (CPL), using the Endurance store developed by National Grid Carbon (NGC), would have required important adjustments to the structure of the risk allocation and to the terms of the Commercialisation Programme.*

In comparing these two conclusions, *the Peterhead/Goldeneye project may best be characterised as “the exception that proves the rule”,* because of the specific nature of the project and project developer. *The singular circumstances of the Peterhead project would seem unlikely to recur.*

COSTS AND OUTCOMES

Both the White Rose and Peterhead projects – the Competition projects - have confirmed that *if bids had been made they would have sought CfD strike prices which were likely to have been within the range forecast by the CCS Cost Reduction Task Force (CRTF) Final Report published in May 2013; £150-200/MWh.* The expected CfD strike prices for the Competition projects were much higher than the expected strike prices for subsequent projects because the Competition sought to develop fully-funded full chain projects, and required each project to carry the full costs of the resulting oversized CO₂ transport and storage (T&S) infrastructure.

Future Phase 2 projects, which planned to use the infrastructure built by either of the two Competition projects, would have required CfDs with strike prices very well below those of the Competition projects. This would have been as a result particularly of the economic savings accruing from sharing the infrastructure developed by the Competition projects, as well as from lower risk premia and smaller contingency requirements.

NGC believes that the unit T&S costs would have dropped by 60-80% for Phase 2 projects utilising the infrastructure put in place by the White Rose project.

It is believed that the desired “Outcome” set out in the CCS Commercialisation Programme ITPD could have been met in each of the new CCS hubs that would have been created if a Competition project had gone ahead in that hub.

THE “VALUE FOR MONEY” CASE

The potential CfD strike prices for the Competition projects were perceived by HMG to be too high, and the future benefits of developing CCS now (including delivering the “Outcome”) judged to be either insufficient or too remote to justify investing in either of the Competition projects.

There is a widespread view that *the assessment of the benefits and costs of CCS power generation against other forms of low carbon power generation suffered from a lack of like-for-like comparison, and did not take into account potential benefits of developing CCS infrastructure for use in decarbonising industrial emissions, heat generation and transport.*

CCS BUSINESS MODEL

The full-chain private sector business model, as established under the Commercialisation Programme, and spelt out in the ITPD, is unlikely to work in the future for at least two reasons:

Firstly, investing in offshore CO₂ storage is currently not, and – under the current policy and regulatory framework – is unlikely to become, an attractive investment proposition for the private sector. This is primarily due to the onerous financial security requirements, uncertain costs and the CO₂ storage liabilities arising from the EU CCS Directive.

Secondly, under the ITPD full chain structure the likelihood and consequence of cross-chain default by either the capture operator or the transport or storage operator proved to be a major challenge to both debt and equity investors in all parts of the CCS chain.

STORAGE RISKS AND LONG TERM STORAGE LIABILITIES

In the ITPD, HMG envisaged that developers would be able to share some of the costs and consequences of “CCS risks” in the first CCS projects with HMG. *It is now clear that HMG would have had to accept the majority of the financial risks arising from developing, operating, monitoring and decommissioning the new CO₂ stores.*

Whilst insurance would have been available to cover some storage risks, this would have been of limited term and capped in value. Amongst other risks, the costs that may arise as a result of CO₂ leakage from the CO₂ store were not considered insurable

Although not legally binding, *Guidance Document 4 of the EU CCS Directive on Financial Securities and the Financial Mechanism (GD4) risks imposing additional and onerous financial obligations on storage operators, beyond the specific requirements of the Directive. This could act as a major deterrent to future CO₂ storage development.*

STORAGE CAPACITY AND INTEGRITY

Despite the decision being taken to withdraw support for the two Competition projects, it is clear that *the CO₂ storage sites developed by the White Rose and Peterhead projects were capable of and ready for development.* These and the geological formations surrounding them are good, large, highly prospective CO₂ stores and remain of interest to project developers.

PROCESS FOR FUTURE DIALOGUE AND PROJECT DEVELOPMENT WITH HMG

After extensive discussions with project developers it is clear that *there is no discernible appetite from any developer to participate in a further UK CCS competition.* However, there is possibly some *appetite from project developers to enter into discussions and bilateral negotiations with HMG to develop new “bespoke” CCS projects that would require a CfD strike price that developers believe could be attractive to HMG.*

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INTRODUCTION

When Ed Davey, former Secretary of State for Energy and Climate Change, launched the UK CCS Commercialisation Programme for Carbon Capture and Storage (CCS) on 3rd April 2012 he said:¹

“ What we are looking to achieve, in partnership with industry, is a new world-leading CCS industry, rather than just simply projects in isolation - an industry that can compete with other low-carbon sources to ensure security and diversity of our electricity supply, an industry that can make our energy intensive industries cleaner and an industry that can bring jobs and wealth to our shores. ”

The Commercialisation Programme included a new Competition, which followed the previous “Demo 1” competition and earlier attempts from BP and SSE to develop the first UK CCS project at Peterhead by storing CO₂ in the Miller oil field. The Competition also followed the launch of European Energy Programme for Recovery (EEPR) and NER300 programmes, which were designed to support the development of CCS across Europe.

On 25th November 2015 the UK Government (HMG) announced that it was withdrawing funding for the CCS Competition.² Thereafter a range of stakeholders in CCS development agreed that there was a need to identify and collate the key lessons learned by participants in the CCS Competition, as well as those engaged in previous efforts to develop CCS projects. This would help ensure that the lessons were recorded and available to help inform the future development and deployment of CCS.

Interviews were conducted with CCS project developers and a selection of other CCS stakeholders between January and April 2016. Views were sought on both the recent UK CCS Commercialisation Programme, and also more generally around experiences with developing CCS projects in the UK and Europe over the last decade.

This document identifies 36 key lessons based on evidence provided by participants. Each lesson is supported by evidence statements and conclusions attributed to relevant party. The document does not set out to make the case for CCS deployment in the UK; nor does it provide any specific recommendations to policy makers. Readers should, however, be able to draw a number of important conclusions from the evidence presented.

The UK CCS Development Forum, chaired jointly by the UK Department of Energy and Climate Change (DECC) and the UK CCS industry, has supported this exercise, and DECC has expressed interest in discussing the policy implications that flow from it as part the process of developing a new approach to CCS, expected to be published in late 2016.

This document should be seen as complementary to the Commercialisation Programme Key Knowledge Deliverables (KKDs).

1. <https://www.gov.uk/government/news/ccs-competition-launched-as-government-sets-out-long-term-plans>

2. [HM Government Statement to Markets Regarding Carbon Capture and Storage Competition \(25 November 2015\)](#)

LESSONS AND EVIDENCE

COMPETITION PROJECTS DELIVERABILITY - UNDER THE "UK CCS ITPD FULL CHAIN STRUCTURE"

1. Peterhead/Goldeneye: Subject to HMG's assessment of affordability and value for money, a CCS full-chain project could have been delivered by Shell at Peterhead, using the Goldeneye store, *within the structure, risk allocation and terms of the Commercialisation Programme, albeit with some amendments.*

- Subject to receiving Final Investment Decision (FID) approval from its Board, Shell intended to submit a fully compliant bid by the end of 2015.
- Shell had not received any feedback that their intended proposals around risk-sharing with HMG (or other terms) would have been unacceptable to HMG, except that its proposals had not yet been assessed by HMG as to whether they would represent value for money.

2. White Rose: After lengthy and detailed exploration with the potential providers of both equity and debt finance to the project, it became clear that delivery of a CCS full-chain project developed at Drax by CPL, using the Endurance store developed by NGC, would have required important adjustments *to the structure of the risk allocation and to the terms of the Commercialisation Programme.*

- CPL believes that the ITPD structure did not provide sufficient insulation to those providing equity and debt finance to CPL against the consequences of possible failure of the new CO₂ Transport and Storage (T&S) infrastructure after the CO₂ had been captured.
- NGC believes that the lack of long term clarity on whether further CCS projects would be developed in the UK in the foreseeable future was of significant concern to infrastructure providers. In addition, storage developers were concerned over the level of return offered by CCS projects versus returns from alternative investment opportunities.
- NGC was unable to secure investment by storage partner(s) in the storage part of the White Rose project under the ITPD terms. Concerns included the contract and regulatory structures, treatment of storage sub-surface performance risk, obligations over long term storage liabilities, the treatment of cost uncertainties, and the impact of cross-chain default by the Generation and Capture (G&C) operator.

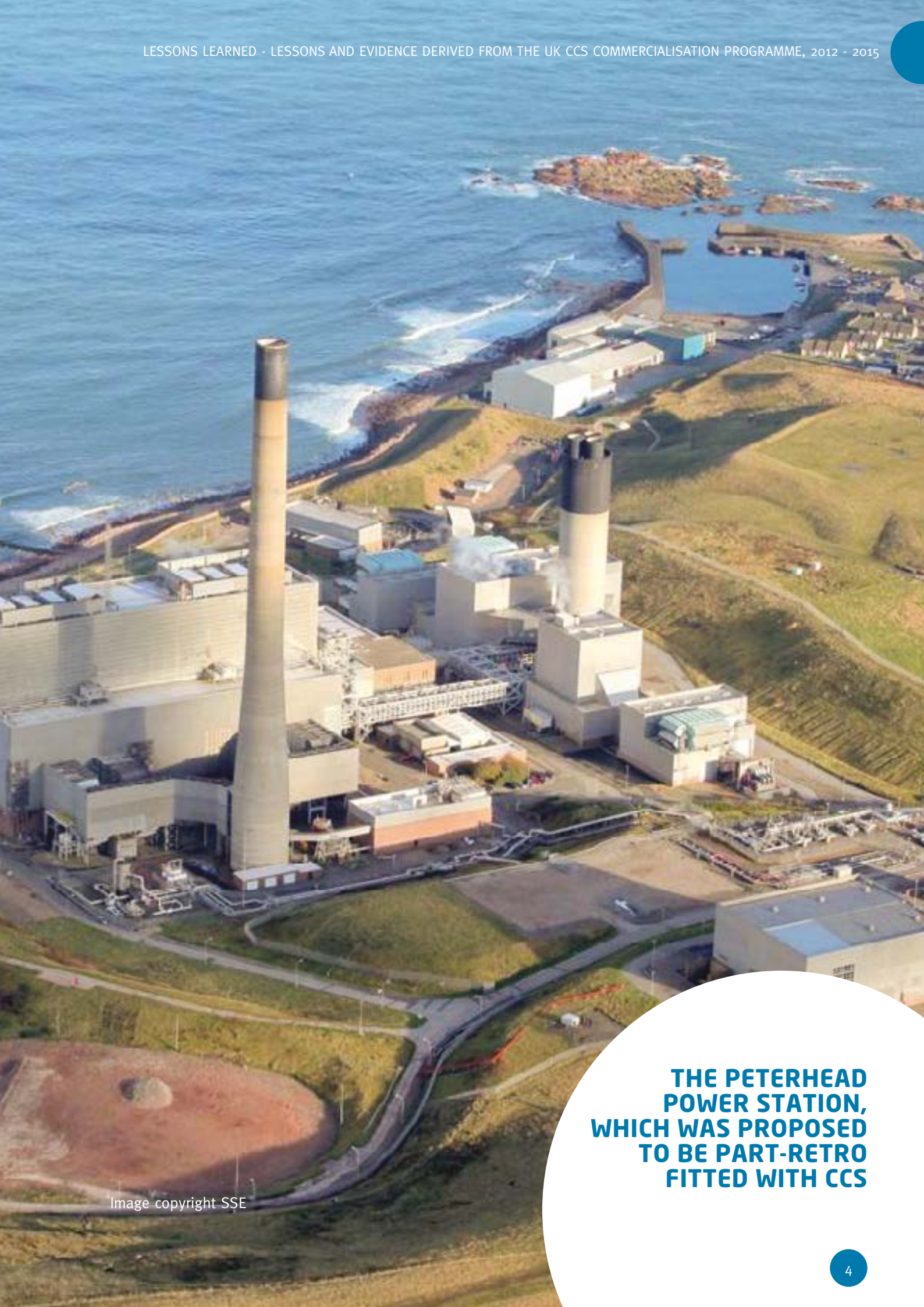
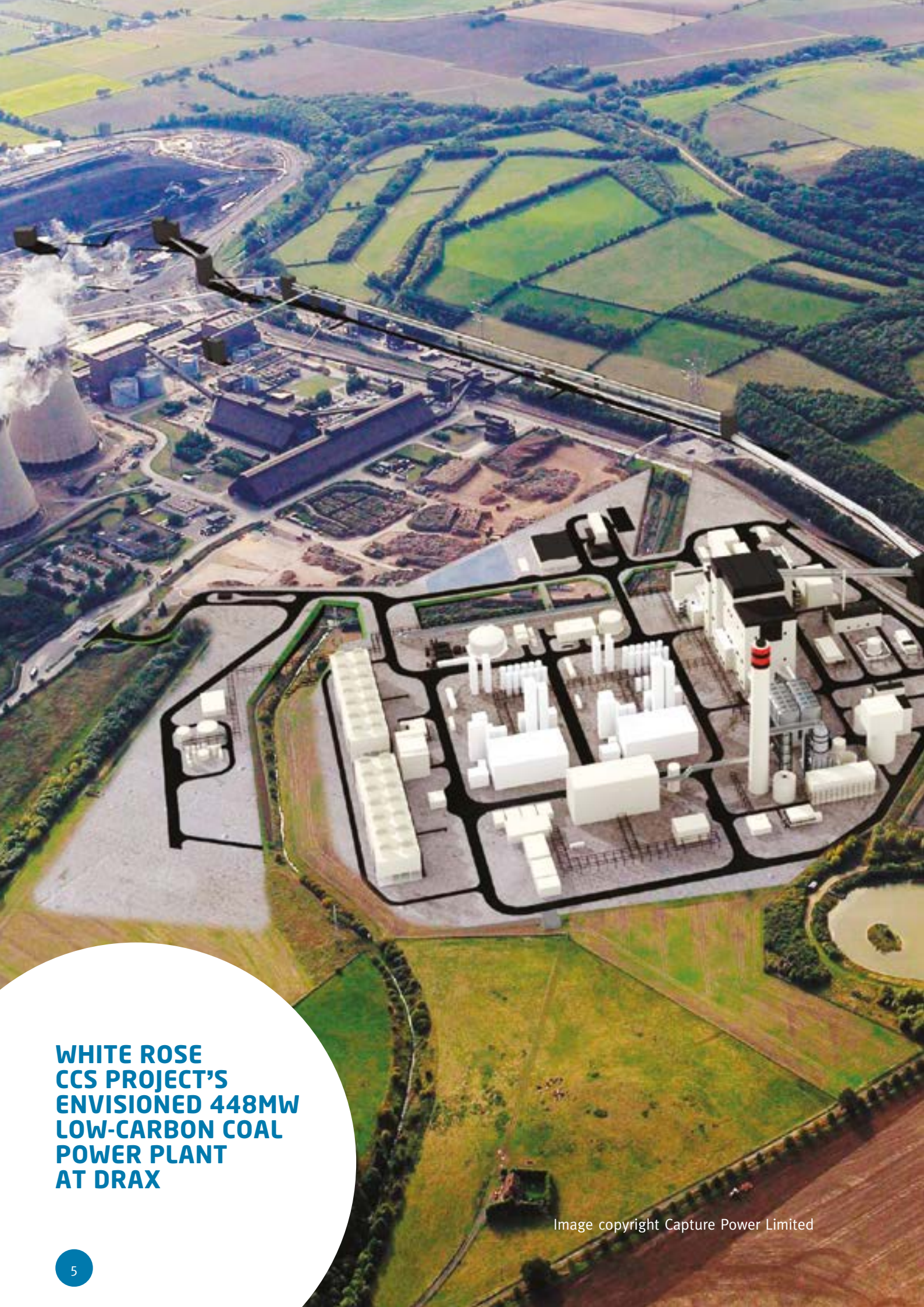


Image copyright SSE

**THE PETERHEAD
POWER STATION,
WHICH WAS PROPOSED
TO BE PART-RETRO
FITTED WITH CCS**



**WHITE ROSE
CCS PROJECT'S
ENVISIONED 448MW
LOW-CARBON COAL
POWER PLANT
AT DRAX**

Image copyright Capture Power Limited

3. *Given the conclusions in 1 and 2 above, the Peterhead/Goldeneye project may best be characterised as “the exception that proves the rule”, because of the specific nature of the project and project developer. The singular circumstances of the Peterhead project, which underpinned the developer’s ability to deliver the project (which were constructed based upon experience of participation in the Longannet venture³), and which would seem unlikely to recur, were:*

i. A single company controlling capture, transport and storage technologies and assets;

ii. A single developer with competence and capability to develop and deliver the project across the full chain;

iii. A developer with financial capacity to deliver the full chain project based on equity without project finance;

iv. A developer with the strategic interest and drive to deliver a complete CCS project;

v. A developer with sufficient knowledge of and confidence in the CO₂ store to take on substantial store performance risk;

vi. A developer with sufficient stature to attract wider industry participation both at investor level, and through the supply chains.

• CPL and NGC recognise that their project did not contain these characteristics. This meant, in particular, that:

- No party was willing to accept the full consequences of cross-chain default between elements of the full chain;
- No party was willing to expose their company to the risk of capital costs and other unknown costs escalating beyond defined limits.

3. The Longannet CCS project was developed by Scottish Power, Shell, National Grid and Aker Clean Carbon under the previous CCS competition, Demo 1

COSTS AND OUTCOME

4. *The bids for both Competition projects (had they been made) would have sought Contract for Difference (CfD) Strike Prices which were likely to have been within the range forecast by the CCS Cost Reduction Task Force (CRTF) Final Report published in May 2013.*

- The CRTF estimated that the first CCS projects would have sought CfD Strike Prices between £150 and £200/MWh. (This estimate was perceived by industry participants in the CRTF to be credible);
- Both Shell and CPL have confirmed that they were expecting to submit bids for CfDs with strike prices within this range.

5. *The expected CfD strike prices for the Competition projects were much higher than the expected strike prices for subsequent projects. This was in large part because each full-chain project was required to carry the full costs of the entire CO₂ transport and storage (T&S) infrastructure of their project, which was performed much larger than that needed for the CO₂ capture plant.*

- Shell intended to bid on the basis of modification and use of existing infrastructure, which would probably have been expandable at low cost to accommodate CO₂ from further projects in the future.
- CPL and NGC progressed their bid on the basis that the new pipeline and storage infrastructure would be “right-sized” (up to 17 MtCO₂ per annum) to allow future projects to share their infrastructure.
- NGC would not have considered participating in the project if the infrastructure was sized for a single project, because its intention was to see development of industry infrastructure that would have allowed them to provide a long-term service to several projects and achieve the desired economies of scale.

National Grid Carbon believes that the unit CO₂ transport and storage costs would have dropped by 60-80% for Phase 2 projects utilising the infrastructure put in place by the White Rose project.

6. Future Phase 2 projects⁴ which would have used the infrastructure built by either of the Competition projects would have required CfDs with strike prices very well below those of the Competition projects; arising particularly from the economic savings accruing from sharing the T&S infrastructure developed by the Competition projects, as well as from lower risk premia and smaller contingency requirements.

- Summit was developing a project without a capital grant that could have used the Goldeneye infrastructure (and existing pipelines); and which it therefore assessed would have required a CfD strike price considerably below the expected CfD strike prices for the Phase 1 projects.
- CPL and NGC progressed their bid on the basis that the new pipeline and storage infrastructure would be “right-sized” (up to 17 MtCO₂ per annum) to allow future projects to share their infrastructure.
- Shell had signed several confidentiality agreements with potential future CCS projects, with the possibility of sharing its T&S infrastructure, and thereby providing a T&S service at costs well below the costs incurred by the Peterhead project.
- NGC developed a proposed charging model for follow on projects, which would have been compliant with the UK CCS Third Party Access (TPA) regulations and guidance.⁵ This would have provided access to infrastructure at very much lower costs than for the White Rose project because the TPA regulations enshrine a marginal cost basis for setting future T&S tariffs.
- NGC believes that the unit T&S costs would have dropped by 60-80% for Phase 2 projects utilising the infrastructure put in place by the White Rose project.

7. The “Outcome” of the CCS Competition was stated in the ITPD as follows:

“ As a result of the [CCS Commercialisation Programme], private sector electricity companies can take investment decisions to build CCS equipped fossil fuel power stations, in the early 2020s, without Government capital subsidies, at an agreed CfD Strike Price that is competitive with the strike prices for other low carbon generation technologies.⁶ ”

It is believed that the “Outcome” set out in the ITPD as the goal for the Competition could have been met in each of the new CCS clusters that would have been created if a Competition project had gone ahead in either region. It is now believed that the costs of future Phase 2 projects, which would have used the infrastructure developed by the Competition projects in either region would have been even lower than the projections in the CRTF Final report.

- Summit was developing a project without a capital grant that could have used the Goldeneye infrastructure (and existing pipelines); and which it therefore assessed would have required a CfD strike price considerably below the CfD strike prices forecast in the CRTF report.
- Sargas Power and Progressive Energy were each considering developing Phase 2 projects using Competition project infrastructure; which they assessed would have required CfD strike prices considerably below the CfD strike prices forecast in the CRTF report.

4. Phase 2 projects would have been the projects developed immediately following the Competition projects and which would have used the same T&S infrastructure developed by the Competition projects

5. [Guidance on Disputes over Third Party Access to Carbon Dioxide Transport and Storage Infrastructure \(DECC, 2014\)](#)

6. <https://data.gov.uk/data/contracts-finder-archive/download/560937/7c3239b1-6e9d-4120-a8a2-07cdc54b56b9>



**COMPUTER GENERATED
IMAGE OF THE
PROPOSED PLATFORM
INSTALLATION AT THE
ENDURANCE STORE**

Image copyright National Grid

STORAGE CAPACITY AND INTEGRITY

8. *The Goldeneye store was capable of and ready for technical development.*

- Shell completed its Front End Engineering and Design (FEED) study and would have been ready to develop the store as part of a CCS project. Shell was also very close to receiving a storage permit from the Oil and Gas Authority (OGA), and its storage permit application had been reviewed by the European Commission as required under the EU CCS Directive.

9. *The Endurance store was (and remains) capable of and ready for development.*

- NGC had completed its FEED study on the Endurance store and believes it is now ready to be developed as part of a CCS project.

10. *Depleted gas fields with proven storage capability and comprehensive production history may already be fully appraised for CCS service to the level of confidence that would be required to obtain a storage permit with seismic appraisal, model construction and without further appraisal wells being drilled.*

- Shell and the OGA believed that no further drilling was needed to fully appraise the Goldeneye store to be ready for detailed design, engineering and construction for CCS.
- Pale Blue Dot concluded in its CO₂ Storage Appraisal Project for the Energy Technologies Institute (ETI) that both the Hamilton and Viking A depleted gas fields would require no further appraisal drilling ahead of an investment decision.⁷

11. *It is possible to appraise a saline aquifer, which has not previously been involved in hydrocarbon production, to the level of confidence that it would be possible to apply with confidence for a CO₂ storage permit.*

- NGC believes that the Endurance store was appraised to a level that would have given it sufficient confidence to progress with a CO₂ storage permit application, with – in its view – no major technical issues to be resolved. To reach that point NGC used seismic appraisal, data from two previous wells, model construction and drilled one new appraisal well.
- The OGA was still reviewing the output of an, independent quantitative risk assessment (QRA) of the integrity of the Endurance store.⁸ The QRA concluded:

“ The risk assessment provides a high level of confidence that long-term containment of the CO₂ planned to be stored will be achieved, and the system will evolve to long-term stability. Risks to human health or environmental receptors associated with loss of containment (in the unlikely event it occurs), displacement of brine and deformation are either low or very low. ”

- Statoil believes that, depending on the store in question, it may be possible to develop saline aquifer stores without appraisal wells if sufficient information can be collected from appraisal or production activities in areas adjacent to the stores and in the same stratigraphic units. This was the case for both Sleipner and Snøhvit, the two Statoil operated CO₂ storage projects in the Norwegian Continental Shelf.

7. [Progressing Development of the UK's Strategic Carbon Dioxide Storage Resource: A Summary of results from the Strategic UK CO₂ Storage Appraisal Project \(Pale Blue Dot, 2016\)](#)

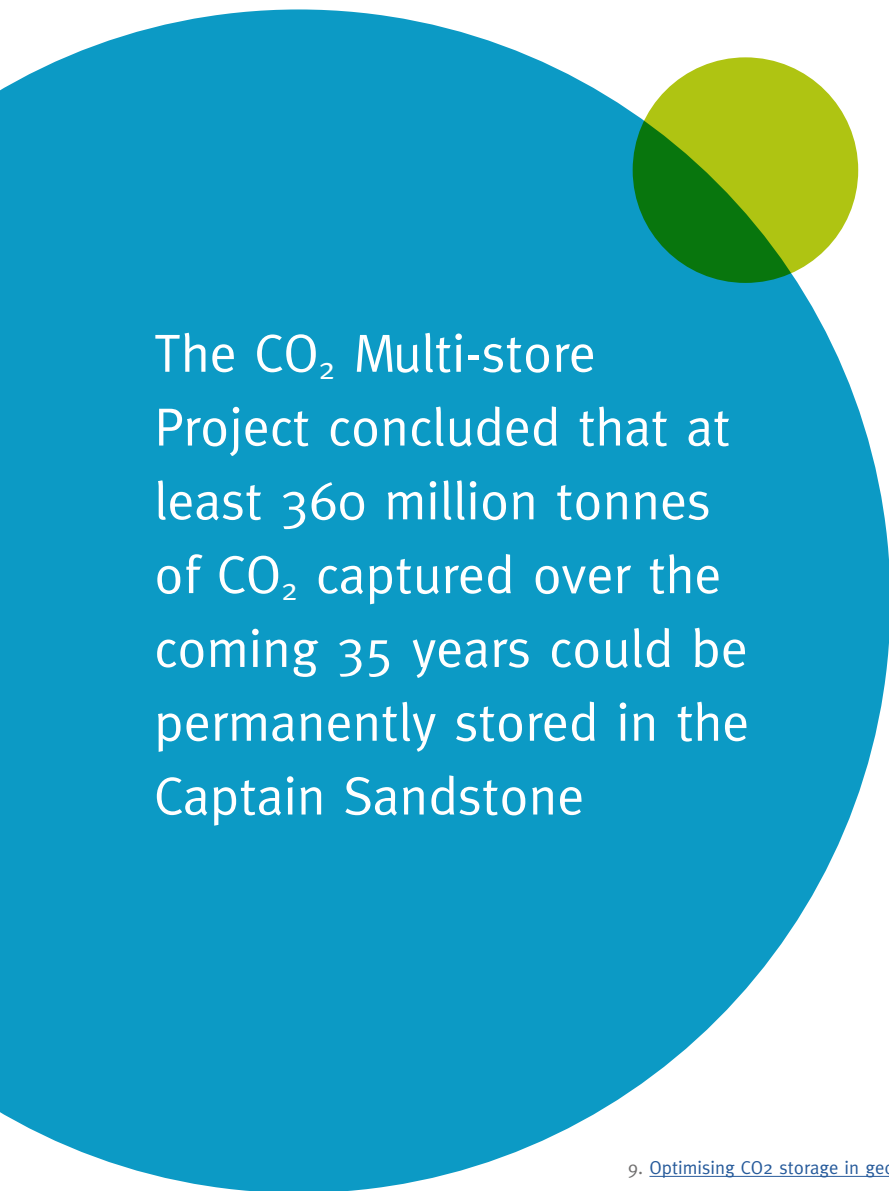
8. This QRA was conducted by Quintessa using its TESLA tool with 3-value logic

12. *It is now known with confidence that the Goldeneye infrastructure could have been extended at relatively low cost to provide very considerable, relatively easily accessible storage capacity in the Captain aquifer in the Central North Sea (of which the Goldeneye field is a part), capable of serving a significant number of CCS projects.*

- The Scottish “CO₂ Multi-store Project” (SCCS, 2015⁹) concluded that at least 360 million tonnes of CO₂ captured over the coming 35 years could be permanently stored, at a rate of between 6 and 12 million tonnes per year, using two injection sites in the Captain Sandstone.

13. *It is now known with confidence that the Endurance infrastructure could have been extended at low cost to provide accessible storage capacity capable of serving a very significant number of CCS projects in the Southern North Sea.*

- The Endurance store formation was shown to have capacity significantly in excess of that planned to be stored by White Rose. The CO₂ Stored programme has estimated that Endurance has a P₅₀ capacity of at least 450 MtCO₂.¹⁰ There was no evidence from either seismic analysis or well flow tests of any compartmentalisation or other factors which might affect this estimate.



The CO₂ Multi-store Project concluded that at least 360 million tonnes of CO₂ captured over the coming 35 years could be permanently stored in the Captain Sandstone

9. [Optimising CO₂ storage in geological formations; a case study offshore Scotland – CO₂MultiStore project](#)

10. www.co2stored.co.uk



Image copyright Shell

**THE GOLDENEYE
PLATFORM IN THE
CENTRAL NORTH SEA:
THE GOLDENEYE
RESERVOIR WAS
THE PROPOSED CO2
STORAGE SITE FOR
THE PETERHEAD CCS
PROJECT**

STORAGE RISKS AND LONG TERM STORAGE LIABILITIES

14. Under the ITPD, developers were to share some of the costs and consequences of so-called “CCS risks” with HMG. Whilst each of the Competition projects would have accepted a share of these risks it was clear that HMG would have had to accept the majority of the financial risk arising from developing, operating, monitoring and decommissioning the new CO₂ stores.

- Shell would have accepted a material share of the financial risk arising from developing, operating, monitoring and decommissioning the new CO₂ store, within agreed definitions of CCS Risks. However, the immaturity of the CCS business limited Shell’s ability to risk shareholder capital and it would have needed to share CCS storage performance risks with HMG.
- CPL and NGC believed that the bulk of the financial impacts of CCS risks in the White Rose project concerned CO₂ storage (such as sub-surface performance). Their bid would have accepted a very limited share in these risks.
- Statoil believes that for early CCS projects, and until the markets matures, the risks and financial burdens associated with offshore CO₂ storage in all countries will have to be shared with the relevant authorities (unless there is an associated income stream from e.g. natural gas production or Enhanced Oil Recovery (EOR)).

15. The Competition project developers consider that the majority of the risks associated with CO₂ storage, which HMG proposed be taken by the developers, could have been adequately quantified and insured against, though any insurance would have been of limited term (probably significantly less than the life of the CfD) and capped in value. However, one of the major risks that was not considered insurable was the cost and impact of CO₂ leakage (i.e. the required surrender of EU Emissions Trading System (ETS) allowances for any emissions from the site, including leakages, pursuant to the ETS Directive).

- Shell found that it could insure against many CO₂ storage risks but not: i) the unquantifiable costs of any CO₂ leakage relating to the surrender of ETS allowances; and ii) cost escalation in the Measurement, Monitoring and Verification (MMV) of CO₂ stored or the costs of any extension to the post-closure monitoring period.
- NGC believes that insurance could have played a significant role in mitigating risks. It felt that the cost of monitoring obligations, decommissioning and the financial contribution would all be reasonably predictable and would have been defined in the storage permit. The cost of such insurance could have been covered via tariff income derived from the CfD, provided contingency funds were available to provide for liabilities incurred before sufficient CfD funding had been established.
- However NGC believes that one area of difficulty would have been the costs and risks relating to the surrender of ETS allowances in the event of a leakage, which was unlikely to have been able to be covered by insurance, as the future value of ETS allowances is unpredictable and therefore unquantifiable.

Guidance Document
4 of the EU CCS Directive
on Financial Securities and
Financial Mechanism could act
as a major deterrent to CO₂
storage development.

FINANCIAL SECURITIES AND FINANCIAL MECHANISM

16. *Guidance Document 4 of the EU CCS Directive on Financial Securities and Financial Mechanism (GD4) risks imposing additional and onerous financial obligations on storage operators that go beyond the specific requirements of the Directive. Whilst the Guidance Documents themselves are legally non-binding, there is a risk that their literal interpretation by a Competent Authority could act as a major deterrent to CO₂ storage development.*

- NGC sought an application of the Directive that was consistent with a “first-of-a-kind” development rather than an application more appropriate to a mature market place. In its view, an application of worst case scenarios would have placed a financial burden on the project, which would have been impossible for NGC to accept.
- The developers of the ROAD project believe that the application of all GD4 recommendations would pose a substantial barrier to CCS development. ROAD believes that the CCS Directive itself gives sufficient flexibility for supportive Member States and Competent Authorities to help manage the risks and liabilities associated with CO₂ storage, but this is likely to involve substantial deviation from GD4.
- The developers of the ROAD project also believe that CO₂ storage should be recognised as being for the benefit of society, with risks and liabilities for developers being lower than for CO₂ emitters.
- Statoil believes that GD4 is too rigid, is a significant barrier to CCS deployment and remains a disincentive for investment.

17. *GD4 suggests that the level of Financial Security required to cover the surrender of ETS allowances in the event of a leakage should be based on the potential total tonnes of emissions multiplied by the market cost of purchasing an equivalent amount of allowances. In setting the level of the Financial Security for the Competition projects the OGA demonstrated a willingness to adopt a more pragmatic approach compared to the more rigid guidance laid out in GD4.*

- Shell sought a risk-weighted approach to monitoring, corrective measures and security.
- After detailed discussions, the OGA agreed to a proposal by Shell that corrective measures and security in respect thereof was only required for non-negligible risk. The OGA assessed all of the potential leakage paths identified by Shell and agreed with Shell which of those presented a non-negligible risk. Corrective measures were then defined and agreed for each of these risks and it was subsequently agreed that security would be posted by Shell for the estimated costs of carrying out those corrective measures, plus an uplift to provide for potential cost overruns.
- Shell found that by taking a sequential approach to agreeing the Financial Security after the rest of the permit application, significant delays in the permitting process were incurred. In its view the Financial Security requirements should be developed in parallel with the rest of the permit application once the risk sections of the permit have been completed.
- In NGC’s view, the OGA was willing to consider the output of extensive Quantitative Risk Assessment analysis conducted by NGC in relation to the security of CO₂ storage at the Endurance store. However, while the proposed quantum of the Financial Securities was not finalised and agreed, NGC believes it could have represented a barrier to concluding the permit and taking a positive FID.

18. *The Storage of Carbon Dioxide (Licensing) Regulations 2010 outline a list of five types of Financial Security that may be provided by projects to satisfy the requirements of the EU CCS Directive. There remains uncertainty as to whether OGA considered this list to be exhaustive or not, and whether or not the OGA can accept other forms of Financial Security.*

- Shell believed that the list of acceptable Financial Securities defined in the Regulations was a non-exhaustive list and that the full range of security options available for oil and gas operations should also have been available to the Peterhead CCS project given the similar technical and operational risks. In its view, an insistence on employing instruments like bank guarantees or escrow accounts could have greatly increased the cost of CCS to consumers.

- Although the OGA may not have approved specific proposals put forward by Shell, it has not ruled out the use of instruments beyond those outlined in the licensing regulations. Its assessment on the use of different instruments to cover Financial Securities was, and will continue to be, made on a case-by-case basis.

UK CCS BUSINESS MODEL

19. *The full-chain private sector business model as used in the Commercialisation Programme and as spelt out in the ITPD (“UK CCS ITPD full chain structure”) is unlikely to work in future, for several reasons. Two key reasons are outlined below:*

UK CCS BUSINESS MODEL - OFFSHORE CO₂ STORAGE

20. *Under the “UK CCS ITPD full chain structure” investing in early offshore CO₂ storage projects is currently not, and is unlikely to become, an attractive investment proposition for the private sector.*

- NGC was unable to attract storage partners in Endurance under the ITPD terms.
- The principal reasons given to NGC for lack of interest by potential competent operators were:
 - ‘Lack of fit with corporate strategic intent’;
 - ‘Lack of confidence in government policy commitment’, and;
 - ‘The time and cost involved in a government procurement’.
- The physical offshore activities of carbon storage are comparable to those of hydrocarbon exploration and production. However NGC believes that the commercial model of the carbon storage business (ostensibly a waste disposal business) is viewed as providing insufficient reward for the potential risk impact and commitment involved.
- It appeared to NGC from discussions with potential project partners that:
 - Returns on investment for the CO₂ storage business were deemed insufficient to justify companies taking the risks in reservoir and well performance that might be taken on by investors in projects producing hydrocarbons;
 - Financial investors were unable to bring the necessary offshore operator skills;
 - Hydrocarbon service companies were not interested in taking equity positions and risk in the CO₂ storage sector
- Statoil believes that early offshore CO₂ storage projects will require guarantees to underwrite some of the storage risks involved.
- The Norwegian government has recently published a document entitled “Further provisions for financial security for CO₂ storage”. This contains the following statement:¹¹

“ The [Norwegian] state has a desire to promote CO₂ storage. [The EU Directive on CO₂ storage] calls for the state to assume final responsibility for all [CO₂] storage locations ... The [Norwegian] state [therefore] agrees to bear some of the risk of [CO₂ storage] projects. This must be taken into consideration regarding the type of collateral that will be required. In particular government guarantees may also be necessary in the initial stage of CO₂ storage where substantial development costs are incurred by the operators. ”

11. [The original Norwegian text reads: “Som nevnt har staten et ønske om å fremme CO₂-lagring. I tillegg legges det i forskriften opp til at staten skal overta ansvaret for samtlige lagringslokaliteter. Disse forholdene signaliserer at staten er innforstått med å bære noe av risikoen med prosjektene. Dette må tas med i vurderingen av hvilken type sikkerhetsstillelse som skal kreves. Særlig nevnes at også statsgaranti kan være aktuelt i den innledende fasen med CO₂-lagring hvor det påløper betydelige utviklingskostnader for operatørene.” \(Nærmere bestemmelser om finansiell sikkerhet for CO₂ lagring, Miljødirektoratet, 2016\)](#)

UK CCS BUSINESS MODEL - CROSS-CHAIN DEFAULT

21. Under the “UK CCS ITPD full chain structure” the likelihood and consequence of cross-chain default by the generation operator, the capture operator, the transport operator or the storage operator in this model was a significant challenge to both debt and equity investors in all parts of the CCS chain.

- Neither the equity nor debt investors in White Rose would accept the full risks and consequences of cross-chain default as required by the ITPD, although both CPL and NGC were prepared to take an element of cross-chain risk on equity.
- Sargas Power identified cross-chain default as a key risk to be taken by the host Phase 1 projects (possibly underwritten by HMG) if it were to use Phase 1 project T&S infrastructure.
- Progressive Energy identified cross chain default as a key risk in a point to point full chain CCS project early in the Competition process. In its view, the tools available to manage this risk in the ITPD (including capital grant, CFD design and shared liabilities with HMG) were not well structured, thereby increasing project costs. In Progressive’s view, a financeable project required more than one store and more than one source of CO₂.

Under the “UK CCS ITPD full chain structure” the likelihood and consequence of cross-chain default by the generation operator, the capture operator, the transport operator or the storage operator in this model was a significant challenge to both debt and equity investors in all parts of the CCS chain.

THE CASE MADE FOR CCS - VALUE FOR MONEY

22. The potential CfD strike prices for the Competition projects were perceived in November 2015 by HMG to be too high to accept.

- Testimony by David Cameron to the House of Commons Liaison Committee - 12th Jan 2016:

“ [We] hoped that the cost [of CCS] would come down ... While I completely believe in the idea ... it seemed to me that the economics of carbon capture and storage really aren’t working at the moment ... [CCS] would cost you, at the current estimate, something like £170 per megawatt-hour ... That compares with unabated gas costing £65, onshore wind perhaps costing £70 and nuclear costing, say, £90.

As things stand, you put the £1 billion in [for CCS] ... and then you have to pay £170 per megawatt-hour—a full £80 more than nuclear, and more than twice as much as gas—and that money will go on bill payers’ bills ...¹²”

23. The future benefits of developing CCS now, including delivering the Commercialisation Programme “Outcome” were deemed in November 2015 by HMG to be either insufficient or too remote to justify investing in either of the Competition projects.

- This decision in the 2015 Spending Review to cancel the CCS Commercialisation Programme was made despite the case being made by the Committee on Climate Change and a range of other independent stakeholders that there would be many future benefits to beginning the development of a CCS industry now, in order to reduce the cost of decarbonising the UK’s emissions in the future.

¹². <http://www.parliament.uk/documents/commons-committees/liaison/2016-01-12-PM.pdf>

24. *Assessment of the costs and benefits of CCS generation against other forms of low carbon energy generation suffered from lack of like-for-like comparison.*

- CCS requires scale and infrastructure development to be cost competitive, and no CCS plant has yet been built in the UK¹³.
- Although they will pay for “their full share of waste management costs”,¹⁴ new nuclear plants will not have to carry the capital costs and risks of investing in nuclear waste disposal facilities - these investments are to be made by HMG,¹⁵ and then charged for when used.
- Power generation fitted with CCS can provide controllable firm and flexible electricity generation, whereas generation from many renewable technologies is periodic and intermittent; and therefore requires back-up supply and additional system inertia. As a result CCS has an inherent value which is not visible in a simplistic assessment of Value for Money based on Levelised Cost of Electricity, nor in a comparison between technologies based on Strike Price alone.¹⁶
- The value of CCS infrastructure, which can then enable decarbonisation of Energy Intensive Industries, hydrogen production, heat production and potentially stimulate the deployment of CO₂ EOR in the North Sea is not currently recognised in DECC’s Dynamic Dispatch Model (DDM) for the electricity system.¹⁷ This means that the additional value that can be derived from right-sized T&S infrastructure is only represented in DECC models as an additional cost, i.e. with no benefit, and the economy-wide value proposition for CCS is not represented fully.

PROCESS FOR FUTURE DIALOGUE AND PROJECT DEVELOPMENT WITH HMG

25. *Whilst interest in CCS remains, there is no discernible appetite from any project developers to participate in a further UK CCS competition.*

- Unattributed evidence - all organisations interviewed have commented that their organisations would be extremely unlikely to participate in any further UK CCS competition for the foreseeable future.

26. *There is appetite from a number of CCS project developers to enter into discussions and bilateral negotiations with HMG on developing new “bespoke” CCS projects (covering industrial CCS, hydrogen and heat, power and possibly EOR) that they believe could be attractive to HMG.*

- Unattributed evidence - At least 3 organisations have said that they would be interested in entering into discussions, aimed at leading to bilateral negotiations with HMG, on developing new “bespoke” CCS projects. Proposals are likely to cover industrial CCS, decarbonised heat from hydrogen, CCS for power generation, and possibly CO₂ EOR.

13. “Economies of scale that can only be unlocked through deploying CCS clusters in the UK provide the majority of [the] potential cost reduction.” Letter to Amber Rudd, (Committee on Climate Change, 28 January 2016, page 7)

14. Long Term Nuclear Energy Strategy, (Department of Energy and Climate Change, 2013, pp 8 and 19)

15. “Radioactive Waste Management Limited (RWM) is a wholly owned subsidiary of the NDA [which is in turn a non-departmental public body]. [RWM] is responsible for implementing Government policy on geological disposal of higher activity radioactive waste”. (Implementing Geological Disposal, Department of Energy and Climate Change, 2014, page 26)

16. “...an inflexible [power generation] system ... would require significant deployment of CCS to reach an emissions target”, (Value of Flexibility in a Decarbonised Grid, Imperial College London, October 2015)

17. DECC Dynamic Dispatch Model (DDM), (Department of Energy and Climate Change, May 2012)

INFRASTRUCTURE - OVER-SIZING AND SHARING TRANSPORT AND STORAGE INFRASTRUCTURE

27. Over-sizing CO₂ T&S infrastructure for simultaneous use by several future projects will, without doubt, generate the best value for money if a number of projects can share the same T&S infrastructure.

- The T&S infrastructure capital costs for White Rose required an increase of only 14% for an increase in capacity of about 600%.



28. There is a mismatch between the size of cost effective offshore T&S infrastructure and the expected volume of CO₂ captured from the first single Generation and Capture (G&C) projects.

- A single gas power plant fitted with CCS would typically capture 1 million tonnes per annum.
- The White Rose infrastructure would have been able to transport and store 17 and 10 million tonnes per annum respectively with relatively low incremental investment.

- SINGLE GAS CCS
- WHITE ROSE STORE
- WHITE ROSE PIPELINE

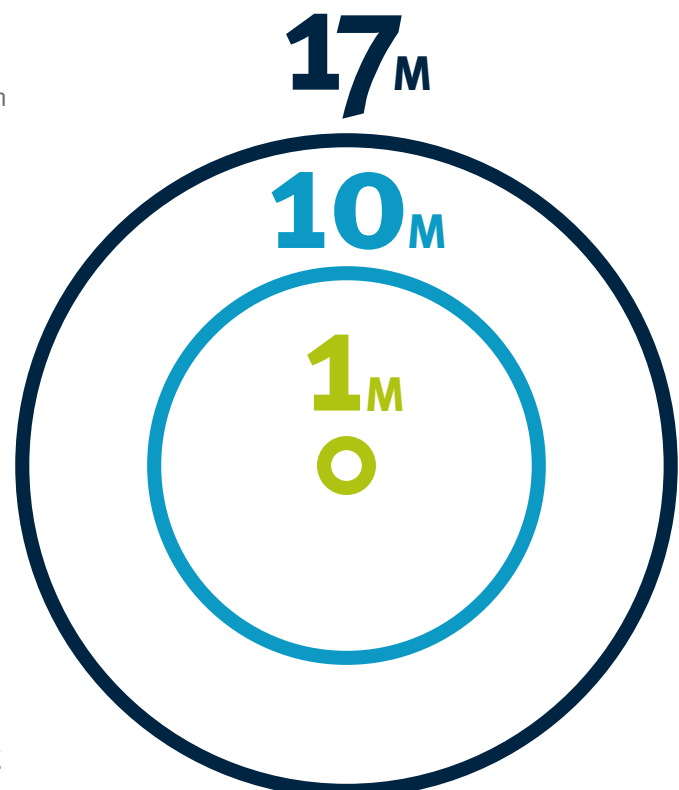
USING EXISTING INFRASTRUCTURE FOR CCS

29. It does seem clear that opportunities to use existing pipelines could give very good value for money.

- The Peterhead and Summit projects both identified considerable savings available from use of existing pipelines, with no significant concerns over the longevity of those pipelines if they are properly suspended when they are not being used, and properly operated after they are re-commissioned.

30. The arguments for or against using existing platforms versus building new platforms or new sub-sea installations is very case-specific.

- Unattributed evidence - several companies described a variety of cases in which using either existing or new sub-sea infrastructure was more logical. No clear pattern could be discerned from these cases.



DEVELOPMENT COSTS

31. *Public funding (UK government, the EU and other national governments) for project development and FEED costs have so far been fundamental in moving projects forward prior to there being any binding contractual commitment to provide a CfD to a project.*

- The Longannet, Kingsnorth¹⁸ and more recently the White Rose and Peterhead projects all received support from HMG to cover some of the costs to carry out project development and FEEDs.
- The Don Valley project is in receipt of EU EEPR funds on a roughly 75/25 basis, with the European Commission funding approximately 75% of the eligible costs.
- The FEED study for Summit's Texas Clean Energy Project was funded largely on an 80/20 basis by the US Department of Energy and private sector participants, with the U.S. Department of Energy funding the majority share of the costs.

32. *Financing of storage appraisal has, to date, necessitated some form of public funding in advance of FID. This is likely to remain the case whilst there is no clear business case for pre-investment in CO₂ storage capacity.*

- Endurance appraisal was co-financed through an EU EEPR grant, because without a recognised storage market, or guarantee of building any CCS projects, the appetite to fund significant early development capital was low.
- Goldeneye appraisal was financed through two competition grants (Longannet & Peterhead), as well as being in large part 'inherited knowledge' from the production of the natural gas resulting in the depletion of the reservoir.

- Statoil would be very reluctant to spend much on store appraisal funding without some form of HMG funding.
- CO₂ storage appraisal feasibility studies currently being undertaken (Spring 2016) by Statoil in the Norwegian North Sea are being funded entirely by the Norwegian Government.

STATE AID

33. *CCS projects with CfDs granted under the Electricity Market Reform (EMR) regime will be deemed in receipt of State Aid, and will require State Aid approval from the EU (as will any projects receiving significant grants). Although State Aid approval is likely to be forthcoming under the existing Guidelines on State aid for environmental protection and energy,¹⁹ because early projects will require individual approval, and a system of blanket approvals will not be available for some time, State Aid approval is likely to add considerable time to the project approval process.*

- The original funding package for ROAD was given State Aid approval in 2011. The developers of the ROAD project believe current guidance on State Aid is at least as favourable now as it was then and therefore there should be no difficulty obtaining State Aid approval for CCS projects in Europe.

18. The Kingsnorth project was developed by E.ON, now Uniper, as part of the previous CCS competition, Demo 1

19. [Guidelines on State aid for environmental protection and energy 2014-2020 \(European Commission, 2014\)](#)

ROUTE TO MARKET FOR ELECTRICITY SALES

34. *CCS projects developed on the basis of CfD revenues appeared to be an attractive proposition to providers of long term Power Purchase Agreements (PPAs)*

- CPL received a very positive response, including specific offers, to its request to the market for PPAs.

35. *Securing a bankable PPA for sale of electricity from a CCS plant is crucial to providers of debt financing.*

- CPL's experience bore this out, and based on its interactions with commercial counter-party traders, they believe it is possible to agree PPA terms for CCS projects that are acceptable to the providers of funding.

POLICY UNCERTAINTY

36. *HMG policy changes over the last 10 years have proved to be a significant factor influencing the development of CCS projects. This has reduced the appetite of many developers, investors and the supply chain to engage in UK CCS project development.*

- Unattributed evidence - several companies have pointed to the following policy changes over the last 10 years as the basis for significant concern to their investors:
 - Lack of strategic clarity surrounding the original Miller/ Peterhead project
 - Removal of all technology options except post-combustion capture on coal during the Demo 1 process;
 - Initial focus only on coal feedstock during Demo 1, and then reintroduction of gas;
 - Periodic uncertainty over HMG appetite for CCS;
 - Lack of consistency over whether CCS projects were demonstration projects, or were starting the delivery of an industry (including the definition of the Commercialisation Programme Outcome);
 - Apparent change in assessment of "affordability" during the 2015 Spending Review;
 - The fracturing of cross-party consensus on energy and climate change policy following (and to some degree before) the May 2015 election.

GLOSSARY

CCS COST REDUCTION TASK FORCE

The CCS Cost Reduction Task Force was an industry-led joint task force established by the UK government to assist with the challenge of making CCS commercially available for operation by the early 2020s.

The objective of the Task Force was to publish a report to advise Government and industry on reducing the cost of CCS so that projects are financeable and competitive with other low carbon technologies in the early 2020s.

The Final Report of the Task Force was published in May 2013.²⁰

“CCS DIRECTIVE”

“The Directive on the geological storage of CO₂ (so-called “CCS Directive”) establishes a legal framework for the environmentally safe geological storage of CO₂ to contribute to the fight against climate change. It covers all CO₂ storage in geological formations in the EU and the entire lifetime of storage sites. It also contains provisions on the capture and transport components of CCS, though these activities are covered mainly by existing EU environmental legislation, such as the Environmental Impact Assessment (EIA) Directive or the Industrial Emissions Directive, in conjunction with amendments introduced by the CCS Directive.” (source: European Commission)²¹

CCS DIRECTIVE GUIDANCE DOCUMENTS

The Directive is supported by 4 Guidance Documents²² covering: (1) CO₂ Storage Life Cycle Risk Management Framework; (2) Characterisation of the Storage Complex, CO₂ Stream Composition, Monitoring and Corrective Measures; (3) Criteria for Transfer of Responsibility to the Competent Authority; and, (4) Financial Security (Art. 19) and Financial Mechanism (Art. 20).

COMPETITION PROJECTS

Defined as the Peterhead and White Rose projects. See further definitions below.

DEMO 1

Demo 1 was a competition for industry to run a project to design, construct and operate the UK's first commercial-scale carbon capture and storage demonstration project at a coal-fired power station, by 2014, with government funding. HMG withdrew from negotiations with the last remaining bidder for funding on 19 October 2011.

INVITATION TO PARTICIPATE IN DISCUSSIONS (ITPD)

The Invitation to Participate in Discussions (ITPD), published in April 2012,²³ set out the UK Government's CCS Commercialisation Outcome and the Bid process at each stage of the Competition for Bidders for UK funding.

It outlined the UK Government's position on a range of relevant issues for Bidders, and detailed both the Evaluation Criteria that would have been applied and the process by which projects were to be selected for contract award.

It contained a draft FEED Contract and outline Project Contract terms, and provided details about the capital and revenue support that was expected to be made available, including assumptions about Contracts for Difference for the generation of carbon free electricity.

20. [CCS Cost Reduction Task Force Final Report \(2013\)](#)

21. http://ec.europa.eu/clima/policies/lowcarbon/ccs/directive/index_en.htm

22. http://ec.europa.eu/clima/policies/lowcarbon/ccs/implementation/documentation_en.htm

23. <https://data.gov.uk/data/contracts-finder-archive/download/560937/7c3239b1-6e9d-4120-a8a2-07cdc54b56b9>

THE OUTCOME As described in the ITPD, the CCS Commercialisation Programme was focused on selecting industrial partners who could make an enduring contribution to delivering the CCS Commercialisation Outcome:

“As a result of the intervention, private sector electricity companies can take investment decisions to build CCS equipped fossil fuel power stations, in the early 2020s, without Government capital subsidy, at an agreed CfD Strike Price that is competitive with the strike prices for other low carbon generation technologies”

PETERHEAD PROJECT The Peterhead Project refers to the full chain CCS project developed by Shell, which sought to retrofit of a unit of the Peterhead power station (owned and operated by SSE) with carbon capture technology and transport and store its CO₂ emissions in the depleted Goldeneye gas field.

PHASE 2 PROJECTS So-called Phase 2 projects were those under consideration for development following completion of the CCS Competition, and which could have accessed CO₂ transport and storage infrastructure established by either the Peterhead or White Rose project. The end of Phase 2 was considered to be the point at which CCS projects in the power sector could compete against other low carbon technologies in technology-neutral auctions for Contracts for Difference.

ROAD PROJECT The Rotterdam Capture and Storage Demonstration Project (ROAD) is an initiative of Uniper Benelux (previously E.ON Benelux) and ENGIE Energie Nederland (previously GDF SUEZ Energie Nederland). As of 2015, ROAD plans to capture 1.1 million tonnes of CO₂ per year from a new power plant at the Maasvlakte and will store the captured CO₂ in a depleted gas reservoir under the North Sea.²⁴

WHITE ROSE PROJECT The White Rose project would have developed a standalone power plant located adjacent to the existing Drax Power Station site near Selby, North Yorkshire, generating electricity for export to the national transmission network as well as capturing approximately 2 million tonnes of CO₂ per year, some 90% of all CO₂ emissions produced by the plant. The CO₂ would have been transported through National Grid’s proposed pipeline for safe and permanent undersea storage in the proposed Endurance CO₂ store.

The project was developed by Capture Power Ltd., established by three companies, GE, Drax and BOC.

²⁴. <http://road2020.nl/en>

ANNEX: COMPLETE LIST OF 36 KEY LESSONS

- 1.** Peterhead/Goldeneye: Subject to HMG's assessment of affordability and value for money, a CCS full-chain project could have been delivered by Shell at Peterhead, using the Goldeneye store, within the structure, risk allocation and terms of the Commercialisation Programme, albeit with some amendments.
- 2.** White Rose: After lengthy and detailed exploration with the potential providers of both equity and debt finance to the project, it became clear that delivery of a CCS full-chain project developed at Drax by CPL, using the Endurance store developed by NGC would have required important adjustments to the structure of the risk allocation and to the terms of the Commercialisation Programme.
- 3.** Given the conclusions in 1 and 2 above, the Peterhead/Goldeneye project may best be characterised as “the exception that proves the rule”, because of the specific nature of the project and project developer. The singular circumstances of the Peterhead project, which underpinned the developer's ability to deliver the project (which were constructed based upon experience of participation in the Longannet venture³), and which would seem unlikely to recur, were:
 - i.** A single company controlling capture, transport and storage technologies and assets;
 - ii.** A single developer with competence and capability to develop and deliver the project across the full chain;
 - iii.** A developer with financial capacity to deliver the full chain project based on equity without project finance;
 - iv.** A developer with the strategic interest and drive to deliver a complete CCS project;
 - v.** A developer with sufficient knowledge of and confidence in the CO₂ store to take on substantial store performance risk;
 - vi.** A developer with sufficient stature to attract wider industry participation both at investor level, and through the supply chains.
- 4.** The bids for both Competition projects (had they been made) would have sought Contract for Difference (CfD) Strike Prices which were likely to have been within the range forecast by the CCS Cost Reduction Task Force (CRTF) Final Report published in May 2013.
- 5.** The expected CfD strike prices for the Competition projects were much higher than the expected strike prices for subsequent projects. This was in large part because each full-chain project was required to carry the full costs of the entire CO₂ transport and storage (T&S) infrastructure of their project, which was perforce much larger than that needed for the CO₂ capture plant.
- 6.** Future Phase 2 projects which would have used the infrastructure built by either of the Competition projects would have required CfDs with strike prices very well below those of the Competition projects; arising particularly from the economic savings accruing from sharing the T&S infrastructure developed by the Competition projects, as well as from lower risk premia and smaller contingency requirements.
- 7.** It is believed that the “Outcome” set out in the ITPD as the goal for the Competition could have been met in each of the new CCS clusters that would have been created if a Competition project had gone ahead in either region. It is now believed that the costs of future Phase 2 projects, which would have used the infrastructure developed by the Competition projects in either region would have been even lower than the projections in the CRTF Final report.
- 8.** The Goldeneye store was capable of and ready for technical development.
- 9.** The Endurance store was (and remains) capable of and ready for development.
- 10.** Depleted gas fields with proven storage capability and comprehensive production history may already be fully appraised for CCS service to the level of confidence that would be required to obtain a storage permit with seismic appraisal, model construction and without further appraisal wells being drilled.
- 11.** It is possible to appraise a saline aquifer, which has not previously been involved in hydrocarbon production, to the level of confidence that it would be possible to apply with confidence for a CO₂ storage permit.

- 12.** It is now known with confidence that the Goldeneye infrastructure could have been extended at relatively low cost to provide very considerable, relatively easily accessible storage capacity in the Captain aquifer in the Central North Sea (of which the Goldeneye field is a part), capable of serving a significant number of CCS projects.
- 13.** It is now known with confidence that the Endurance infrastructure could have been extended at low cost to provide accessible storage capacity capable of serving a very significant number of CCS projects in the Southern North Sea.
- 14.** Under the ITPD, developers were to share some of the costs and consequences of so-called “CCS risks” with HMG. Whilst each of the Competition projects would have accepted a share of these risks it was clear that HMG would have had to accept the majority of the financial risk arising from developing, operating, monitoring and decommissioning the new CO₂ stores.
- 15.** The Competition project developers consider that the majority of the risks associated with CO₂ storage, which HMG proposed be taken by the developers, could have been adequately quantified and insured against, though any insurance would have been of limited term (probably significantly less than the life of the CfD) and capped in value. However, one of the major risks that was not considered insurable was the cost and impact of CO₂ leakage (i.e. the required surrender of EU Emissions Trading System (ETS) allowances for any emissions from the site, including leakages, pursuant to the ETS Directive).
- 16.** Guidance Document 4 of the EU CCS Directive on Financial Securities and the Financial Mechanism (GD4) risks imposing additional and onerous financial obligations on storage operators that go beyond the specific requirements of the Directive. Whilst the Guidance Documents themselves are legally non-binding, there is a risk that their literal interpretation by a Competent Authority could act as a major deterrent to CO₂ storage development.
- 17.** GD4 suggests that the level of Financial Security required to cover the surrender of ETS allowances in the event of a leakage should be based on the potential total tonnes of emissions multiplied by the market cost of purchasing an equivalent amount of allowances. In setting the level of the Financial Security for the Competition projects the OGA demonstrated a willingness to adopt a more pragmatic approach compared to the more rigid guidance laid out in GD4.
- 18.** The Storage of Carbon Dioxide (Licensing) Regulations 2010 outline a list of five types of Financial Security that may be provided by projects to satisfy the requirements of the EU CCS Directive. There remains uncertainty as to whether OGA considered this list to be exhaustive or not, and whether or not the OGA can accept other forms of Financial Security.
- 19.** The full-chain private sector business model as used in the Commercialisation Programme and as spelt out in the ITPD (“UK CCS ITPD full chain structure”) is unlikely to work in future, for several reasons.
- 20.** Under the “UK CCS ITPD full chain structure” investing in early offshore CO₂ storage projects is currently not, and is unlikely to become, an attractive investment proposition for the private sector.
- 21.** Under the “UK CCS ITPD full chain structure” the likelihood and consequence of cross-chain default by the generation operator, the capture operator, the transport operator or the storage operator in this model was a significant challenge to both debt and equity investors in all parts of the CCS chain.
- 22.** The potential CfD strike prices for the Competition projects were perceived in November 2015 by HMG to be too high to accept.
- 23.** The future benefits of developing CCS now, including delivering the Commercialisation Programme “Outcome” were deemed in November 2015 by HMG to be either insufficient or too remote to justify investing in either of the Competition projects.

- 24.** Assessment of the benefits and costs of CCS generation against other forms of low carbon energy generation suffered from lack of like-for-like comparison.
- 25.** Whilst interest in CCS remains, there is no discernible appetite from any project developers to participate in a further UK CCS competition.
- 26.** There is appetite from a number of CCS project developers to enter into discussions and bilateral negotiations with HMG on developing new “bespoke” CCS projects (covering industrial CCS, hydrogen and heat, power and possibly EOR) that they believe could be attractive to HMG.
- 27.** Over-sizing CO₂ T&S infrastructure for simultaneous use by several future projects will, without doubt, generate the best value for money if a number of projects can share the same T&S infrastructure.
- 28.** There is a mismatch between the size of cost effective offshore T&S infrastructure and the expected volume of CO₂ captured from the first single Generation and Capture (G&C) projects.
- 29.** It does seem clear that opportunities to use existing pipelines could give very good value for money.
- 30.** The arguments for or against using existing platforms versus building new platforms or new sub-sea installations is very case-specific.
- 31.** Public funding (UK government, the EU and other national governments) for project development and FEED costs have so far been fundamental in moving projects forward prior to there being any binding contractual commitment to provide a CfD to a project.
- 32.** Financing of storage appraisal has, to date, necessitated some form of public funding in advance of FID. This is likely to remain the case whilst there is no clear business case for preinvestment in CO₂ storage capacity.
- 33.** CCS projects with CfDs granted under the Electricity Market Reform (EMR) regime will be deemed in receipt of State Aid, and will require State Aid approval from the EU (as will any projects receiving significant grants). Although State Aid approval is likely to be forthcoming under the existing Guidelines for Energy and Environmental Aid,¹⁷ because early projects will require individual approval, and a system of blanket approvals will not be available for some time, State Aid approval is likely to add considerable time to the project approval process.
- 34.** CCS projects developed on the basis of CfD revenues appeared to be an attractive proposition to providers of long term Power Purchase Agreements (PPAs)
- 35.** Securing a bankable PPA for sale of electricity from a CCS plant is crucial to providers of debt financing.
- 36.** HMG policy changes over the last 10 years have proved to be a significant factor influencing the development of CCS projects. This has reduced the appetite of many developers, investors and the supply chain to engage in UK CCS project development.



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