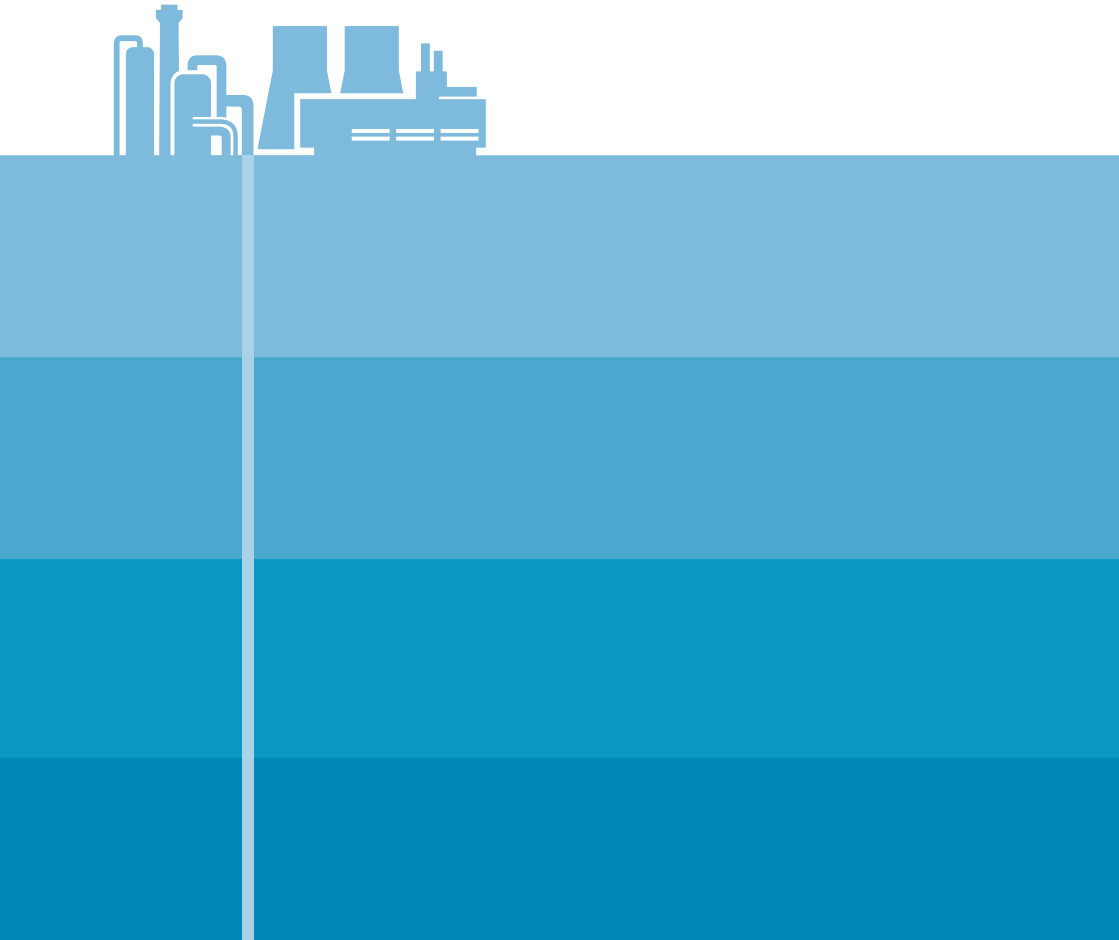
Carbon Capture and Storage Association

DELIVERING CCS

Essential infrastructure for a competitive, low-carbon economy




The White Rose CCS project
Image copyright Capture Power Ltd


The Peterhead CCS project
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1 INTRODUCTION

Developing a domestic Carbon Capture and Storage (CCS) industry promises to be a significant prize for the UK economy. There is clear evidence that CCS will be an essential tool to reduce CO_2 emissions at the lowest cost to the UK economy. For example, the Energy Technologies Institute (ETI) has calculated through its energy systems modelling that **without CCS the cost of reaching the UK decarbonisation goals in 2050 could double, costing the UK economy an additional £32bn per year or 1% of GDP in 2050[1]. No other technology has such a dramatic impact on the costs of achieving a low-carbon economy.** As well as keeping energy bills as low as possible, the development of CCS can help to maintain the future competitiveness of UK industry e.g. steel, cement and chemicals, as it is the only technology available to decarbonise these essential sectors.

To deliver the considerable economic benefits of CCS **it is necessary to institute a progressive build-out of CCS so that by 2030 the UK has in the region of 10GW of power stations fitted with CCS** and between 40 – 10 $MtCO_2$ being captured from energy intensive industries every year. At this scale a total of between 40 – 50 Mtpa of UK CO_2 emissions will be abated by 2030[2], making a material contribution to meeting UK carbon budgets.

Development of enabling transport and storage infrastructure of sufficient capacity is essential to provide early investor confidence that can underpin the required investment in CO_2 capture facilities. In particular early appraisal of multiple storage sites, which have an inherently long lead-time and require significant investment, must be facilitated over the life of this parliament.

Delivering this scale of CCS deployment by 2030 will benefit the UK's broader strategic objectives of reducing CO_2 emissions at least cost, ensuring a secure energy system and stimulating investment in new jobs and businesses, specifically;

- **Deploying CCS, alongside renewables and nuclear, could deliver electricity prices around 15% lower in 2030 than decarbonising without CCS[3].**
- **Fossil fuel CCS power plants are a firm, despatchable generation technology that complement baseload nuclear and intermittent renewables to support a diverse and secure energy supply.**
- **Captured CO_2 could be used for Enhanced Oil Recovery (CO_2 EOR) in the Central North Sea, lowering the cost of CCS, increasing the proportion of recoverable oil and extending the life of oil and gas infrastructure.**
- **A CCS industry will bring additional economic benefits to the UK: generating valuable export opportunities to other emerging CCS markets; creating tens of thousands of jobs associated with the construction and operation of UK CCS plants; and providing CO_2-emitting industries with a long-term future[4].**

The UK is approaching a critical stage in the development of CCS. **Decisions taken in the period of the current parliament will be key to enabling the UK to deploy CCS at a large-scale.** To deliver a CCS industry this report identifies three key steps that will retain momentum on the first projects;

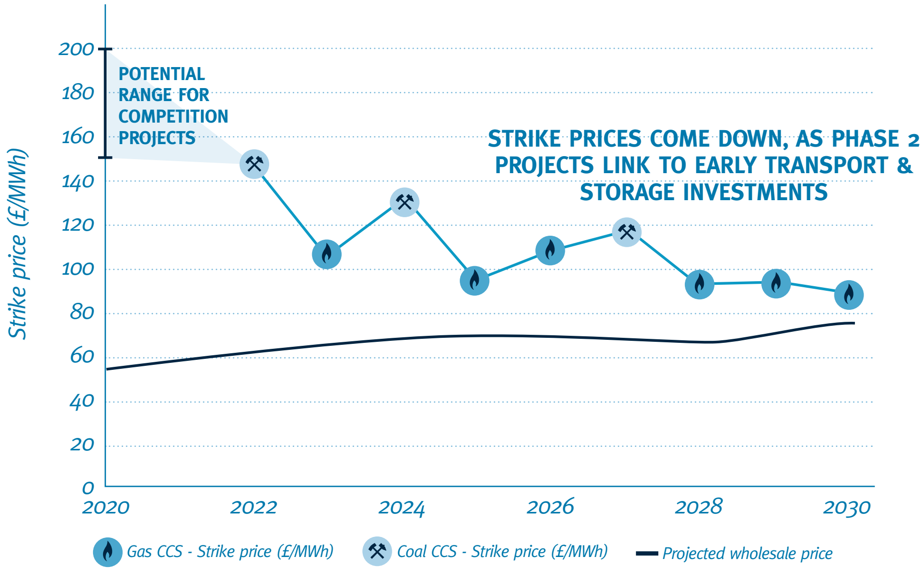
1. **Delivering two competition projects as the critical foundation for a UK CCS industry**
2. **Enabling a second phase of CCS in parallel to the two competition projects**
3. **Establishing grant funding of up to £100 mn to bring forward adequate storage appraisal**

1 Energy Technologies Institute Energy Systems Modelling (ESME)
2 CCS Sector Development Scenarios in the UK (Element Energy and Pöyry for ETI, 2015)
3 The Economic Benefits of Carbon Capture and Storage in the UK (CCSA and TUC, 2014)
4 Ibid

2 CONTRIBUTION OF CCS TO UK ENERGY AND CLIMATE PRIORITIES

Recent analysis by the ETI has provided new insights on the contribution that CCS can make to two of the UK's energy policy priorities; the delivery of cost-competitive, low-carbon technologies and achievement of the UK's legally-binding CO_2 reduction objectives. The evidence behind the detail set out below is largely based on this recent ETI analysis (contained in the report CCS Sector Development Scenarios in the UK (Element Energy for ETI, 2015)).

FIG 1. FORECAST DEVELOPMENT OF CCS STRIKE PRICES[5]



Each strike price represented on the graph reflects the parallel deployment scenario in figure 5.

5 CCS Sector Development Scenarios in the UK (Element Energy and Pöyry for ETI, 2015)
6 Based on estimates that to reach CCS costs of £100/MWh or below, 2.5 GW of installed CCS capacity will be required: CCS Sector Development Scenarios in the UK (Element Energy and Pöyry for ETI, 2015)
7 UK Offshore Wind in the 2020s: Creating the Conditions for Cost Effective Decarbonisation (Green Alliance, 2014)
8 CCSA Analysis

2.1 CCS CAN RAPIDLY BECOME COST-COMPETITIVE WITH OTHER LOW-CARBON TECHNOLOGIES

The UK's future low-carbon electricity is expected to be supplied by a diverse mix of technologies including offshore wind, solar, nuclear and fossil fuel power plants with CCS. Compared with the other key low-carbon technologies CCS has not yet received the commensurate investment to enable costs to come down. However, recent analysis (see figure 1) shows that CCS has clear potential to rapidly become cost-competitive with other low-carbon technologies reaching costs of below £100/MWh by the mid-2020s.

Importantly, the total installed capacity of CCS-power plant required to deliver cost-competitiveness is low - around 2.5GW[6] – this would not require a large investment on behalf of Government. **This level of installed capacity and cost-reduction could be achieved through the first five to six plants developed in the UK. The annual cost of supporting 2.5 GW of CCS plants through Contracts for Differences (CfDs) is expected to be in the region of £1.1 bn** and compares favourably with the investment required to commercialise other low-carbon technologies. For example, it has been estimated that 15GW of installed offshore wind capacity is required to reduce costs to £100/MWh[7]. The cost of supporting this volume of offshore wind, calculated on an equivalent basis to CCS, is around £3.6bn per year (Table 1).

Care should be taken in simply comparing strike prices to understand the relative costs – or value – of different technologies as they have different generation characteristics. CCS is a firm, despatchable technology – i.e. it produces power when required – which is fundamentally different from intermittent technologies, such as some renewables, which only generate when environmental conditions allow.

TABLE 1 INVESTMENT TO COMMERICALISE CCS AND OFFSHORE WIND[8]

	Offshore wind (existing/ contracted)	Offshore wind (additional)	Total offshore wind required to reach £100/MWh	CCS capacity required to reach £100/MWh
Installed capacity	9.4 GW	5.6 GW	15 GW	2.5 GW
Equivalent annual CfD costs	£2.7 bn	£0.9 bn	£3.6 bn	£1.1 bn

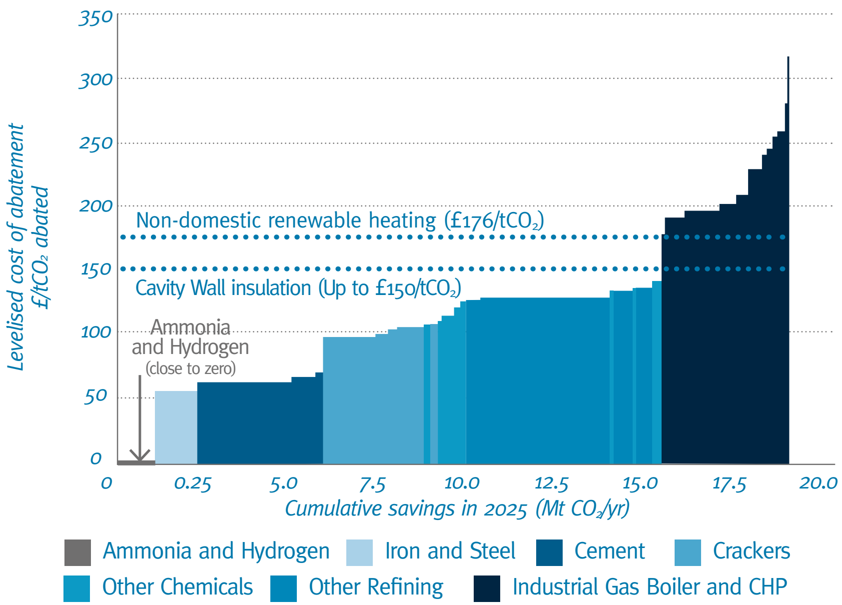
The full system costs of renewable energy are not fully reflected in strike prices, for example intermittent technologies require back-up generation to ensure that adequate capacity is always available. The cost of providing this back-up capacity is not reflected in the strike prices.

CCS can be used in other applications beyond the power sector – with significant benefits. For example, the combination of CCS and gasification technologies can produce a cost-effective low-carbon source of hydrogen, which can be used as a zero-carbon fuel in sectors such as transport and heating. CCS can also be applied to sustainable bioenergy (energy from biomass) to produce negative carbon dioxide emissions – i.e. removing emissions from the atmosphere. It is likely that these technologies will play an increasingly important role in delivering global climate change goals.

There are also significant opportunities to cost-effectively deploy CCS in many industries – iron and steel, chemicals, cement and refining – where it is the only technology that can significantly reduce the CO_2 emissions which are frequently produced from the industrial process.

In industrial applications, using existing technologies, more than 6 million tonnes of CO_2 could be captured from industrial facilities every year by 2025 at a cost below £75/tCO_2 (figure 2). By comparison, non-domestic renewable heating technologies have an abatement cost of around £176/tCO_2 abated while cavity wall insulation can cost as much as £150/tCO_2 abated[9].

FIG 2. COMPARING COSTS OF ABATEMENT: INDUSTRIAL CCS AND OTHER POLICIES[10]



2.2 CCS CAN MAKE A SIGNIFICANT CONTRIBUTION TO DELIVERY OF THE FOURTH AND FIFTH CARBON BUDGETS

A progressive roll-out of CCS that builds on the delivery of the two competition projects with the parallel deployment of phase 2 projects will be capturing significant volumes of CO_2 during the 2020s. This will enable CCS to make an important contribution to the delivery of the UK's fourth and, in particular, fifth Carbon Budgets.

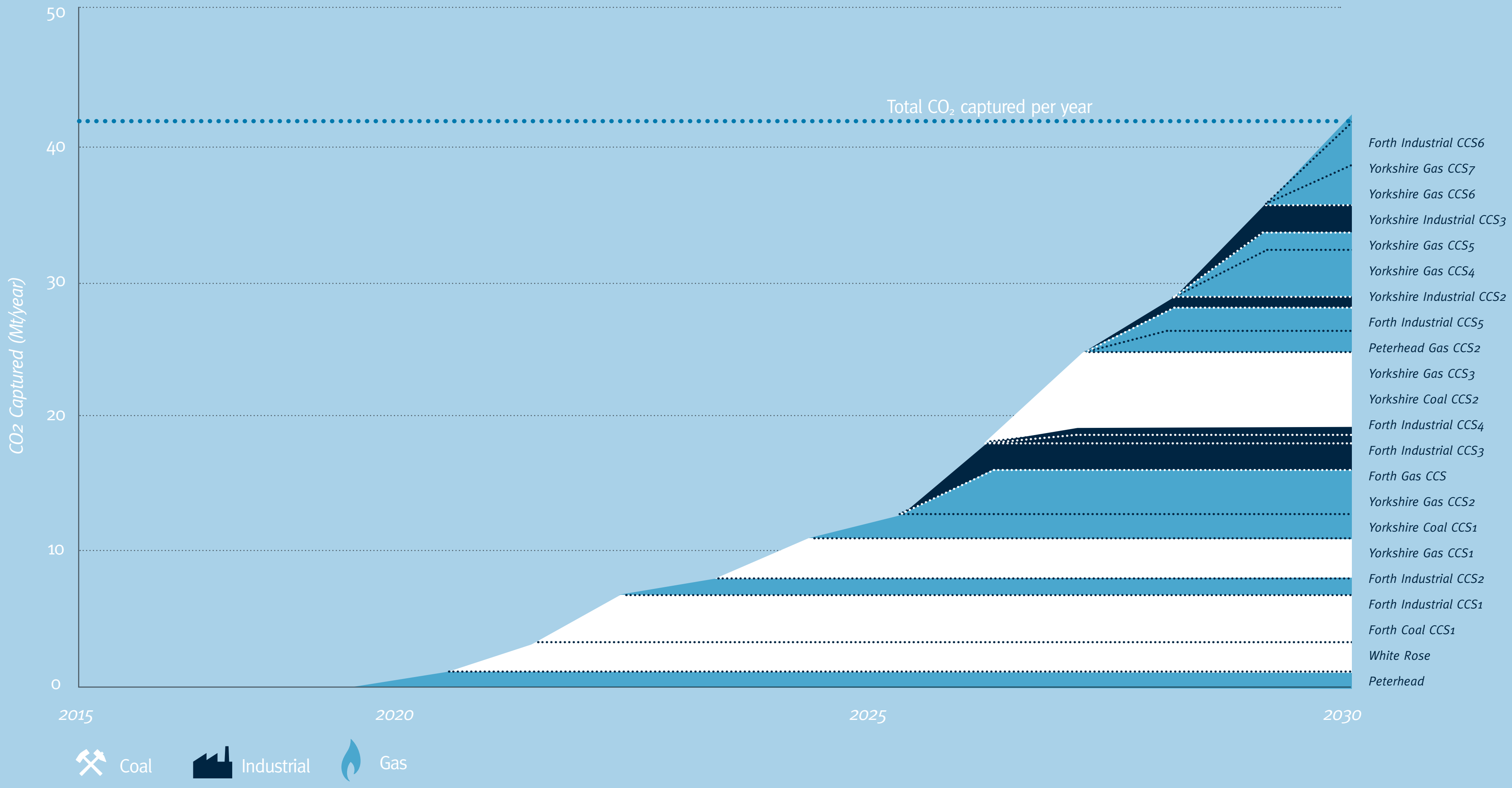
The fourth Carbon Budget, 2023 – 2027, covers the period in which we can expect the competition and early phase 2 projects to be operating and CCS to have become cost-competitive with the other low-carbon technologies. Over this five-year period CCS could contribute a total of 90 MtCO_2 abatement to the UK's decarbonisation effort.

Looking further ahead to the fifth Carbon Budget, which runs from 2028 – 2032 and will be legislated for in 2016, CCS can be expected to make a much greater contribution to emissions reductions. During this period CCS will be cost-competitive and a steady, progressive deployment of the technology will have created a robust supply chain enabling the UK to deploy the technology at greater scale, around 1 – 2 GW per year. Over this period CCS could contribute 170 Mt of CO_2 reduction (figure 3).

	Fourth Carbon Budget	Fifth Carbon Budget
CCS abatement potential	90 MtCO_2	170 MtCO_2

9 Demonstrating CO2 Capture in the UK Cement, Chemicals, Iron and Steel and Oil Refining Sectors by 2025: A Techno-Economic Study (Element Energy, 2014)
10 Ibid

FIG 3. CUMULATIVE CO_2 CAPTURE TO 2030[11]



11 CCS Sector Development Scenarios in the UK (Element Energy and Pöyry for ETI, 2015)

3 ACTIONS REQUIRED TO DELIVER CCS

ACTION 1

3.1 DELIVERING TWO COMPETITION PROJECTS AS THE CRITICAL FOUNDATION FOR A UK CCS INDUSTRY

REQUIREMENTS;

- **Enable Final Investment Decisions on two competition projects by early 2016**
- **Retention of the £1bn of capital funding for the CCS competition**
- **Access to CfDs in the current Levy Control Framework (LCF) period for two competition projects**

The previous Government launched the CCS competition in 2011 and the two "preferred bidder" projects[12] are making good progress on their engineering studies and permitting activities. The competition remains on track to enable final investment decisions to be made by early 2016.

It is hard to overstate how important the successful conclusion of the current competition is to the future of CCS in the UK. **Failure to deliver two competition projects will seriously hinder the development of CCS in the UK, setting the industry back by a decade or more.** The projects provide the foundations upon which the future CCS industry will be built, establishing essential infrastructure that can be utilised by phase 2 projects[13]. Proceeding with only one competition project instead of two will close off the CCS opportunity in the region without a project, jeopardising the UK's ability to develop CCS at scale in the 2020s and therefore its ability to meet climate objectives at lowest cost.

The previous Government allocated £1 bn of capital funding for CCS in the 2010 spending review. To date around £100 mn of this allocation has been spent on engineering studies and permitting of the two projects in the competition. It is absolutely essential that the remaining funds are retained for the CCS competition and allocated appropriately, in order that two projects can be constructed.

In addition, the two competition projects must have access to CfDs. The EMR Delivery Plan, released in December 2013, clearly shows that 0.6 GW of CCS (i.e. the combined capacity of the two competition projects) is expected to be brought forward by 2020 within the constraints of the existing LCF[14]. This funding must be ring-fenced for the two competition projects, which are expected to begin generating towards the end of the first LCF period, around 2019.

DECC has publicly committed to "over £1 bn" of the LCF still being available for allocation to future renewables and CCS projects under their central scenario by 2020 / 21[15]. Based on the conclusions of the UK CCS Cost Reduction Task Force[16] it is anticipated that each competition project will require £155 – 246 mn per year in CfD support[17].

The two competition projects' draw on this first LCF period will be modest. By the end of the current period they would require less than 10% of the funds available in 2020/21[18] (even under a high CCS cost scenario) and only a minor percentage (around 1%) of the total funds available in the first LCF period.

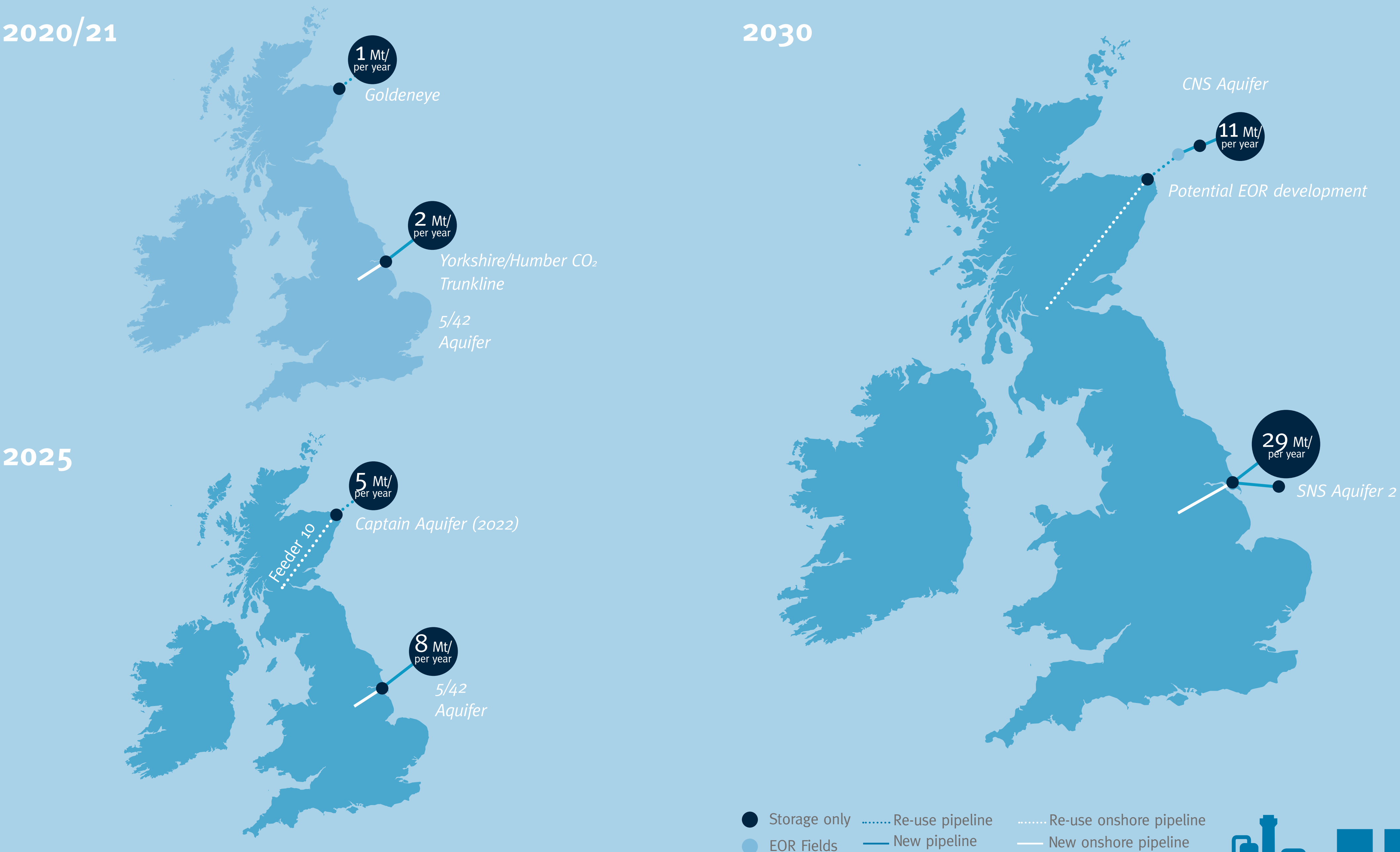
The competition projects, in addition to providing decarbonised electricity, will establish essential infrastructure that will form the basis for the UK's CCS industry. Both projects have been designed to provide substantial additional pipeline capacity beyond their requirements allowing other CO_2-emitters in those regions to cost-competitively access CO_2 transport and storage infrastructure.

The combined capacity of the pipeline infrastructure installed by the two competition projects would be 24 $MtCO_2$ per annum, providing the backbone CCS infrastructure required by the UK until the mid to late 2020s (figure 4). This early installed infrastructure is the key driver for cost-competitive power and industrial CCS and therefore makes a significant contribution to limiting the cost of decarbonisation.

To provide an idea of the scale of this additional capacity, 24 $MtCO_2$ per annum would be sufficient to meet the needs of all the industrial CCS technical potential available in the UK until 2025 (figure 2) or 6GW of fossil-fuel power plants fitted with CCS (assuming even coal / gas mix) and highlights the importance of both projects proceeding and delivering this infrastructure.

12 The two preferred bidders in the Government's CCS competition are the White Rose coal-CCS project in Yorkshire and the Peterhead gas-CCS project in Scotland.
13 In addition to establishing early infrastructure the two competition projects are highly complementary; they will develop CCS on both coal and gas power plants using different capture technologies and use different geological storage sites (a depleted gas reservoir and saline formation).
14 National Grid EMR Analytical Report (National Grid, 2013)
15 EMR Update – Indicative CfD Budget Notice (DECC, 24 July 2014)
16 CCS Cost Reduction Task Force Final Report (2013)
17 These numbers are based on previously published figures contained in the Cost Reduction Task Force Final Report. Actual CfD support will be dependent upon the outcome of commercial discussions currently ongoing between projects and the Government
18 Based on upper limits to electricity policy levies contained within the Levy Control Framework Update: Extending the Framework to 2020/21 (DECC, 2013)

FIG 4. BUILD-OUT OF CO_2 TRANSPORT AND STORAGE NETWORKS[19]



19 This figure represents the "Concentrated scenario" in the ETI report CCS Sector Development Scenarios in the UK (Element Energy and Pöyry for ETI, 2015). Two alternative scenarios are also set out in this report.

ACTION
2

3.2 ENABLE A SECOND PHASE OF CCS TO BE DEVELOPED IN PARALLEL TO THE TWO COMPETITION PROJECTS

REQUIREMENTS;

- **Develop investable CCS CfD design and allocation methodology**
- **Establish CCS technology "minima" of 1.5 GW of phase 2 additional CCS projects allocated CfDs by 2020**
- **Develop an industrial CCS investment mechanism to enable deployment of CCS in energy intensive industries**
- **Ensure that progress on industrial CCS is maintained while an investment mechanism is established**

The previous Government recognised that a second phase of CCS power projects is required to deliver cost-competitive power CCS in the 2020s[20]. It is essential that the development of the early second phase of projects is brought forward without delay and undertaken in parallel to the development of the competition projects (figure 5). This requires the Government to finalise the design and allocation methodology of CCS CfDs and to allocate the first CfDs to second phase projects before the competition projects have begun operating.

The alternative of undertaking a sequential approach to deployment (figure 6), i.e. waiting until the competition projects are operating before commencing phase 2, will prevent the UK from developing a CCS industry at scale by 2030. This risks the UK economy entailing significant additional costs as decarbonisation goals have to be delivered through the deployment of alternative, more costly technologies.

To deliver cost-competitive CCS power in the 2020s it is necessary to allocate CfDs to an additional 1.5 GW of CCS plants before 2020 (see figure 1 above). These projects would progressively come on line from the early 2020s, after the end of the current LCF period. This essential second phase will confirm the cost reduction trajectory and therefore inform future CCS CfD allocation rounds. It is estimated that the 1.5 GW of CCS capacity will equate to three CCS power plants and that the draw on the LCF for each project will range from £158 – 308 mn p.a.[21].

Establishing a commitment to a CCS technology "minima" of 1.5 GW of power CCS over the period 2015 – 2020 is realistic given the scale of recent historical investments in other low-carbon technologies. Over the period 2010 to early 2015 the UK installed 13 GW of renewable capacity comprising: 3 GW offshore wind; 4.7 GW onshore wind; 2.5 GW solar and 2.5 GW biomass. Looking forward, there have been calls for a technology minima of 1.5 GW of offshore wind per year over the 2020s[22]; a deployment rate five-times higher than proposed here for CCS.

With regards to industrial CCS, there are also opportunities to deploy cost-effective industrial CCS projects as soon as policies and transport and storage infrastructure is established. Analysis undertaken by the Teesside Collective proposes potential investment mechanisms and should inform the development of industrial CCS policy in the UK. The EU is also currently establishing a new innovation fund which will support industrial innovation including CCS, presenting opportunities for UK industrial projects to access European funds.

It is important that progress on Industrial CCS is maintained whilst a funding mechanism is being developed. The required investment to support the Teesside Collective[23] to progress towards a final investment decision is around £70 million and would enable a Teesside industrial CCS cluster to be operational by the mid 2020s.

20 CCS in the UK: Government Response to the CCS Cost Reduction Task Force (DECC, 2013)
21 These calculations are based on data contained within figures 1 and 5.
22 UK Offshore Wind in the 2020s: Creating the Conditions for Cost Effective Decarbonisation (Green Alliance, 2014)
23 http://www.teessidecollective.co.uk/

FIG 5. PARALLEL ROLL-OUT[24]

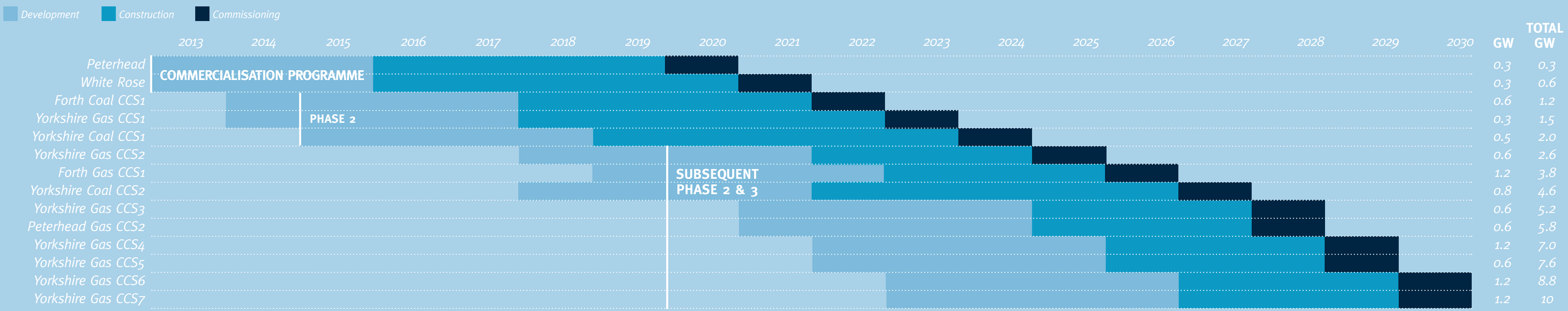
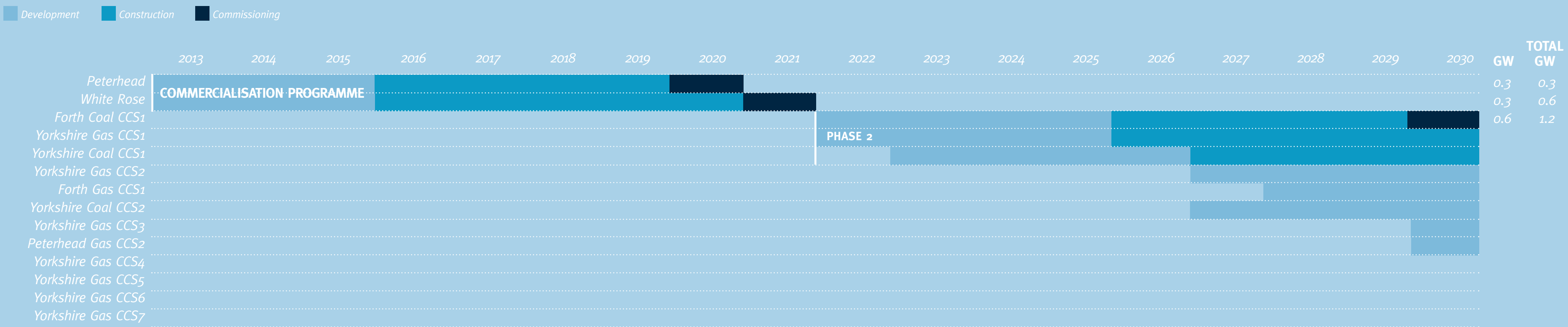


FIG 6. SEQUENTIAL ROLL-OUT[25]



24 CCS Sector Development Scenarios in the UK (Element Energy and Pöyry for ETI, 2015)
25 CCSA Analysis

ACTION 3

3.3 CONTINUED DEVELOPMENT OF UK CO_2 STORAGE CAPACITY

REQUIREMENT;

- **Establish grant funding of up to £100 mn to bring forward adequate storage appraisal**

The roll-out of CCS deployment in the UK is dependent upon the timely development of adequately defined storage sites that can accept the large volumes of CO_2 generated from the power or industrial facilities fitting CCS.

The two competition projects will establish storage sites in two regions – the Southern and Central North Sea. These sites have additional storage potential and create the possibility to expand from the competition storage sites to provide the capacity required for phase 2 projects.

It is estimated that the two competition projects could provide at least 240MtCO_2 of total storage capacity[26].

This appraisal work has been largely supported through capital grants provided by the UK Government and European Commission (awarded in 2010 and 2009 respectively).

To support the deployment of CCS over the 2020s around 700 MtCO_2 of storage capacity needs to be fully appraised and bankable by the mid-2020s[27]. To develop a portfolio of storage sites that could deliver the required capacity would entail a total investment of approximately £100 mn over the period to 2020[28].

At present there is no instrument that directly supports early investment in storage capacity. The provision of grant funding, equivalent to that received by the competition project's storage sites, is required to enable appraisal of this additional storage capacity. This investment is necessary to provide confidence on the availability of storage capacity in order that power generators and industrial emitters can in turn invest in developing capture facilities.

26 This storage capacity figure is a probabilistic estimate based on analysis undertaken by ETI: http://www.eti.co.uk/wp-content/uploads/2015/03/Den-Gammer-Presentation-19th-march.pdf
27 CCS Sector Development Scenarios in the UK (Element Energy and Pöyry for ETI, 2015)
28 Delivering CO2 storage at the lowest cost in time to support the UK decarbonisation goals (UK Transport and Storage Development Group, 2015)

4 CONCLUSIONS

For over a decade the UK has recognised the importance of commercialising CCS in order to promote UK growth, deliver secure energy and drive ambitious action on climate change. The UK has a tremendous advantage of well understood geology for CO_2 storage close to large concentrations of CO_2 emissions. To realise this potential the UK has one of the most advanced policy and regulatory frameworks in the world to support CCS. The combination of the CCS competition and the recent reforms of the electricity market mean that the UK is now well-placed to make CCS a reality.

The UK is approaching a period when the decisions made will determine whether the UK is able to secure its goal of delivering a cost-competitive CCS industry in the 2020s. This report sets out three steps that will enable this outcome;

1. **Deliver two competition projects to create the foundation of a future UK CCS industry**

2. **In parallel to the development of the CCS competition bring forward a second phase of CCS projects in the power and industrial sectors**

3. **Establish the funding to further appraise the UK's CO_2 storage assets.**

Committing to these actions is necessary, realistic and modest when compared to the resources that have been allocated into advancing other low-carbon technologies. Furthermore the benefits of successfully developing a commercial CCS industry – including lower costs of decarbonisation, retention of energy intensive industries and synergies with the UK oil and gas industry – will repay this initial investment many times over.

Around the world there are now more than 20 large-scale CCS projects either operating or under construction[29]. If the UK wishes to remain one of the leading countries that are seeking to develop this technology then it is essential that the CCS opportunity is grasped.

29 The Global Status of CCS, 2014 (Global CCS Institute, 2014)

5 GLOSSARY

Carbon Budgets
Five-year periods of interim targets for Greenhouse Gas (GHG) emissions reductions to track progress towards the UK's legally binding target to reduce GHG emissions by 80% by 2050

CCS – Carbon Capture and Storage
A set of technologies which capture, transport and store carbon dioxide emissions from point sources such as power stations or industrial facilities

CfD – Contract for Difference
A Government policy mechanism to support investment in low carbon technologies – the CfD provides generators with a guaranteed price for their electricity output

CO_2EOR – CO_2 Enhanced Oil Recovery
The injection of carbon dioxide into a near-depleted oil field to produce otherwise unrecoverable oil

Despatchable Generation
Sources of electricity that can be turned on or off, or ramped up or down, within a short period of time and in response to fluctuations in demand

FID – Final Investment Decision
The point at which a project developer and/or Government determines whether or not to proceed with an investment

LCF – Levy Control Framework
A cost control mechanism introduced by Government, which provides an upper limit on the total cost of energy policies to consumers

Minima
A concept introduced under Electricity Market Reform (EMR) whereby Government commits to a minimum deployment level for a particular generation technology over the course of a Delivery Plan Period

Mt CO_2
Million tonnes of CO_2 (carbon dioxide)

Mtpa
Million tonnes per annum

Phase 2
The second phase of CCS projects (following the two projects in the Government's CCS competition) which are necessary to realise cost reductions and enable CCS to become cost-competitive with other low-carbon technologies in the 2020

Strike Price
The agreed price that a generator with a CfD receives per unit of clean electricity output – defined in terms of pounds per megawatt hour (£/MWh)

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