Department for
Business, Energy
& Industrial Strategy

CARBON CAPTURE, USAGE AND STORAGE

A Government Response on potential business models for Carbon Capture, Usage and Storage

August 2020

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Ministerial Foreword

The UK has a proud record in tackling climate change and protecting the environment. We were the first major economy in the world to set a target in law for 'net zero' emissions, ending the UK's contribution to global warming in three decades.

We know that deploying Carbon Capture Usage and Storage (CCUS) and low carbon hydrogen production will play an essential role in meeting our net zero commitment, but it can help us achieve so much more.

CCUS has the potential to deliver a stronger, greener UK by transforming our industrial heartlands, supporting clean growth and providing new economic opportunities for British companies and supply chains through international investment. It is a technology where Britain can lead the world.

Targets are important – but on their own they are not enough. They must be backed by clear and decisive action. It is time for the UK to catalyse the potential of CCUS.

This government response represents a significant milestone. It sets out the progress we have made on business models to incentivise CCUS and our new CCS Infrastructure Fund, announced at Spring Budget 2020. It also outlines our ambitious delivery plans for 2020 and beyond as we seek to deploy CCUS in the UK across this decade.

This year has brought unprecedented challenges. The impacts of Coronavirus (COVID-19) are felt in nations across the globe and virtually no industries are untouched. These challenges mean it is now more important than ever that we take decisive action on climate change.

CCUS will be a crucial part of our green recovery. It is essential that we act now to put ourselves on track to meet our net zero emissions target by 2050, as well as driving growth across the UK and providing high skill, well-paying jobs for all sections of our society.

Section 1: Executive Summary

Introduction

Carbon Capture, Usage and Storage (CCUS) can play an essential role in reaching net zero. It can be an engine to drive cleaner, sustainable growth, transforming our industrial heartlands. It can also unlock new jobs and innovative businesses, raising productivity and competitiveness across the UK.

We are committed to deploying CCUS this decade. We are determined to realise the key strategic opportunities of CCUS in a way that is affordable and value of money for the consumer and taxpayer.

Alongside the CCS Infrastructure Fund, announced at Budget, we will continue to develop and implement new CCUS business models. The consultation, 'Business Models for Carbon Capture, Usage and Storage', published in 2019, was a necessary first step in this process. It sought views on possible new business models for CCUS and outlined government's work in developing potential business models for low carbon hydrogen production.

Summary of responses received

We received 72 responses to the consultation on CCUS business models. Around a quarter of responses were from large business, and a further quarter from SMEs, with the remainder being from special interest groups, trade associations, academics, private individuals and other interested parties.

Summary of stakeholder engagement

We conducted a series of engagements, alongside the CCUS consultations, with key stakeholders and interested parties. We held over 15 events with a combined attendance of approximately 350 individuals. These events focussed on the questions and issues set out in the consultation.

This response also takes into account additional engagement that has taken place during 2020. This includes ongoing work with the CCUS Expert Groups and early engagement with industry on the CCS Infrastructure Fund, announced at Budget.

BEIS will continue to work with the relevant devolved administrations to ensure that the proposed policies take account of devolved responsibilities and policies across the UK to facilitate successful deployment.

Overview

This Government Response comprises six sections: (1) Deploying CCUS in the 2020s; (2) Parameters, Integration and Usage; (3) CO_2 Transport and Storage; (4) Power CCUS; (5) Industrial CCUS; and (6) Low Carbon Hydrogen Production.

A summary of each section is set out below.

Deploying CCUS in the 2020s

Section 2 of this consultation response sets out the government's position on deploying CCUS in the 2020s.

Key findings:

- Government recognises the critical importance of CCUS and low carbon hydrogen to our current net zero strategies. In our view, they will play a vital role in levelling up the economy, enabling the low carbon economic transformation of our industrial regions, and supporting high value jobs.
- As the Budget makes clear, we are committed to investing at least £800 million to facilitate deployment of CCUS in at least two UK sites across the decade. We will work with industry as we progress work to develop the design and delivery of the Fund.
- The delivery of operational CCUS clusters will require co-ordinated, strategic planning. For government, key strategic priorities include timely deployment and delivering value for money by maximising CO_2 capture per pound of government investment, unlocking private sector investment, maximising future learning for clusters and reducing impact on consumers and taxpayers. We will engage with industry, and advisors where necessary, to ensure that the priorities of industry, including the development of pathways to decarbonisation and markets for low-carbon goods, are supported through the deployment of CCUS-enabled industrial clusters. A detailed delivery plan is set out on page 15.
- BEIS will continue to work with the relevant devolved administrations to ensure that the proposed policies take account of devolved responsibilities and policies across the UK to facilitate successful deployment.

Parameters, Integration, and Usage

Section 3 sets out the parameters that will guide the government's ongoing development of CCUS and hydrogen business models. It also explains our current position on integrating business models, and how the use of CO_2 can be harnessed as part of the CCUS chain.

Key findings:

- Government has developed a set of key principles to guide decision-making throughout the design process for CCUS business models and the CCS Infrastructure Fund, based on our initial parameters. A key feature of the ongoing design work will be to seek to ensure that the business models and Fund incentivise decarbonisation and cost reductions whilst minimising market distortions. They are set out in greater detail on page 17.
- Through our engagement with CCUS and Hydrogen Expert Groups we have continued work to design a portfolio of business models for CO_2 Transportation and Storage (CO_2 T&S), power, industry and low carbon hydrogen.
- The resolution of integration issues, such as cross chain risk, will be critical to the successful delivery of CCUS-enabled industrial clusters. We will continue to work with

the CCUS Expert Groups and our technical, commercial and legal advisers, as well as other stakeholders to advance the development of solutions to address these issues.

CO_2 Transport and Storage

Section 4 of this consultation response outlines the Government's proposed approach to CO_2 T&S.

Key findings:

- CO_2 T&S networks are integral to the efficient and cost-effective decarbonisation of our economy. These networks can enable the deployment of firm and flexible low carbon power in a low cost, flexible electricity system; support at-scale low carbon hydrogen for use across the economy; provide a pathway for negative emissions through Bio-Energy CCUS (BECCS) and Direct Air Capture with Carbon Sequestration (DACCS); and support the low carbon economic transformation of the UK's industrial heartlands.
- Government will progress work on the T&S business model, and is currently minded, for an enduring model, to support T&S infrastructure being operated through an economic form of regulation, drawing on experiences from other regulated network models.
- In developing this option further we will consider the application of CCS Infrastructure Fund for the early projects to support improved value for money.

Power CCUS

Section 5 of this consultation response outlines the government's approach to power CCUS.

Key findings:

- We will decarbonise the electricity system predominantly through deploying renewables but in order to maintain security of supply and keep costs low we will need to balance renewable intermittency. To do this we will need system flexibility, energy storage and non-weather dependent, low carbon power generation. We consider that thermal power with CCUS (power CCUS) is one technology which can provide this type of power at scale.
- That is why government announced at budget that, using consumer subsidies, it will support the construction of the UK's first CCUS power plant. That support will be subject to the Control on Low Carbon Levies and establishing value for money for the consumer.
- Government will continue to develop a CCUS power business model, and we are currently minded to progress work on a mechanism which consists of a payment for availability of low carbon generating capacity, and a variable payment. A combination of these payments could enable a plant to operate flexibly, providing value to a low carbon electricity system with growing renewable capacity, and still provide sufficient certainty to investors. We are working in collaboration with industry, through the Expert Group on Power CCUS, to do this.

- In doing so, we will seek to avoid locking consumers into higher cost pathways to low carbon electricity. Over the medium term, we will keep under review our strategy for bringing forward power CCUS as part of a low carbon electricity system. As with the Contract for Difference (CfD) for renewables, this may mean that the approach outlined in this Government Response is adapted over time as the market evolves.

Industrial CCUS

Section 6 of this consultation response sets out the government's approach to Industrial CCUS.

Key findings:

- CCUS is an important technology to decarbonising industry, particularly those hard to abate sectors – cement, chemicals, steel and iron and refineries. It is why we are committed to progressing CCUS in industrial clusters over the decade, supported by the CCS Infrastructure Fund.
- Government will progress work on a business model for industrial CCUS, and is minded, for initial projects, to proceed with an approach that combines upfront capital support and an industrial CfD.
- An industrial CfD would provide support to cover the ongoing operational costs as well as allowing capex investment from the industrial owner to be recovered. We will work closely with industry in designing and testing the industrial contract proposal and, in doing so, the approach outlined in this government response may be adapted.
- While outside of the consultation, in addition to deployment of Industrial CCUS in clusters, government also commissioned a study into CCS deployment at dispersed industrial sites, which has been published alongside this document[1]. The business model for Industrial CCUS is designed to support industrial sites within and outside of clusters

Low Carbon Hydrogen Production

Section 7 of this consultation response outlines the government's approach to enabling low carbon hydrogen.

Key findings:

- There is a clear role for a business model to stimulate private sector investment in low carbon hydrogen production. Government will, therefore, progress work to assess potentially viable options to support deployment of low carbon hydrogen production capacity. This could include support through the CCS Infrastructure Fund.

[1] CCS deployment at dispersed industrial sites by Element Energy on behalf of the Department for Business, Energy and Industrial Strategy (August 2020).

- Industry broadly agrees that the business model should be focused on the costs of low carbon hydrogen production, though consideration must be given to the wider value chain.
- The scope of the business model should include provision for all low carbon production methods.
- There is a lack of consensus on an appropriate hydrogen business model, and we will work closely with industry to assess potential options.

Section 2: Deploying CCUS in the 2020s

Benefits of CCUS

The UK is at the forefront of action on climate change. We are reducing our emissions faster than any other major economy and are the first major economy to set a ‘net zero’ greenhouse gas emissions target. We have broken the cycle of economic growth and rising emissions, cutting our emissions by more than 40% while growing our economy by two thirds.

To sustain this track record, we need to unleash innovative technologies that tackle emissions and bring clean growth right across the UK. It is increasingly clear that CCUS will have a significant role to play in a net zero world, particularly in supporting the decarbonisation of industry and power, the production of low carbon hydrogen and Greenhouse Gas Removal (GGR) technologies[2]:

- Business and industry are significant contributors to the UK’s carbon emissions, accounting for 25% of UK emissions[3]. By capturing and permanently storing these CO_2 emissions, CCUS can transform our industries into zero carbon global leaders, enabling key sectors (including Energy Intensive Industries, power, heat and transport) to be competitive in a net zero economy;

- In power, Combined Cycle Gas Turbines (CCGTs) currently provide reliable and dispatchable power to homes and businesses right across the UK. However, in 2018, CCGTs emitted around 45 $MtCO_2$/year, equivalent to over 12% of all UK emissions[4]. We anticipate that natural gas will continue to provide an important source of dispatchable generation in the future. CCUS, therefore, could help decarbonise this capacity by capturing up to 95% of emissions, while continuing to provide important system benefits;

- Low carbon hydrogen could transform the UK’s energy system. It could offer significant flexibility and optionality in hard to decarbonise sectors, which will be crucial in the transition to net zero. However, some current hydrogen production methods, such as methane reformation and biomass gasification, create CO_2 as a by-product. CCUS could help solve this emissions problem by capturing the CO_2 before it is emitted into the atmosphere; and

- There are some parts of the economy that may be difficult to decarbonise by 2050. BECCS and DACCS technologies could directly reduce CO_2 concentrations in the atmosphere, delivering negative emissions which will set us on track to meet our net zero target.

CCUS also has the potential to drive regional productivity, delivering a stronger, greener UK. It could help transform our industrial heartlands, stimulating the development of new supply chains (domestically and internationally) and attracting inward investment. As a country we are particularly well positioned to take advantage of this opportunity. We have significant stores for CO_2, particularly in depleted oil and gas reservoirs deep underground off the UK coastline. The

[2] Such as bioenergy with CCS (BECCS) and direct air capture with carbon sequestration (DACCS).
[3] Final UK greenhouse gas emissions national statistics, available at: https://www.gov.uk/government/collections/final-uk-greenhouse-gas-emissions-national-statistics#2020
[4] BEIS internal analysis using DUKES and UK Greenhouse Gas Inventory data.

department's recently published CCUS Energy Innovation Needs Assessment[5] shows that the UK could potentially store more than 78 billion tonnes of CO_2[6]. To put this into context, we could store equivalent of current total UK CO_2 emissions each year for over 200 years. Harnessing this natural advantage, the UK could capture up to £10 billion of a c.£200 billion market in 2050[7].

Delivering net zero, and unlocking the potential of CCUS, will involve an enduring partnership between the public and private sector.

Government action

As a government we recognise the need for strategic infrastructure investment. That is why we have set an ambition to establish a 'net zero carbon' cluster by 2040 – the first of its kind in the world – backed by up to £170 million of government funding. It is why we have also provided £315 million for the Industrial Energy Transformation Fund to support heavy energy users become more energy efficient and cut their carbon emissions. In August last year we announced a new £250 million Clean Steel Fund to support the UK steel sector to transition to lower carbon iron and steel production through new technologies and processes, including CCUS and hydrogen. At the same time, we also announced a new £100 million Low Carbon Hydrogen Production Fund to support the deployment of low carbon hydrogen production capacity.

This investment is just the start. The announcement of a new CCS Infrastructure Fund provides additional support and contributes to what we believe is a huge industrial opportunity, which will support the Industrial Decarbonisation Challenge. In addition, we have committed to support the deployment of the UK's first privately financed CCS power station, using consumer subsidies. In Spring 2021, we will launch our industrial decarbonisation strategy, setting out how government will work with industry to decarbonise in line with our ambitions for net zero.

The CCS Infrastructure Fund

At Budget in March 2020, the Chancellor announced 'at least £800 million' for a new CCS Infrastructure Fund. The Fund will facilitate the delivery of CCUS in at least two clusters, one by the mid-2020s; and a second by 2030 – including the infrastructure to support the construction of the UK's first private financed gas CCS power station by 2030.

Alongside the required business models for CCUS, the Fund will provide a pathway to the deployment of low carbon technologies which can support:

- the Industrial Clusters mission to establish the world's first net-zero carbon industrial cluster by 2040 and at least one low-carbon cluster by 2030;
- the UK reaching net zero emissions by 2050; and

[5] The Energy Innovation Needs Assessments (EINAs) support evidence and analysis on the role of different technologies in the UK's future energy system. The CCUS EINAS report published in 2019 is accessible via the link below: https://www.gov.uk/government/publications/energy-innovation-needs-assessments
[6] Pale Blue Dot: Progressing Development of the UK's Strategic Carbon Dioxide Storage Resource (2016) The report is accessible via this link: http://www.eti.co.uk/project/strategic-uk-ccs-storage-appraisal/
[7] The Energy Innovation Needs Assessments (EINAs), (2019) is available at: https://www.gov.uk/government/publications/energy-innovation-needs-assessments

- economic revitalisation in our most industrialised regions, helping to level up the economy and enabling a clean, resilient recovery from COVID-19.

We have now commenced work to design the Fund. We have begun some early engagement with the sector and intend to continue this dialogue throughout 2020.

At this stage we do not wish to exclude any technologies from being eligible for funding and are considering how the CCS Infrastructure Fund may best be used to support T&S, industry, power and low carbon hydrogen CCS projects. As we design the Fund, we will work with the sector to determine the gaps in funding that are unlikely to be delivered by private finance, or the alternative sources of government funding outlined above. We will consider the impact of our approach on the taxpayer and the consumer.

In their 2018 Progress Report to Parliament[8], the Committee on Climate Change (CCC) assessed that "*deploying CCS at scale in the 2030s will require deployment of CO_2 infrastructure and initial capture projects at a level of around 10 $MtCO_2$ per annum being captured and stored by 2030*" and reaching 20 $MtCO_2$ per annum by 2035 to allow for progress towards the deployment levels we will require by 2050. The CCUS Cost Challenge Taskforce report identified this staged approach as crucial to allow the creation and de-risking of the CCUS industry before expansion during the 2030s. The CCC's 2020 report[9] re-iterates that CCUS is "*a necessity, not an option for the UK's net-zero objectives*", requiring significant progress in the 2020s to deliver a major T&S infrastructure servicing multiple clusters.

Recognising this requirement to scale up at pace over the coming decade, the CCS Infrastructure Fund will be an integrated element of our work to establish enduring business models. It will be deployed to support strategic requirements for CCS infrastructure where government can play an enabling role in bringing down the risk and costs of CCS. To support this, we will produce a value for money framework that will start from our high level principles (see page 17) and a measurable set of assessment criteria that meets our objectives for the Fund.

Outline of key phases of expected work for the Fund design:

CCUS Delivery

We want to ensure that the UK has the right delivery capability to enable our ambition to deploy CCUS from the mid-2020s. This includes the capability within central government, but also within local authorities and devolved administrations across the UK, the private sector, and investment community.

In our consultation, we asked the question: What capabilities are needed for the delivery of CCUS in the UK? We received 42 responses to this question from stakeholders, with most respondents broadly agreeing with our proposed capabilities. Some respondents identified

[8] The CCC's 2018 progress report to Parliament can be found at: https://www.theccc.org.uk/publication/reducing-uk-emissions-2018-progress-report-to-parliament/
[9] The CCC's 2020 progress report to Parliament can be found at: https://www.theccc.org.uk/publication/reducing-uk-emissions-2020-progress-report-to-parliament/

additional capabilities needed to enable CCUS deployment. In particular, some respondents suggested government commitment to reduce the political risk and the implementation of required legislation were essential capabilities for CCUS deployment.

We have recently appointed external commercial, technical and legal specialist advisory teams to support us to work towards our CCUS ambitions. We will continue to assess further government capability requirements and will also work with industry to ensure that the private sector also has the relevant delivery capability, drawing on a range of evidence sources and learnings from across the world to inform our policy development, including the Global CCS Institute's new report: Overview of organisations and policies supporting the deployment of large-scale CCS facilities.[10]

Developing business models for CCUS

We must also develop a sustainable commercial framework, together with a clear risk allocation, for CCUS. We must ensure that CCUS business models enable UK companies to compete and grow in the global economy while reducing their carbon footprint. It is essential that these models can:

- Stimulate future private sector investment in CCUS, driving scale-up and market development;
- De-risk (to an appropriate level) the delivery and successful commercial operation of CO_2 infrastructure;
- Support initial carbon capture projects;
- Support cost reductions; and
- Catalyse, along with other enablers, the project pipeline and the domestic supply chain, permitting timely delivery and a ramp up in deployment during the 2030s as required.

The consultation last year on potential business models for CCUS, and the principles for a low carbon hydrogen business model, was an important step forward. This government response, in turn, is a significant milestone as we look to develop a policy framework that will help realise the key strategic opportunities of CCUS and low carbon hydrogen.

We believe that targeted, focused and two-way engagement through the newly-established CCUS Expert Groups can accelerate the delivery of CCUS business models. The intention is to pool knowledge, capability and resources to progress decision making on the business models, within the parameters of government value for money considerations. The CCUS Expert Groups were launched in February 2020, and Hydrogen Expert Group in May 2020, with subsequent, ongoing meetings focusing on power CCUS, industrial capture and CO_2 transport and storage and low carbon hydrogen.

Impacts of COVID-19

Virtually no industries are untouched by the global impacts of COVID-19. Lockdown measures taken by countries, including the UK, to reduce transmission of COVID-19 has led to significant

[10] GCCSI's report (published June 2020) can be found at: https://www.globalccsinstitute.com/resources/publications-reports-research/

reductions in the demand for oil, gas and some industrial commodities, while demand for some commodities, such as chemicals, have seen increased demand.

Whilst it is too soon to fully understand what the impacts of COVID-19 will be on these sectors, we recognise that there may be constraints on both industry and government in the coming months. We will consider this as we continue to work with industry to progress the CCUS business models and the design of the CCS Infrastructure Fund.

The challenges posed by COVID-19 do not minimise the importance of innovative, green technologies. CCUS deployment in the 2020s is an essential part of a clean resilient recovery, driving job creation in the UK's industrial heartlands, bolstering the value of goods and services in regions, and tackling emissions to put us on track to meet our net zero target.

CCUS delivery action plan

This decade will be critical for CCUS; one in which the public and private sectors need to transition from planning, to the operational delivery of the UK's first CCUS clusters.

To achieve this over the course of 2020 and 2021, government has developed a CCUS delivery action plan, which is currently proposed as follows:

- Development of commercial frameworks and delivery capability, and continued engagement with projects on this, along with framing the scope and objectives of the CCS Infrastructure Fund during 2020;
- Award funding under the second phase of the Industrial Decarbonisation Challenge by the end of 2020;
- Provide an update on commercial frameworks for industry, CO_2 T&S networks and power by the end of 2020;
- Update on our assessment of potential business models to deploy low carbon hydrogen by the end of 2020;
- Publish a draft value for money methodology and criteria and metrics for assessing affordability of CCUS enabled industrial clusters at the end of 2020; and
- Progress business models for CCUS and low carbon hydrogen at pace, with a view to finalising business models within the next two years, in line with expected FIDs for projects.'

BEIS will continue to work with the relevant devolved administrations to ensure that the proposed policies take account of devolved responsibilities and policies across the UK to facilitate successful deployment.

Section 3: Parameters, Integration and Usage

Parameters

Our approach to investable and sustainable business models is informed by our overarching objectives for CCUS deployment:

- supporting the **net zero transition**;
- building resilience through **decarbonisation of the wider economy**; and
- contributing to the **levelling up** of the UK economy.

Flowing from these overarching objectives are a number of ambitions for the 2020s, including: establishing at least two clusters by 2030, with the first by the mid-2020s; supporting the UK's first power CCUS project using consumer subsidies; and, importantly, enabling the capture and storage of sufficient volumes of CO_2 to put us on a pathway to net zero.

In 2019, we set out the following parameters to guide our approach to CCUS business models:

- The models should be market based and incentivise CCUS to provide value to the economy. They should drive decarbonisation and be compatible with market operation and existing market frameworks.
- The design of the models should instil confidence among investors and should attract innovation and new entrants to the market.
- The models should be cost efficient – providing value for money for taxpayers and bill payers, driving cost reductions and attracting new investment.
- There should be appropriate and fair cost sharing between the government and CCUS developers, being mindful of impacts on taxpayers and bill payers.
- There should be an appropriate allocation of risk between the government and CCUS developers, that evolves as the CCUS industry matures.
- The models should have the potential to become subsidy free.

Question One sought views on whether we had identified the right parameters to guide the development of CCUS business models.

We received 50 answers to this question. Respondent's views coalesced around what the parameters should reflect and avoid.

Some respondents argued that the parameters should ensure: efficient and cost-effective delivery of the government's 2050 net zero target; that industry stays and grows within the UK; that there is appropriate and fair cost sharing; that government sets standards and precedents for the rest of the world to follow; and that the parameters should facilitate learning and cost reductions.

Other respondents suggested that the parameters should reflect: the specific characteristics of First of a Kind (FOAK) projects as well as subsequent deployment; CCUS' ability to support a wider range of options and choices for decarbonised energy; the value of jobs created and retained; and that the parameters should reflect not just value to economy but also value to society and the environment.

Respondents also stressed that the CCUS parameters should account for the full chain value of each component in the chain. For example, the strike price from an abated gas generator should account for the wider economic benefits of supporting strategic infrastructure, the benefits of skills jobs in the UK, and the facilitation of economic benefits felt by local areas.

Finally, some respondents noted that these CCUS parameters should seek to avoid investment leakage; cross subsidisation across CCUS components; and the distortion of economic competition.

Government's view:

We welcome respondent's views on these parameters. In light of these consultation responses and further engagement, we propose the following key principles to guide our decision-making throughout the design of the CCUS business models and the CCS Infrastructure Fund:

Decarbonisation – our policies should incentivise efficient capture, utilisation and storage of CO_2 where production is necessary but should not incentivise production of CO_2 or result in perverse outcomes.

Sustainable financing – our policies should instil confidence among investors and attract new domestic and international entrants to the market in a sustainable manner, and have the potential to be subsidy free.

Economy – our policies should create value to the UK economy and support high-value jobs.

Cost reductions – our policies should harness opportunities to drive down cost through innovation, learning by doing and competition as appropriate.

Market and flexibility – our policies should be market based and **minimise distortions** in existing markets. They should be compatible with existing market frameworks but retain the flexibility to respond to market conditions and public needs as markets and the economy evolve.

Value for money – our policies should be cost-efficient, providing value for money for taxpayers and consumers, and provide a risk-adjusted fair return to investors whilst recognising the first of a kind nature of the sector that with industry, we need to develop.

Fair and reflective costs – the cost of deploying CCUS should be reflective and fair, and not undermine UK industrial competitiveness.

We continue to regard these as guidelines, recognising that there may be trade-offs, and will consider these principles alongside our objectives as we continue to design CCUS business models and develop the CCS Infrastructure Fund.

Integrating CCUS Business Models

Question 2 sought the views of respondents on how they thought the business models might be integrated.

Respondent's views were varied and included:

- Support for a simple business model across the power and industrial sectors, as well as hydrogen production;
- Belief that the integration of business models will be crucial;
- Recognition that the interface between models will need careful definition (including the treatment of risk);
- Inappropriateness of integrating business models given the very wide range of CCUS activities; and that applying a single set of parameters for all users may not work;
- Preference for a business model that separates CO_2 T&S from capture;
- Belief that, while a separated business model could be the default, there are circumstances where a fully integrated model may have benefits e.g. for localised projects aimed at storing carbon emissions from offshore oil and gas production; and
- Requirement for government to understand how business models co-ordinate and integrate across the CCUS chain for first projects.

Government's view:

Our view is that CCUS and low carbon hydrogen will likely play an essential role in decarbonising a number of key sectors of the economy. It is clear that previous attempts to commercialise CCUS, utilising a full chain model[11], have not been successful. Our intention, therefore, is to create a series of individual business models for power, industry, low carbon hydrogen, and transportation and storage. This approach is consistent with, and takes account of, the range of advice previously submitted to government (such as from the National Audit Office, Lord Oxburgh's Parliamentary Group on CCS, the CCUS Cost Challenge Taskforce and Parliamentary committees).

In designing these individual business models, we recognise that each model should interact efficiently across the CCUS chain. We will be working with industry across 2020 to understand and optimise these dynamics.

From a practical perspective, project developers will need to work with local and regional authorities and other relevant bodies to coordinate the activities of the CCUS-enabled industrial cluster. In particular, there should be a co-ordinated understanding, across each cluster, of how individual capture facilities interface with any CO_2 T&S network.

We understand the need for potential anchor projects to have a reasonable level of confidence in the future pipeline to take final investment decisions. The appropriate allocation of risk across the chain will be a key focus of activity as we continue to develop the business models.

[11] i.e. a model encompassing all aspects of the capture, transportation and storage together.

Carbon Utilisation

Carbon Capture and Utilisation (CCU) involves the recycling of captured CO_2 into other products, such as cement, polymer processing, fertilisers and synthetic membranes. An Ecofys/Imperial College London report for BEIS estimated that the total size of the UK market in 2016 was in the range of 400-500 ktCO_2/yr[12] A Carbon180 report estimates the potential available market for products in sectors where carbon utilisation could be applicable to be worth over $5 trillion worldwide[13].

Although an emerging market, government recognises the economic potential and climate change benefits of CCU. As the UK decarbonises to meet its net zero target, we want to create value for UK companies. We also want to create thousands of future-proof, planet-saving, profit-making jobs all around the UK. That is why government is funding innovation in this area. Through BEIS' Energy Innovation Programme (2010-2015, 2016-2021), we have directly funded approximately £5.6m to CCU innovation projects.

In June 2019, we provided £4.2 million to Tata Chemicals to help construct the first commercial, purpose-built CCU facility in the UK. Once operational in 2021, 40,000 tonnes of CO_2 a year will be captured and used to make soda ash and sodium bicarbonate that is used by glass, food, pharmaceutical and chemical manufacturing sectors.

Through R&D and innovation funding the UK is now home to Econic Technologies[14], Carbon8 Systems[15], and CCm Technologies[16], three world-leading innovators in carbon utilisation.

Government intends to further explore the opportunities for carbon utilisation. For instance, there are still uncertainties around the extent to which some CCU technologies reduce and permanently store CO_2. We want to engage with the sector in 2020 to understand lifecycle emissions, consider what future innovation support might be required, and ensure that there is a stable and efficient regulatory framework that supports the development of carbon utilisation.

[12] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/799293/SISUK17099AssessingCO2_utilisationUK_ReportFinal_260517v2__1_.pdf

[13] https://carbon180.org/reports

[14] http://econic-technologies.com/, BEIS originally funded Econic Technologies ~£100k in 2012-2013. Econic Technologies has been funded in the following UKRI programmes: https://gtr.ukri.org/organisation/BA3803E9-A589-435F-850E-95D42DFC9575

[15] http://c8s.co.uk/, Carbon8 Systems has been funded in the following UKRI programmes: https://gtr.ukri.org/organisation/8E147ECF-44EF-482C-A5FE-1C81AE2A390A

[16] https://ccmtechnologies.co.uk/, BEIS is funding CCm Technologies ~£540k through the Energy Entrepreneur Fund (EEF) scheme. CCm Technologies has been funded in the following UKRI programmes: https://gtr.ukri.org/organisation/A1A00770-EE4C-4BC6-877E-DD42619E77AA

Section 4: CO_2 Transport & Storage

Introduction

CO_2 Transportation and Storage (T&S) networks are integral to the efficient and cost-effective decarbonisation of our economy. These networks can enable the deployment of firm and flexible low carbon power in a low cost, flexible electricity system; support at-scale low carbon hydrogen for use across the economy; provide a pathway for negative emissions through Bio-energy with CCUS (BECCS) and Direct Air Capture with Carbon Sequestration (DACCS); and support the low carbon economic transformation of the UK's industrial heartlands.

CO_2 T&S networks also have the potential to become strategic national assets. With an estimated 78 billion tonnes of CO_2 storage capacity in the UK Continental Shelf[17], the UK can lead the world both in the provision of CO_2 services, and in the storage of domestic and, potentially, international CO_2 emissions. Government's commissioned analysis suggests that this transportation and storage potential could be worth up to £14 billion in UK exports by 2050[18].

Likewise the shipping of CO_2 can play an important strategic role in unlocking the potential for CO_2 storage services, providing additional revenue streams for CO_2 T&S business models and stimulating collaboration across our industrial clusters and with our European neighbours. That is why, in partnership with the Netherlands and Norway, we proposed a provisional amendment to the London Protocol to allow for cross-border transportation and storage of CO_2 which was successfully passed at the International Maritime Organisation in October 2019. This represents a significant milestone for cross-border transport of CO_2.

We recognise that the development of CO_2 T&S networks in the UK will be complex infrastructural undertakings that are likely to involve a variety of approaches, including the development of new onshore and offshore infrastructure, the potential for re-use of existing oil and gas infrastructure and use of CO_2 shipping to extend a network's reach. We have consulted separately on the re-use of oil and gas assets for CCUS projects and our government response is published alongside this document.[19]

The diversity of our industrial regions and the future low carbon transition currently means that planned CO_2T&S networks are being developed by different entities. This means that each CO_2 T&S network, over its lifetime, will need to be flexible enough to accommodate multiple and different types of users with varying demand profiles and will need to be able to anticipate and accommodate future CO_2 volumes which may require expansion of the network. Each network will therefore have its own unique characteristics. We are mindful of these characteristics as we develop the design of an enduring business model for CO_2 T&S.

In the consultation we set out that we would explore whether a different business model to the fixed price model of the previous CCS Competition could be an investable proposition when

[17] Energy Technologies Institute LLP, Taking stock of UK CO_2 Storage, 2017 https://www.eti.co.uk/insights/taking-stock-of-uk-CO2-storage
[18] Source: Table 8 of the CCUS EINAS, available at: https://www.gov.uk/government/publications/energy-innovation-needs-assessments.
[19] The response to the consultation on the re-use of oil and gas assets for CCUS projects can be found at: https://www.gov.uk/government/consultations/carbon-capture-usage-and-storage-ccus-projects-re-use-of-oil-and-gas-assets

considering the requirements for CO_2 T&S networks and we sought views on a number of models.

THE MODELS EXPLAINED

Regulated Asset Base (RAB)

The T&S company would receive a licence from an economic regulator, which grants it the right to charge a regulated price to users in exchange for delivering and operating the T&S network. To prevent monopolistic disadvantages, the charge is set by an independent regulator who considers allowable expenses, over a set period of time, to ensure costs are necessary and reasonable. Model variants could include the provision of financial support to decrease the upfront capital expenditure.

Government-owned model

Government would set up a regulated publicly owned CO_2 T&S network, which would be responsible for delivering and operating the T&S infrastructure. Central to this model is the privatisation of the network as the CCUS market matures.

Cost Plus Open Book

Direct operational payments from government to cover all properly incurred costs annually, on an open book basis, with an addition of agreed profit margins and return on investment. Widely used in transport and infrastructure projects.

Waste sector type contractor

Payment of a fee per unit of CO_2 injected and stored. An arrangement could be established where funding from local authority budgets can be supported by private finance credits.

Hybrid

A combination or evolution of various models could be adapted to incorporate positive traits of some models and minimise negative aspects of others.

In this chapter we have considered the consultation responses relating to CO_2 T&S and indicated which model we are minded to progress. We have also outlined the next steps required to design and implement a model which adheres to our core business model parameters.

Consultation Responses

Overview

We asked four questions on CO_2 T&S in our consultation. These were: (1) Have we identified the most important challenges in considering the development of CO_2 networks? (2) Do you agree that a T&S fee is an important consideration for any CO_2 T&S network? In your view, what is the optimal approach to setting the T&S fee? (3) Of the models we have considered for CO_2 T&S, do you have a preference, and why? And (4) Are there any models that we have not considered in this consultation which you think should be taken forward for CO_2 T&S, and why?

The majority of respondents provided views on these questions, including respondents primarily concerned with industrial decarbonisation, hydrogen production or power CCUS.

We are grateful to those who responded. All the points raised by respondents have been considered, and this chapter summarises the most significant issues raised.

Identifying the most important challenges for the development of CO_2 networks

Question 5 asked respondents if we have identified the most important challenges in considering the development of CO_2 networks. There were 39 responses to this question.

A significant majority agreed that the key challenges set out in our consultation were the most important.

Several respondents wanted to draw attention to specific challenges, such as:

- The need for CO_2 T&S networks to cater for international users – particularly to encourage the shipping of CO_2 where appropriate and addressing issues posed by the London Protocol;
- The reliability and sustainability of CO_2 supply, highlighting the need for the network to operate to agreed standards to provide greater certainty of volume. To support this, it is argued that the T&S operator should take responsibility for compression and quality checks of CO_2 composition and pressure; and
- The importance of assessing scalability and determining the optimal size of T&S infrastructure to allow for anticipatory investment. It is suggested that this could avoid potential stranded asset risks and additional costs associated with the mismatch between supply and demand if assets are oversized or undersized.

The importance of a T&S fee

Question 6 asked respondents if they agree that a T&S fee is an important consideration for any CO_2 T&S network, and what they view as the optimal approach to setting the T&S fee. 35 respondents answered this question.

The vast majority agreed that the T&S fee is an important consideration for any CO_2 network and its business model. However, there was no clear consensus on the optimal approach to setting or structuring the fee. Notable themes included:

- That any T&S fee should have a fixed capacity element which, in certain circumstances during early network development, could be funded by government to recover capital expenditure and return on investment;
- That each capture project is charged a fee (e.g. on a £/tonne of CO_2 basis) for use of a T&S network to help ensure investor certainty;
- That a fixed T&S fee should be charged initially, which evolves to a fee based on utilisation of the network. An alternative could be a fixed 'maintenance' type fee topped up based on usage;

- That a volumetric fee should be implemented underpinned by a minimum send or pay obligation;
- That assistance towards a T&S capacity fee is necessary for industrial CO_2 capturers to ensure that first movers are not at a competitive disadvantage; and
- A mixed response to the Cost Challenge Taskforce proposal for the first anchor project in a cluster initially pay a higher fee which reduces as more emitters join the network.

Respondents did not make specific comments on the design of the RAB-based formula for T&S fees proposed by the Cost Challenge Taskforce, which we set out in our consultation.

Preference for proposed models

Question 7 asked respondents if they have a preferred model of those considered for CO_2 T&S and why. 45 respondents answered this question, with the majority stating a clear preference of a model for CO_2 T&S.

Out of these respondents:

- There was a strong preference towards a RAB model for delivering CO_2 T&S. However, there was no consensus on the ownership structure for the RAB or level of government support which might be required;
- Some provided a view on a specific type of RAB model. A significant proportion favoured the Private Sector RAB model or the Private Sector RAB model combined with a government grant. A few respondents expressed support for a Public RAB model;
- The majority of respondents who did not prefer a RAB stated preference towards government-owned model;
- There was a broad preference not to pursue the full-chain model used in previous CCS competitions due to potential increased costs of the project and investor uncertainty arising from cross-chain risks;
- Some suggested that different models may be required for different CCUS projects, based on regional economic variations, and that the model should differentiate between FOAK and NOAK CCUS projects, taking different risk profiles into account; and
- A limited number of respondents stated they do not have a preference for a model. A few stated that any of the three business models proposed by the CCUS Advisory Group could be suitable.

Other models for consideration

Question 8 asked respondents if there are any models not considered in the consultation that should be taken forward for CO_2 T&S, and why. 26 respondents provided a response to this question. Of these responses:

- The majority referenced models already considered in this consultation or did not suggest any new models; and
- A few respondents suggested a different model to consider for taking forward CO_2 T&S – these were splitting transport and storage into two separate business models and creating a model where shipping plays a significant role in the structure.

Government's View

As discussed in our consultation, the development of CO_2 networks in the UK presents a number of unique challenges to be addressed when designing a business model which supports their long-term deployment across our industrial heartlands. Our view, and the challenge we face, is that each T&S network must be able to accommodate multiple and different types of users with varying demand profiles and the business model must be sufficiently flexible to recognise various potential network designs and growth profiles.

Developers, investors and users of T&S networks must also have visibility over the allocation of T&S specific risks such as stranded asset risks, varying build out rates between a capture plant and T&S infrastructure, potential long-term storage leaks and unknown liabilities.

We recognise that the business model must also provide investors with confidence over the reliability and sustainability of CO_2 supply which is important for revenue certainty. We agree with respondents to this consultation on the need for the network to operate to agreed standards to provide greater reliability of volume. We also share the view on the importance of assessing scalability and determining the optimal size of T&S infrastructure in order to allow for anticipatory investment which could avoid potential stranded asset risks and additional costs associated with the mismatch between supply and demand if assets are oversized or undersized.

Finally, we acknowledge that whilst large upfront capital expenditure will be required initially to construct onshore and offshore T&S infrastructure, once built the operational costs and the incremental costs of network expansion would be expected to be lower. It will be important that the financing and funding model reflects this and can support investment and returns across the life of these assets.

A regulated T&S network

Our view is that given CO_2 T&S networks are likely to be operated as regional monopolies, which encompass a range of different network users and emitters operating under different commercial models, we are minded to progress the development of a new regulated network model under which future T&S networks can be developed and operated. We believe this would enable the development of regional T&S networks that can provide certainty to both investors and the network users in terms of revenue flows, risk allocation and service provision. We would expect each regulated network for CO_2 T&S to adhere to a core set of indicative principles set out below:

- Regulated: by an independent body to oversee industry and support deployment in line with government policy. Defined in legislation where appropriate.
- Codification: the high-level relationship between owners, operators and regulators is clearly articulated.
- Transparency: an evidence-based approach leading to well understood mechanisms/methodologies including revenue calculations. Opportunity for stakeholders to comment, engage and potentially challenge decisions.
- Stability: providing a framework for long term stable investment in a project that is likely to have a long operating life.
- Adaptability: given cost uncertainty in the short run any framework will need to include reviews and allow for the possibility of expansion.

- Equitable risk sharing: investors to own an appropriate level of risk which is clearly understood and commensurate with returns received by investors. Provision of a fair return to investors over the lifetime of the project

The enduring model would also need to recognise the unique differences between the CO_2 T&S business compared to other existing regulated networks, including the diverse user base operating under different capture business models, the unique T&S specific risks and the broad regulatory landscape under which T&S networks will operate.

Financing and Funding

To establish a commercial framework that enables and supports stable investment in projects that are likely to have a long but potentially varied operating lives, it is vital that the right financing and funding structures are in place. These will help ensure that both upfront costs of building the infrastructure are met and allow a system to generate revenue to pay for T&S assets over their lifecycle effectively.

The CCUS Cost Challenge Taskforce[20], the BEIS Select Committee on CCUS[21] and the CCUS Advisory Group[22] all shared the view that due to the characteristics of a CO_2 T&S network, a RAB funding model would be a suitable funding model in the long-term and should be considered in more detail. The majority of respondents to this consultation also identified the RAB funding model as their preferred model for operation of CO_2 T&S networks, however there was no consensus on how government capital could be used for construction of T&S networks.

The RAB model referred to in this document is a generic economic regulation model. The model would consist of a regulated revenue stream determined by a building block approach, paid to the T&S company (T&SCo) during operation by users of the T&S network, determined by an economic regulator. This is to mimic the incentives that would be faced by the market if it were competitive.

The starting point of the economic regulation funding model is that the model would consist of a number of ‘building blocks’ and would be regulated by an economic regulator. Each building block represents a category of cost incurred by the project company in the course of performing its business functions. The building blocks would be scrutinised by the relevant economic regulator to ensure that costs are efficient and are the constituents of Allowed Revenue. As a starting point, we would draw on applicable elements of economic regulation models for greenfield projects (e.g. offshore transmission assets and interconnectors) and brownfields project (e.g. gas and electricity transmission and distribution networks under RIIO) with adjustments to facilitate the specific characteristic of T&S projects.

Our qualitative analysis has shown that a regulated network funding model can be an effective tool to address natural monopoly issues associated with regional T&S networks, with the following key benefits:

[20] Delivering clean growth: CCUS Cost Challenge Taskforce report, July 2018 https://www.gov.uk/government/publications/delivering-clean-growth-ccus-cost-challenge-taskforce-report
[21] BEIS Select Committee Report: Carbon Capture Usage and Storage: third time lucky? April 2019 https://www.parliament.uk/business/committees/committees-a-z/commons-select/business-energy-industrial-strategy/inquiries/parliament-2017/inquiry9/
[22] Investment Frameworks for the Development of CCUS in the UK, CCUS Advisory Group, July 2019 http://www.ccsassociation.org/news-and-events/reports-and-publications/

- It is a proven tool to address challenges associated with natural monopolies – The presence of an economic regulatory regime to regulate fees charged by the owner of the natural monopoly infrastructure and create other mechanism to mimic that of perfectly competitive markets has been adopted successfully in other natural monopoly sectors such as electricity, gas and water sectors;

- Expansion of CCUS – We believe the model can provide flexibility to accommodate uncertainty, notably demand and operational costs (due to FOAK application). A price control review feature within a RAB model could incentivise efficient deployment of capital (i.e. network expansion to meet anticipated need in the future and therefore support future growth of the CCUS market);

- Cost reduction – The model could provide the flexibility and ability to address future uncertainty by allowing for financing costs to be lower than a traditional contractual funding model. Flexibility of the RAB model could also allow efficiency gains and cost reduction benefits (as part of transition from FOAK to NAOK) through learning-by-doing to be incorporated as part of future price control reviews of early projects, providing a clear path for increased efficiency (i.e. output/£) – similar to the regulated utilities sectors.

- Familiarity – Investors and private sector developers are familiar with the RAB model, observed under other sector such as electricity, gas and waters. Adopting a similar approach for CO_2 T&S could reduce the financing premium required due to familiarity and track record of the funding model in other sectors.

- Unlock private sector investment – The building block approach can allow for recovery of financing costs and therefore facilitate large debt raises, as well as provide a clear statement of the investors' sunk cost in the T&SCo (i.e. the value of the RAB would reflect an efficient deployment of capital from the investors). This, coupled with the economic regulator's political independence and duty to finance as observed in other regulated utilities sector established would minimise the political risk of government adjusting the T&S fees and reducing the ability of the investor to recover their capital investment in the T&SCo.

- This reduces the degree of HMG behaving opportunistically in seeking to lower the price of service at marginal cost. This model would be attractive to those with longer term investment horizons.

For these reasons, we will continue to analyse the potential benefits of the T&S network being funded through a regulated network model in the long term. We believe that a T&S network developed under a regulated funding model has the potential to exhibit risk-reward investment characteristics similar to regulated utilities with adjustments for construction risks and CCUS specific risks. We are also considering the benefits and feasibility of using government capital through the CCS Infrastructure Fund for example, to help to facilitate the timely deployment of early projects.

Economic and market regulator

In accordance with our indicative core principles for a new regulated network model for T&S, an independent body is likely to be required to oversee the development of the network and support deployment in line with government policy. We consider that both an economic regulator and a market regulator will be required. The economic regulator would be responsible for overseeing the economic regulatory regime for the T&S network. The market regulator would oversee the connection of capture plants to the T&S network, similar to the Oil and Gas

Authority (OGA)'s role in awarding offshore CO_2 storage licences. The economic regulator and market regulator roles could be performed by a single entity.

Government is considering whether to utilise an existing regulatory body to oversee the operation of CCUS T&S networks. This option would minimise the delays inherent in, and avoid the additional costs of, establishing a new regulatory body. Existing regulators also have a proven track record. We believe this could also help create market confidence and attract investment. An alternative option could be to establish a new regulatory body to undertake this function.

Progressing the Business Model

Funding model

Whilst we are minded to develop a business model for T&S networks that draws from established forms of economic regulation, such as the RAB funding model (given the aforementioned features of a T&S network which lend themselves well to such a model), we also recognise there are a particular challenges for CO_2 T&S which must be addressed through the design of the model. This will be a key focus of our ongoing work.

We recognise, for example, that as we build out the network from a small user base, one of the unique features of a CCUS T&S network is that it could serve customers from many different industries operating under distinct business models (industrial CCUS, power CCUS, hydrogen production with CCUS), both domestically and potentially from abroad, and having slightly different demand profiles over the life of the asset.

This presents a challenge when designing the revenue mechanism for a possible T&SCo. We will need to consider the implications of the possibility that the first emitters connecting to a T&S network (anchor projects) may be loaded with the initial costs of using the network. We also need to consider how to manage demand risk and how this might be viewed by investors in network infrastructure. We will continue to engage with industry on these and other issues as we develop the appropriate funding model.

T&S risks and risk allocation

Our expectation is that CO_2 T&S networks will have similar characteristics to other types of regulated assets. To deliver these characteristics, a suitable risk sharing framework needs to be developed. In developing this risk framework we currently believe that it should be based on the principle that risks should be allocated to the party that is best able to manage them.

A sustainable and enduring T&S business model must therefore provide confidence to investors through the effective management of T&S risks. There needs to be clear visibility around the principal construction and operational risks and the overall costs of developing T&S networks. Further, it will be important to ensure that there is a transparent and equitable allocation of those risks and costs between the owners and users of the network - one which enables private sector investment and is capable of evolving over time, while providing value for money for the taxpayer and consumer.

We will work with the CCUS T&S Expert Group to develop a shared understanding of the risks associated with the development of T&S networks, their quantum, and likelihood.

Supporting network roll-out

There is a role for government to support and incentivise the investment of CO_2 infrastructure, particularly for first clusters. To ensure T&S networks are investable propositions in the UK we will consider government intervention to address the inherent market failures, including using the CCS Infrastructure Fund alongside sustainable commercial frameworks to help unlock capital investment. That could for example (as one scenario) involve the Fund being used to oversize T&S capacity so early customers do not end up paying very high unit charges. Another example could be to provide grant funding to wholly build segments of the early network.

To improve our understanding of the sector and deployment potential, we have embarked on a price discovery phase and commenced work to explore standardisation opportunities for T&S in order to develop a common understanding of the construction and operation costs and risk associated with deploying T&S networks across the UK. Having a more in depth understanding of the deployment potential in the UK will help to ensure government is able to support roll out in the most effective way.

Regulating T&S networks

We are working closely with regulatory bodies across the UK to ensure the right regulatory framework and associated guidance is in place to support CCUS projects across the value chain and through the entire life cycle of projects. This is particularly important for enabling the timely deployment of T&S networks which are complex infrastructure undertakings spanning a variety of regulatory regimes and approvals processes. As part of this process, we have recently established a CCUS Regulation Forum to ensure, where possible, that a coordinated, comprehensive and consistent approach is taken across the UK and we will continue to engage with industry to ensure the appropriate enabling framework is in place.

Next Steps

As we move towards the implementation phase for CCUS in the UK, and utilising commercial, technical and financial expertise (including our CCUS Expert Groups) we will work to determine the optimal regulatory pathway. This will include an assessment of:

- How to establish a new regulated network model that enables and supports stable investment in projects that are likely to have a long (but potentially varied) operating life; and the most suitable ownership, financing and funding structures to underpin this;
- The role and duties of an economic regulator, particularly how prices/cash flows and allocation of risks are established and how revenue certainty could be maintained in the landscape;
- The role and duties of a market regulator, particularly how prospective network users connect to the gathering network and how third party access agreements are managed;
- How to ensure that any regulatory regime is capable of adapting over time as the market for CO_2 storage services expands, while ensuring value for money for the taxpayer/consumer; and
- How any regulatory regime can incentivise cost reduction, innovation and good quality performance.

We will also continue our work on price discovery and risk allocation in the second half of 2020, primarily through the T&S CCUS Expert Group as well as our commercial, legal and technical advisors, to develop a common understanding of:

- The construction and operation costs of T&S networks in the UK, including an understanding of the full technical specification of any T&S network.;
- The risks inherent in the development of T&S networks, their quantum, and likelihood. Government recognises that effective management of T&S risks will be vital for the development of a sustainable T&S business model, providing confidence to investors. Government and the private sector will need good visibility of the principal construction and operational risks;
- How accessing the CCS Infrastructure Fund, and other forms of government intervention, can reduce costs to consumers;
- How best to provide revenue certainty to developers and their investors, including through the design of any potential T&S fees, information about what circumstances a T&S fee might apply and how they could be charged on users of the T&S network; and
- How any support or incentivise mechanism can transition from FOAK CCUS projects to mature T&S networks serving multiple capture facilities.

In undertaking this work we aim to:

- Provide an update on the business model for CO_2 T&S networks for CCUS in Q4 2020.

Section 5: Power CCUS

Introduction

Decarbonising our electricity sector has been a UK success story. From 2016 to 2018, we drove down the electricity grid carbon intensity by over 22%, from 268 to 208gCO_2/kWh[23]. We know that more must be done, however, if we are to deliver our overarching net zero target. That is why at the Budget in March 2020, government announced it will support the construction of the UK's first CCS power plant by 2030, using consumer subsidies.

Whilst we cannot predict today exactly what the generating mix will look like in 2050, we can be confident that renewables will play a key role. However, in order to decarbonise whilst maintaining security of supply and keeping costs low, we will need to balance renewable variability against demand. To do this we will need system flexibility, energy storage and non-weather dependent, low carbon power generation. We consider that thermal power with CCUS (power CCUS[24]) is one technology which can provide this type of power at scale. This view is shared by other organisations, such as the CCC.

Government recognises that market failures prevent the deployment of the first power CCUS projects in the UK. Consistent with the over-arching parameters, as set out in the Introduction to this government response, we are committed to developing power CCUS business models that can:

- Incentivise and enable power CCUS to dispatch after low marginal cost technologies such as renewables and nuclear, but ahead of other unabated power plants as part of a flexible electricity system;
- Provide sufficient certainty to investors to unlock private sector investment and expertise;
- Provide the minimum necessary support, compatible with fiscal rules, and have a pathway to reducing support;
- Consider how to enable a competitive allocation process, incorporating learning from the success of the process for allocating renewable CfDs competitively to secure best value for money and reduce costs over time;
- Ensure that costs are affordable for electricity consumers and/or taxpayers; and
- Through consumer subsidies, support the construction of the UK's first privately financed CCS power station, to be operational by 2030.

Any business model must be sensitive to ongoing technological innovation and the range of technology options for electricity system decarbonisation. Technological and operational

[23] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/840015/DUKES_2019_MASTER_COPY.pdf. Page 96

[24] In this document we use the term 'power CCUS' to cover technologies which have CCUS technology applied directly to a thermal power plant, including pre-combustion, post-combustion, and oxy-fuel technologies. This encompasses both new build CCUS power plants and retrofitted CCUS power plants. In addition, hydrogen-fired power plants which are standalone from hydrogen production infrastructure could be considered under the power CCUS business model discussed in this document, however, this will depend on the development of a hydrogen production business model.

process improvements for power CCUS, trade-offs between post-combustion CCUS and hydrogen-fired technologies, and the development of novel technologies could potentially change how we seek to decarbonise the electricity system. Innovation also has the potential to alter the options available to us to decarbonise that system cost effectively, bringing forward new, lower cost and more efficient generating technologies. It will also stimulate the market to identify additional revenue streams from low carbon electricity generation assets.

It is important, therefore, that we avoid locking consumers into higher cost pathways to low carbon electricity. Over the medium term we will keep under review the approach we take to bring forward power CCUS as part of a low carbon electricity system, including considering the appropriateness of other market mechanisms, such as the Capacity Market. As with the CfD for renewables, this may mean that the model outlined here is adapted over time as the market evolves.

THE MODELS EXPLAINED

In our consultation document we proposed two models based on the Contract for Difference scheme: a ‘Standard Contract for Difference for CCUS’ (“Standard CfD”); and a ‘Dispatchable Contract for Difference for CCUS’ (“Dispatchable CfD”).

The Standard CfD is closely based on the existing CfD design for renewables. It consists of a difference payment between the wholesale electricity price and an agreed strike price in order to give investors certainty of returns. Where wholesale prices are lower than the strike price, a payment would be made from the Low Carbon Contracts Company (LCCC) to the generator. In the case where wholesale prices are higher than the strike price, the generator would pay back to the LCCC. In the case of CCUS, the strike price would be calculated to incorporate the Levelised Cost Of Electricity (LCOE) of the generation and carbon capture elements of the plant. In addition, our consultation paper suggested this mechanism may require fuel price indexation to be incorporated, in order to ensure that the plant would operate at times of high fuel prices and to ensure consumers would benefit from lower costs at times of lower fuel prices.

The alternative model, the Dispatchable CfD, aims to incentivise the flexible generation of the power plant by providing two payments: one for low carbon availability; and one to incentivise a power CCUS plant to dispatch ahead of an unabated equivalent plant but behind renewables and nuclear. This aims to enable plants to play either a baseload or the mid-merit role we primarily see CCUS as performing.

Consultation Responses

Overview

We asked four questions on power CCUS in our consultation. These were: (1) Have we considered the most important challenges in considering the development of CCUS power projects? (2) Of the models we have considered for power CCUS, do you have a preference, and why? (3) In your view, should any potential funding model(s) be applicable across all power CCUS technologies (including but not limited to CCGT with post-combustion capture, BECCS, and pre-combustion capture or hydrogen turbines)? and (4) Are there any models that we have not considered in the consultation which you think should be taken forward for power CCUS, and why?

The majority of respondents provided views on these questions, including respondents primarily concerned with industrial decarbonisation or hydrogen production.

Identifying the most important challenges for developing power CCUS projects

Question 9 asked respondents to provide views on whether BEIS had identified an appropriate range of challenges for power CCUS. 37 responses were received.

The overall approach set out in the consultation document was welcomed. The majority of respondents agreed the value of power CCUS in decarbonising the electricity system is its ability to provide mid-merit, dispatchable, low carbon power. Decarbonising mid-merit power enables greater renewable deployment and could contribute to lower total electricity system costs. However, balancing the inherent uncertainty of this dispatchable role with the need to provide sufficient certainty to investors to ensure deployment of power CCUS can proceed is a key challenge for the business model. The majority of respondents also agreed that gas-fired power CCUS would be an effective technology to pursue in providing low carbon dispatchable power, though respondents also recognised that alternatives may become more viable in the future.

Some respondents also highlighted a number of additional challenges that government should consider when developing a power CCUS business model. These included:

- The LCOE metric is not effective for valuing firm, flexible generation. By focusing on £/MWh, technologies like offshore wind and power CCUS are compared without consideration of the type of generation that they provide, e.g. firm dispatchable vs. intermittent generation. It was proposed that dispatchable generation should therefore be valued with another metric or approach to avoid an imbalanced comparison;
- BECCS was not considered explicitly enough in relation to the power CCUS business models;
- Energy Intensive Industries (EIIs), as major electricity consumers, could pay a significant portion of the total support that that may be allocated for power CCUS; and
- Capturing the fossil fuels burned in power plants only reduces emissions in the downstream element of the supply chain. Upstream practices, such as the extraction and transport process, are also considerable greenhouse gas emitters, (notably in the form of methane which has a greater Global Warming Potential (GWP) than CO_2).

Preferences for proposed models

Question 10 asked respondents to discuss their preferred model out of those considered. 57 responses were received:

- Of those which expressed a preference, the majority of responses preferred the Dispatchable CfD, agreeing with the principle of incentivising power CCUS facilities to dispatch after renewables and nuclear, but before unabated equivalent generation;
- Some respondents stated that the standard CfD could also be a financially acceptable alternative, but recognised that this could lead to power CCUS facilities being incentivised to run when there is limited system need;
- Some respondents who indicated a preference for the Dispatchable CfD stated support for the principles behind the model but noted that it may be complex to administer; and

- Some respondents also proposed a support mechanism for BECCS power projects. Proposals advocated BECCS plants running as baseload to maximise the production of negative emissions, supported by a ‘negative emissions top-up’ to either the Standard CfD or Capacity Market payments.

Inclusion of power CCUS technologies under one model

Question 11 sought views on the value of creating a model that would be applicable across all power CCUS technologies, including CCGT with post-combustion capture, BECCS and pre-combustion capture or hydrogen turbines. 33 responses were received:

- Of those which expressed a view, the majority of respondents saw the advantage of a unified approach across a range of technologies, though many of these thought that such a model may not apply to BECCS. The primary reason given for a unified approach was to support competitive tension between the technologies and to avoid technology lock-in.
- Hydrogen power generation was notably referenced in this regard, with respondents advocating that it should be able to compete with post-combustion plants under a unified model.

Other models for consideration

Question 12 sought views on whether there were alternatives to the Standard and Dispatchable CfDs that respondents wished BEIS to consider for supporting power CCUS. 31 responses were received:

- The majority of respondents did not propose alternative models.
- A minority suggested models primarily for incentivising BECCS, such as a standard CfD accompanied by an additional negative emissions payment, as discussed in question 10. A small minority of respondents suggested that the Regulated Asset Base model was their preferred alternative to any form of CfD for bringing forwards investment in power CCUS.

Government’s View

Government recognises the need to incentivise the deployment of power CCUS in the UK. Consistent with the over-arching parameters (see Section 3), our current preference is for a revenue mechanism which:

- Incentivises power CCUS to operate flexibly, dispatching after renewables and nuclear, but ahead of other unabated power plants as part of a flexible electricity system;
- Has the capacity to be competitively allocated;
- Provides fair return on investment with appropriate risk allocation and without overcompensation; and
- Ensures that the costs are affordable for electricity consumers. Any power CCUS business model would be subject to value for money and affordability assessments. In making such assessments, government will assess the total system costs of power CCUS.

We will conduct further work in 2020 to understand, in detail, the structure of a revenue mechanism for power CCUS. However, based on the above objectives, we are minded to progress work on a mechanism which consists of a payment for availability of low carbon generation capacity, and a variable payment. A combination of these payments could enable a plant to operate flexibly, providing value to a low carbon electricity system with growing renewable capacity, and still provide sufficient certainty to investors. Further detail on how these elements of a prospective mechanism could look is given below.

Availability Payment

A payment for availability of low carbon generation capacity could provide investors with sufficient certainty, by providing a known stable investable level of return. In addition, if renewable capacity grows between now and 2050, and power CCUS plants are required to dispatch in a mid-merit role, developers can expect load factors to decrease overtime, which could further reduce the certainty of revenue from the direct sale of electricity.

The proposed availability payment could be a stable regular payment from a counterparty to the generator. This could be paid based on the availability of low carbon generation plant, could be set relative to the cost of the generation and capture plant, taking into account capture rate availability, and could be indexed to inflation. Therefore, it is likely that the availability payment may be reduced, for example, in the case of unscheduled outages of the plant or underperformance against an expected capture rate.

Variable Payment

In order to avoid overcompensation, a variable payment may be needed to incentivise power CCUS plants to operate flexibly, dispatching after renewables and nuclear, but ahead of an unabated equivalent plant. In the absence of a sufficiently high carbon price, power CCUS facilities could be uncompetitive with unabated plants. In this case, a variable payment could be needed to account for a power CCUS plant's additional costs, relative to those of an equivalent unabated plant. This payment could place power CCUS plants ahead of an unabated plant in the merit order.

The proposed variable payment could be provided as a top up on wholesale market revenue to reduce the effective short-run marginal cost of a power CCUS plant if this is greater than the short-run marginal cost of an equivalent unabated plant. This could then incentivise a power CCUS plant to dispatch in the market ahead of an unabated equivalent. However, if carbon prices are sufficiently high, the variable payment is unlikely to be required as market signals would indicate the power CCUS plant should already be dispatching ahead of an unabated equivalent, and would receive returns through the direct sale of electricity in the wholesale market.

In order to ensure fair returns to investors, based on the risk allocation, a cap of some form could be placed on the revenues that the plant could receive. It is anticipated that the calculation of both the variable payment and any cap may have to be undertaken on a regular basis to take account of changes in the fuel and carbon price relative to electricity prices. These could be calculated relative to an equivalent unabated reference plant.

Reference plant

Further work is required to identify an appropriate reference plant(s) against which any variable payments could be benchmarked. As an example, for a CCGT with post-combustion CCUS plant, this could be an equivalent class CCGT, or the most efficient CCGT available on the market at the time of contract signature. The characteristics of the reference plant (such as efficiency factors and variable operational cost) could be used as a comparator for those of the power CCUS plant under consideration, and be used with fuel and carbon reference prices to calculate any variable payment to be provided.

Transport and Storage (T&S) Fee

Further work is necessary to determine the optimal means to support and incentivise the deployment of CCUS T&S infrastructure in the UK, and what implications this has for any payments from a power CCUS plant to a T&S operator, such as whether any fee is incorporated into the power plant support mechanism or is administered separately. As explained in the chapter on T&S, we will provide a core set of principles on the ownership and funding model for T&S by the end of 2020. We expect that this will set out under what circumstances, a T&S fee might apply, and, if it should, whether it should comprise of a fixed and variable element.

Outages

We are currently considering how the payments under the business model would be affected by outages, and in particular, how these reflect allocation of cross-chain risks. This includes consideration of, for example, whether the proposed availability payment would still be paid to the power CCUS plant in the event of a T&S operational outage, where that outage is not the fault of the power CCUS operator. Further consideration is needed, for example, to what might happen in the event of a T&S outage, and whether a plant could run unabated, but then may not be eligible for any proposed variable payments. In addition, further work is needed to establish what may happen if there are permanent outages of the T&S network, which could lead to a plant running unabated indefinitely and so leading to a permanent reduction in or termination of the availability payment.

BECCS in the power sector

We will explore the best use of sustainable biomass for BECCS in the power sector, along with its other applications such as heat or hydrogen production. Any mechanism to support such deployment will need to align with wider biomass and GGR policy. Vivid Economics proposed a number of options in a recent study commissioned by BEIS[25], which will inform the development of our strategic approach to negative emissions. We will publish a call for evidence on negative emissions technologies later this year.

Next steps

As we move towards the implementation phase for CCUS in the UK, and utilising commercial, technical and financial expertise (including our CCUS Expert Groups) where necessary, we will:

- Continue to work with the Expert Groups to finalise the optimal revenue mechanism to incentivise the deployment and operation of power CCUS in the UK, including consideration of the risk sharing framework and details of the initial contracts such as the duration;

[25] https://www.gov.uk/government/publications/greenhouse-gas-removal-policy-options

- In order to inform future policy on greenhouse gas removals (GGRs), a call for evidence on negative emissions technologies and carbon pricing is expected to be launched later this year, covering GGR power technologies such as BECCS as well as other GGRs such as DACCS. This will build on evidence gathered through the HM Treasury consultation on Carbon Emissions Tax.[26]
- Continue to assess these contracts, and the process for awarding them, in the context of power CCUS technology development and a future evolving electricity system. This could include, for example, more closely integrating power CCUS mechanisms with other schemes within the wider electricity market in future.
- Continue to consider technological improvements and changes and how these may change our approach; and
- Develop draft standard terms for future power CCUS contracts.

To help develop the chosen model with industry, we will be seeking input from industry through the BEIS led Power CCUS Expert Group which we established in February 2020. We will also discuss with individual stakeholders, in particular project developers and the investment community.

We will aim to:

- Provide an update on the business models for power CCUS in Q4 2020.

[26] The HM Treasury consultation on Carbon Emissions Tax can be found at: https://www.gov.uk/government/consultations/carbon-emissions-tax

Section 6: Industrial CCUS

Introduction

Business and industry account for 25% of UK greenhouse gas emissions. Whilst energy efficiency improvement options for industry are currently available, options for 'deep' decarbonisation are more expensive and less developed. As we transition to a net zero economy, CCUS will be fundamental to securing the long-term competitiveness of energy intensive industries, supporting clean growth around the UK, protecting existing jobs and generating new jobs and economic opportunities.

CCUS is not currently investable for most industrial sectors as the high cost of deploying CO_2 capture and transporting and storing the CO_2 cannot be passed on to consumers by businesses operating in competitive global markets. Businesses are also likely to be deterred from investing by uncertainty over the future carbon price and how it will affect both their overall competitiveness and the case for deploying CCUS. Additionally, businesses may face challenges raising capital finance to invest in CCUS until costs come down as a result of higher deployment, proven results and more efficient supply chains. This is exacerbated by there being a minimal premium attached to low carbon industrial products.

In order to address these specific challenges and support the deployment of industrial carbon capture, a business model for industrial CCUS is needed. Whilst this government response focuses on CCUS, we aim to develop a model that would be capable of evolving to support industrial decarbonisation through other low carbon technologies.

In the CCUS business models consultation, we highlighted three potential business models for industrial CCUS: CO_2 'Contract for Difference' model, a 'tradeable CCS certificates plus obligation' scheme and a 'cost plus open book' model.

THE MODELS EXPLAINED

Contract for Difference (using a CO_2 reference price):

A CfD strike price is agreed per tonne of CO_2 abated, based on the expected costs of building and operating the industrial carbon capture assets. The emitter partly funds the cost of capture by selling any excess free CO_2 allowances (or equivalent)[27] and the government (through a CfD counterparty) pays the difference between the CfD strike price and a defined reference price (linked to the prevailing CO_2 allowance price) for an agreed period of time.

Tradeable CCS Certificates Plus Obligation:

An obligation is created requiring emitters to surrender a specified number of CCUS certificates based on the size of their emissions. These certificates are awarded to emitters deploying CCUS on a per tonne of CO_2 abated basis. Parties within the obligation scheme can choose whether to deploy CCUS to earn certificates or purchase them from other emitters that have a surplus.

[27] This element of the model is subject to the design of the UK's future carbon pricing policy.

Cost Plus Open Book:

Capital costs are co-funded on the basis of open book project information sharing and the emitters' capital costs are repaid with agreed returns. The emitter is directly compensated by government for properly incurred operating costs.

In addition to the models set out by government, the CCUS Advisory Group (CAG) set out their own recommendations for potential models. These were: a model based on a CO_2 Contract for Difference supported by a partial government grant for early projects; and a model based on a regulated decarbonisation service company.

CAG CO_2 Contract for Difference supported by upfront government grant:

Capital costs are financed by the private sector, supported for early projects by partial government grant, with government making payments to the emitter over an agreed period once the plant is operational to cover repayment of the private sector capital plus an agreed return (under an open book approach). Ongoing operating costs are covered by a CO_2 Contract for Difference.

CAG Regulated Decarbonisation Service Company:

A company is established to raise private sector finance to invest in CO_2 capture projects on industrial sites and provide a "decarbonisation service" to industrial emitters. Revenue support flows from government to the service company, which eliminates the need for industrial producers to invest directly in the capture plant.

Consultation responses

Overview

The Department received a large number of high-quality responses to these questions, including responses from research bodies, iron and steel, cement and chemical sectors, oil and gas companies, CCUS projects, cluster partners, trade bodies and others, which formed a critical foundation to deciding which business model we are minded to progress.

The consultation asked five questions of industry. These were:

(1) Have we considered the most important challenges in considering the development of CCUS for industry? (2) Of the models we have considered for industry CCUS, do you have a preference, and why? (3) Are there any other models that we have not considered in this consultation which you think should be taken forward for industry CCUS, and why? (4) In your view, are there any models which best work across all industrial sectors where CCUS could have a role to play? and (5) What actions should government and industry take to establish demand for low carbon industrial products?

Identifying the most important challenges for the development of CCUS for industry

Question 13 asked what the most important challenges were when considering the development of CCUS for industry. There were 43 responses to this question.

Most responses to this question agreed that CCUS will be fundamental to the decarbonisation of industry and acknowledged that the Department had considered many of the key challenges that would need to be addressed in developing an industrial CCUS business model.

Briefly summarised, these challenges covered the need to:

- Provide an appropriate level of financial incentive to attract investment whilst driving efficiency gains and cost reductions;
- Appropriately share risk and costs between industry and government;
- Take into account differing abatement costs across sectors;
- Overcome the difficulties posed by the high upfront capital costs of projects; and
- Support industry to long term subsidy free decarbonisation.

There are a number of further challenges that were stressed by respondents:

- It is essential that the business model supports and promotes clean growth within energy intensive industries and does not damage their international competitiveness. Many of our industries operate in global commodity markets which restricts their ability to pass on costs to consumers, and so careful consideration must be given to avoid carbon offshoring.
- Energy intensive industries are made up of industries that include a wide range of complex and technical processes requiring different technological solutions for decarbonisation. The final business model must be able to account for differences in the cost of capture between industries by differentiating and providing flexibility on the level of support, whilst also taking into account cost effectiveness of CO_2 abated as a key metric for providing financial support.
- The business model should help industry to manage their carbon price risk as we transition to net zero, and not overly expose them to fluctuations in the Emissions Trading System (ETS) certificate prices.

Preference for proposed models

Question 14 asked industry to choose a preferred model out of the models set out by the Department and to state reasons for choice. There were 28 responses to this question.

Many respondents to this question chose not to state a preference on a business model and instead focussed on the challenges a business model would need to address. From those that did, there was broad support for a CfD, cost plus open book, and the two models put forward by the CAG. Responses relating to the models proposed by the CAG will be covered in the next question.

Industrial CfD

The CfD was seen as having the potential to provide a good balance between revenue certainty for emitters and value for money for taxpayers. Its compatibility with carbon pricing was also noted as a positive. The main benefit of this approach was its proven track record in supporting the deployment of, and cost reduction in, low carbon electricity generation in the power sector and the ability for it to move from bilateral negotiation to competitive auctions.

Whilst it was widely suggested that a CfD could be a suitable method of addressing the ongoing operational costs, there were concerns over the treatment of capital expenditure for early projects. Respondents stated that if a CfD were to be used to cover the capital expenditure needed for the initial infrastructure build, then the strike price would need to be front loaded so as to facilitate a more rapid payback of capital spend. However, there were some views that front loading the strike price would make projects appear more expensive.

There were concerns that a fixed price CfD could be difficult to negotiate given the differences in costs across industry and the current uncertainty over project costs. Respondents also highlighted the need to ensure that the business model incentivises true decarbonisation and does not create any perverse incentives to produce more CO_2 in order to receive a greater level of subsidy.

Although certainty on the availability of operating cost support is needed, industry respondents highlighted that there are lock in risks that need to be carefully considered. These lock in risks include the risk that, under contract, an emitter could be obligated to supply CO_2 to a T&S network after substitute decarbonisation options such as alternative technologies or production methods have been developed.

Respondents considered that the CfD model has a number of potential significant benefits such as the ability to drive cost reductions and appropriately subsidise industry for costs incurred by deploying CCUS and the potential to support a number of industrial decarbonisation technologies.

Cost Plus Open Book

The cost plus open book model was seen as the simplest to understand and implement. It was supported primarily due to the bilateral arrangements of the model and the bespoke nature of each contract making it easier to take into account any site-specific factors affecting the viability of a project. It was also noted that costs would be repaid in the form they are incurred rather than being converted to a per tonne of CO_2 basis.

The main drawback to the model is that it does not incentivise cost reductions that will contribute to the long-term affordability of industrial decarbonisation. Some respondents said that a pain/gain sharing mechanism would help address this problem, though this would add to the complexity of the model. Overall, the level of support needed for this model may make it more difficult to transition to subsidy free CCUS over time.

Certificates and obligation

The certificates and obligation model was not widely supported with many respondents saying that an obligation would put additional costs onto industry that they would not be able to pass through to their customers, resulting in a high risk of carbon offshoring. This would be particularly prevalent in businesses that are internationally owned and have a wide range of markets to deploy their capital in.

Further to this, the model was seen to be complex in its operation and implementation. If the certificates were only valid for CCUS then the model would not be technology neutral, and if they were valid for other technologies then the model may feel, to some emitters, like a second carbon price (on top of the existing ETS system). Due to the current lack of operational CCUS projects in the UK, there could be a lack of liquidity in the market for certificates. This could make it difficult to set initial levels of obligation without additional support from government for early projects.

Other models for consideration

Question 15 asked whether there were any models not considered in the consultation that could be taken forward for industry. There were 13 responses to this question.

Aside from the three models set out by the Department in the consultation document, the most commonly supported models were the “regulated decarbonisation service company” and the “CfD and upfront government grant” models proposed by the CAG.

Regulated decarbonisation service company

This model was supported as an alternative primarily due to its ability to assist companies in investing in capture assets and raising the required project finance.

CfD and upfront government grant

There was strong support for this model as many felt that it combines the best features of both the CfD and the cost plus open book models. Respondents noted that by co-funding the project capex through an open book grant, the capital exposure for businesses could be reduced whilst reducing the cost of capital. Additionally, using a CfD for ongoing operating costs is a well understood mechanism that should help to secure investor confidence.

Cross-cutting models with a role for CCUS

Question 16 asked whether there are any models which best work across all industrial sectors where CCUS could have a role to play. There were 15 responses to this question.

As discussed earlier in this chapter, respondents emphasised the differences between businesses and industries that fall within the broad definition of energy intensive industries. For this reason, there was a strong suggestion that no single model could incentivise the whole of the industrial base to deploy CCUS.

Government and industry action to help establish demand for low carbon industrial products

Question 17 asked what actions government and industry should take to help establish demand for low carbon industrial products. There were 30 responses to this question.

There were a variety of responses to this question with most suggesting the need for a range of mechanisms that could help market creation for low carbon products.

These included measures such as changes to building regulations, mandating use of low carbon products in public procurements and the introduction of product standards to allow better differentiation between products.

Government’s view

CCUS will be a key technology in decarbonising the UK’s industrial base. It is, for some industries, one of the only viable options to decarbonise. This is particularly the case for those with a high proportion of process emissions, such as the cement industry.

Section 3 of this document set out our overall principles, which encompass delivering our decarbonisation goals and creating value for the UK economy while delivering value for money for taxpayers and remaining affordable to government. To achieve this, the model for industrial carbon capture will need to instil confidence among investors, maintain the competitiveness of businesses deploying CCUS and drive cost reductions.

We aim to develop a model that will incentivise deployment of early projects, whilst having the flexibility to evolve for later phases of deployment and being capable of supporting a range of projects across different industrial sectors. As CCUS costs come down and the carbon price increases, we expect to reduce the level of government support provided to new projects through the business model, achieving a sustainable and cost-effective mechanism. Our long-term vision is subsidy-free decarbonisation.

We consider that support for CCUS should not be at the expense of other decarbonisation options for industry and will explore whether the model can evolve to support industrial decarbonisation through other low carbon technologies.

In allocating support, we aim to deliver cost-effective decarbonisation, for which a key metric will be the cost per tonne of CO_2 abated, alongside wider benefits from innovation, learning and supply chain development that will enable the costs to come down over time and support job creation in a low carbon economy. Further work will be undertaken on determining the process for allocating support to projects.

Amongst other measures, government support for an emerging market for low carbon industrial products could facilitate the transition to subsidy free decarbonisation by enabling a greater proportion of costs to be passed on to consumers. Policies to support the development of a market could include public procurement of low carbon products, low carbon product standards and certification schemes. Government is actively engaging stakeholders on these policy options.

In the following section, we set out which business model we are minded to progress for industrial CCUS and the reasons for this.

Progression of Business Models

Of the models outlined in the consultation, a CfD, combined with upfront grant support from government for early projects, received the most support. This aligns with previous evidence gathered from the 2018 Element Energy study[28] as well as the Lord Oxburgh led Parliamentary Advisory Group on CCS report on the critical role of CCS[29].

Contracts for Difference have a number of benefits. They have been successfully used in the power sector to support investment and deployment in a range of low carbon electricity generation technologies, for example offshore wind, and are well understood by government and investors. They can be allocated through both bilateral and competitive processes. A fixed strike price can provide industry and investors with certainty and an incentive to reduce costs (though further consideration is needed on the interaction with the carbon price). Competitive allocation, where possible, could also help drive cost reduction.

There are specific challenges in supporting initial projects that may make reliance on an industrial CfD, on its own, unattractive. Until CCUS has been deployed at commercial scale it

[28] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/759286/BEIS_CCS_business_models.pdf
[29] http://www.ccsassociation.org/news-and-events/reports-and-publications/parliamentary-advisory-group-on-ccs-report/

may be difficult for businesses to attract cost effective finance for capital investment. Stakeholder evidence to date suggests that the industrial Contract for Difference on its own will be more attractive when the CCUS market is more mature, there is greater clarity on the cost of CCUS technologies, and a reduction in the cost of deployment, including the cost of raising finance, has been secured. Providing upfront government co-funding for a proportion of capital expenditure would reduce the challenge of raising significant finance for an industrial owner and could reduce the overall costs of the initial industrial CCUS projects in the UK.

Based on the evidence presented to date, which we will continue to develop and test, we believe this model could:

- address the higher capital and operational costs of initial projects;
- evolve to operate without upfront government co-funding for the capital expenditure as the CCUS sector matures and costs decrease;
- be competitively allocated (though we have not yet made a decision on when to introduce competitive allocation);
- evolve to support deployment of other low carbon technologies to deliver industrial decarbonisation;
- be linked to the carbon price and reflect changes in the carbon price in the level of support given; and
- evolve over time to take account of the development of a low carbon products market.

We consider that the other two models set out by government in the 2019 consultation are less likely to meet all our objectives for the reasons below.

A certificates and obligation model would impose additional costs on industry that they would not be able to pass through to their customers, resulting in a high risk of carbon offshoring. It would also be complex, for example with the interaction with the carbon market. We are therefore not minded to proceed with this model.

A cost plus open book model has some advantages. It is relatively simple to understand, reduces risks to the industrial owner and the level of financial support can be tailored to the needs of the individual project. However, it is less capable of incentivising cost reductions as government takes on cost risk and there is less opportunity to maximise returns through reducing costs below an agreed price. This model would also be administratively expensive if a large number of individual contractual arrangements need to be agreed between government and industrial owners. Whilst we are not minded to proceed with detailed design of this model as a long term solution, we acknowledge it could be an appropriate model for initial projects.

On balance, we are minded to progress a model based on a Contract for Difference, combined with the option of upfront capital support from government for early projects. We are carrying out further work and analysis on the potential detailed design of this model, which will enable us to further develop our proposals ahead of publishing a final business model.

At this stage, we envisage such a model could evolve over three distinct phases:

Phase 1 Industrial Contract for Difference with upfront capital support:

This phase would involve some upfront government co-funding of the capital costs of building the capture plant, alongside a Contract for Difference to provide revenue support for an agreed duration after the carbon capture plant is operational. A strike price would be agreed per tonne of CO_2 abated, and we see benefit in linking the model to the carbon price, though further work is needed to define an appropriate reference price for this model. The CfD payments would cover the operating cost of capture (including additional fuel costs), recovery of the capex investment made by the owner of the industrial facility (including financing costs), and any costs for accessing the CO_2 T&S infrastructure. Project development activity (pre-FEED and FEED) is supported through existing government grant schemes.

Phase 2 Transition to competitively allocated Contract for Difference:

Once early deployment enables risks and costs to be reduced, and the cost of private finance comes down, we anticipate this phase could be supported by a competitively allocated industrial Contract for Difference, whilst upfront government co-funding of the capital costs would be phased out. Project development activity could be funded by industry and the costs recovered through the Contract for Difference.

Phase 3 Market-based approach:

Cost reductions in CCUS technology and increased cost pass-through enabled by a developed market for decarbonised industrial products, alongside a policy framework that enables UK producers to compete effectively in global markets for their products, could allow CCUS to be sustained by the market CO_2 price alone. In this phase, government action would be limited to addressing any remaining market failures.

Next Steps

We will progress further detailed analysis of an industrial Contract for Difference combined with upfront government capital co-funding for initial projects. We are working closely with industry to do this through the BEIS-led Industrial CCUS Expert Group, alongside bilateral engagement with stakeholders.

The key areas we are focussing further policy development are:

- determining the process for allocating support to projects, including considering how this will evolve over time, the opportunity for a competitive process and the options for industrial facilities that are not located in industrial clusters;
- assessing the appropriate balance of government and private sector finance for the upfront capital costs;
- integrating the industrial Contract for Difference element of the model with current and potential future UK carbon pricing policy, including considering the interaction with free allocation of allowances and setting an appropriate reference price (the level from which the government ‘tops up’ to the agreed strike price per tonne of CO_2 abated);
- clarifying the interface between the industrial CCUS model and the T&S model, including how cross-chain risks are managed and how the T&S fee is paid to the T&S operator;

- deciding on the counterparty for industrial Contracts for Difference;
- allocating risks appropriately, an example being the lock in risks raised by consultation respondents, such as the risk that, under contract, an emitter could be obligated to supply CO_2 to a T&S network after substitute decarbonisation options such as alternative technologies or production methods have been developed; and
- key components of the contract, including duration, appropriate payback period for capital investment, obligations, protections and metering.
- Continue to refine and assess the industrial business model, and the process for awarding contracts, in the context of any industrial CCUS technology developments and developments in a future evolving carbon market and market for low carbon products.

We aim to:

- provide an update on the proposed design of the industrial CCUS business model before the end of 2020, including updated analysis;
- have a final business model in place in 2022.

Section 7: Low Carbon Hydrogen Production

Introduction

Low carbon hydrogen has the potential to support the UK's efforts to transform and decarbonise the energy system in line with the 2050 net zero target. While it is not possible to be certain of the precise role it will play in 2050, applications and the scale of demand, BEIS analysis and that from the CCC suggests a major increase in, and decarbonisation of low carbon hydrogen production methods is required. We see low carbon hydrogen as a lead option for decarbonising industry, and potentially having a role in power, transport and the way we heat our homes, including blending in the near term.

We are committed to developing low carbon hydrogen as a flexible and strategic decarbonised energy carrier, alongside electricity and other decarbonised gases, and are developing new policy to bring forward the technologies and supply chain needed to grow the hydrogen economy. This includes the development of a low carbon hydrogen production business model, essential to progress the at-scale deployment of low carbon hydrogen in the 2020s and beyond.

The low carbon hydrogen production chapter in the July 2019 consultation document sought views on the scope of a low carbon hydrogen business model, and on the main challenges a business model will need to address. The consultation was broadly welcomed by respondents as a positive step to realising the deployment of low carbon hydrogen at scale in the UK's energy system.

There was consensus across the majority of respondents on the following:

- That a business model is needed to support low carbon hydrogen, and more analysis and evidence is needed to identify and evaluate options.
- That the main challenges identified in the consultation were valid and addressing them is important when designing an effective business model.
- Additional cost of low carbon hydrogen compared to high carbon alternative fuels – respondents agreed that this is the main barrier and needs to be sufficiently addressed to enable end users to switch.
- Ensuring that low carbon hydrogen production facilities are an investable proposition as demand grows and changes – respondents suggested creating a strong investment case was important for the model, particularly for early projects, and guaranteed demand could provide certainty to invest.
- Ensuring low carbon hydrogen is deployed where it makes the greatest contribution to our decarbonisation goals, rather than where it commands the highest market price – a majority of respondents agreed that low carbon hydrogen could play varying roles in different sectors. Respondents indicated that any approach to address this needs to avoid being overly prescriptive.

- How to take account of the carbon price – Respondents agreed the carbon price needs considering in the level of support provided. Several responses supported the use of a stable price, such as an auction reserve price.
- A majority agreed that the business model should focus on the capital and operating costs of a low carbon hydrogen production facility, though consideration should be given to the wider hydrogen value chain.
- That the scope of the model should include support for all low carbon hydrogen production methods.

We define low carbon hydrogen in this government response as either methane reformation with CCUS, electrolysis or biomass gasification with CCUS. We recognise there are other, less developed methods to produce low carbon hydrogen, though they are not explored in detail at this stage. Discussion of low carbon hydrogen in this chapter refers to our definition above.

The responses to this consultation have informed the next phase of work, which consists of the Department commissioning a detailed assessment of potential business models to enable low carbon hydrogen production at scale.

This chapter will cover:

- Responses to questions 18-22 of the CCUS business models consultation including the government view
- The key themes identified from the responses
- Next steps

Consultation Responses

Overview

Hydrogen production costs as a focus for a future business model

Question 18 asked whether respondents agreed if a hydrogen business model should focus on the costs of hydrogen production. There were 35 responses to this question:

- Several respondents agreed that the focus on hydrogen production costs was correct at present, with some highlighting the importance of maintaining simplicity at this stage of business model development.
- Around a third of respondents suggested that the scope of the business model should be extended to consider, and in some cases include the full value chain. Some responses suggested considering using different models for different parts of the value chain and highlighted that other support mechanisms could be used for end uses of hydrogen, such as the Renewable Transport Fuel Obligation in the transport sector.
- One key finding was that respondents mostly agreed that a major barrier is the significant capital and operating costs of a hydrogen production facility, which was an important issue outlined in the consultation.

Business model support for a range of low carbon hydrogen production methods

Question 19 asked whether the business model should support both CCUS-enabled hydrogen production and renewable production methods, and if so, how that might work. There were 41 responses to this question.

There was almost unanimous support for the model to incentivise a range of low carbon production methods, with some users suggesting imports should also be supported by the model. A majority of responses indicated support for all low carbon hydrogen production methods. Other respondents indicated that developing different models for different production methods could be most effective to support deployment.

Many responses highlighted that different low carbon production methods may play different roles in the energy system, with both likely to play a role in meeting our net zero target:

- CCUS-enabled hydrogen production is more likely to be important in producing centralised, low carbon hydrogen at scale which could support efforts to build markets for low carbon hydrogen;
- Electrolytic hydrogen could play a role in decentralised production, with near-term opportunities in integration of renewables capacity, in transport and sector coupling between electricity and gas systems. Some respondents highlighted that in the longer term, electrolysis could provide opportunities for large scale production.

Responses suggested that the model could be designed to drive down costs of different production methods that are likely to be needed to deliver net zero.

Identifying the most important challenges for the development of a business model for hydrogen production

Question 20 asked whether we had identified the most important challenges which need to be considered when designing a hydrogen business model. There were 36 responses to this question.

Several responses agreed that we had identified the most important challenges in the development of hydrogen production business models.

Respondents also identified the following challenges:

- Need for CO_2 T&S infrastructure to be deployed.
- Technical and safety challenges across the hydrogen value chain, particularly in novel use cases.
- Regulatory barriers such as current hydrogen limits in the Gas Safety Management Regulations (GSMR).

Additional cost of hydrogen in comparison to high carbon alternative fuels

Several responses highlighted that they believed that the additional cost of low carbon hydrogen compared with high carbon alternatives was a fundamental challenge currently inhibiting the use of low carbon hydrogen in the energy system. Respondents argued that the additional costs will need to be fully addressed through a business model when compared to high carbon alternatives. Some responses also noted that the carbon price was insufficient in the near term to fully address the cost gap which suggests that some additional support is likely to be required to achieve this.

Respondents also raised points highlighting the importance of agreeing a calculation methodology for comparing low carbon hydrogen with high carbon alternatives and other low carbon fuels. Suggestions included comparing energy system costs, rather than just production costs. Respondents suggested this approach would help to understand the implications of distribution and end use costs on the level of support that may be required, as well as the effectiveness of low carbon hydrogen as a decarbonisation option compared to other low carbon fuels.

Ensuring hydrogen is deployed where it has the greatest decarbonisation value, rather than where it commands the highest market price

Several responses agreed that we had identified the most important challenges, except for the challenge of whether to deploy low carbon hydrogen where it has the greatest decarbonisation value, rather than where it commands the highest market price. These responses argued that precisely determining the decarbonisation value or allocating certain amounts of low carbon hydrogen to specific end uses would risk overcomplicating support mechanisms for low carbon hydrogen production which could impact the investment proposition of a business model.

Some responses highlighted that low carbon hydrogen should be deployed in end use sectors where it is most cost-effective, indicating that cost reductions could be driven by applying technology neutrality. These responses indicated that it would be beneficial to provide further clarification on our goals for deploying low carbon hydrogen.

Despite this, a number of responses agreed with our view that hydrogen could have different decarbonisation potential when deployed in different end use sectors, and that low carbon hydrogen should primarily flow to those sectors where there are limited cost-effective decarbonisation options or where it plays a role in the wider energy system. For example this could include industrial fuel switching, heavy transport or peaking power applications.

Ensuring that hydrogen production facilities are an investable proposition

There was broad agreement that designing a strong investment case would be crucial to the success of a model, with several suggestions highlighting the need for a clear deployment strategy to provide certainty on long-term ambitions for low carbon hydrogen production.

Respondents also agreed with the challenge of addressing the hydrogen demand risk for investors. Several respondents from industry and transport sectors suggested that low carbon hydrogen deployment should be sequenced, with an initial focus on sectors including industry and transport, with deployment in power, storage and synthetic fuel production coming later as the market develops. Other respondents highlighted that power could play a role in the nearer term, particularly for flexible power demonstration, and that storage could play a nearer term role, particularly as a potential balancing mechanism for fluctuations in demand for hydrogen.

There was broad agreement that blending hydrogen into the gas grid could provide a significant source of guaranteed revenue initially, reducing demand risk for investors, although this option would be subject to cost-effectiveness and demonstration of the safety case.

How to take account of the avoided carbon price

Respondents generally agreed with the challenge of taking account of the avoided carbon price in the level of support provided by the model, though the level that this is set at could impact users' decision to switch to low carbon hydrogen. Several responses favoured a stable carbon price, such as an auction price reserve.

Identified approaches to address the main challenges in designing the model

Question 21 asked for reflections on the approaches identified to address the main challenges in designing the model. There were 31 responses to this question.

There was general agreement with the approaches we identified to address the main challenges in designing the model, with responses tending to reflect the interest of the sector represented by the respondent.

Additional cost of hydrogen in comparison to high carbon alternative fuels

Several responses suggested that the cost of low carbon hydrogen should be compared with other low carbon fuels rather than high carbon alternatives. These responses highlighted the importance of considering costs to end users and some responses suggested that this could be addressed by using different business models for different end uses.

Ensuring that hydrogen production facilities are an investable proposition

Five responses highlighted the need for a clear government roadmap or strategy which would allow more confidence in investment in early projects, could drive an increase in low carbon hydrogen production capacity, and give an indication of the appropriate sizing requirements for hydrogen production facilities. Further responses highlighted the need to stimulate demand to drive investment in large scale production, and that government should work to encourage usage in sectors of likely high demand.

Ensuring hydrogen is deployed where it has the greatest decarbonisation value, rather than where it commands the highest market price

There was a limited number of proposals to address this challenge. Three respondents argued against allocating specific volumes of hydrogen to different end uses, stating the importance of the simplicity of the model and the need for a level playing field for technologies to compete.

Taking account of the avoided carbon price

Respondents generally accepted that the carbon price should be factored into the level of support provided as part of the business model. Some respondents favoured a capped or stable carbon reference price. One respondent highlighted that industrial users would need some relief from carbon price liabilities or there would be no incentive to invest in low carbon hydrogen production.

Evaluation of business models in the next phase of work

Question 22 asked for views on which business models we should evaluate in the next phase of our work. There were 32 responses to this question.

Most responses did not suggest a specific model to evaluate, which reinforces the view outlined in the consultation that there is a need to undertake further research to undertake an effective evaluation of potential business models. Some responses commented on principles that the model should include provision for, such as the need for the business model to prioritise flexibility in the design of the model in order to adapt to changing costs, technological and future market developments.

Five responses suggested evaluating a Contract for Difference (CfD) model, while a further two responses suggested a hybrid grant-CfD model (with a grant for capital costs and a CfD for operational costs).

Three responses suggested exploring an obligations-based approach. Several responses suggested the importance of aligning with other policies, with four responses suggesting that the Renewable Transport Fuel Obligation (RTFO) should be expanded to include low carbon hydrogen production aligned to the scope of our business models work.

Three responses suggested evaluating the business models outlined by the CCUS Advisory Group (CAG) in their July 2019 report on Investment Frameworks for Development of CCUS in the UK.

One response suggested using a Regulated Asset Base (RAB) model for hydrogen production, while a further two responses suggesting using a RAB model for specific end uses – power and transport.

Government's view

We are committed to progressing the development of a low carbon hydrogen production business model, which is essential to progress the at-scale deployment of low carbon hydrogen, in the 2020s.

We agree with the view of several respondents that focusing on production costs is likely to be the most effective approach to unlocking investment, although we intend to explore demand side approaches in our next phase of work. We also recognise that it is important to consider the wider value chain when designing the business model, in particular ensuring demand for the supply of low carbon hydrogen and options to support hydrogen distribution.

Consideration will need to be given to other potential sources of support for end users, such as the Renewable Transport Fuels Obligation (RTFO). We will evaluate the interactions between a low carbon hydrogen production business model and the wider value chain, by testing whether potential models interact effectively with current and/or potential distribution and end use support frameworks.

We aim to develop a low carbon hydrogen business model that operates cost-efficiently, supporting innovation, competition and cost reduction.

CCUS enabled and electrolytic production methods

As part of our focus on a low carbon hydrogen production business model we will consider how to support different low carbon hydrogen production methods during our next phase of work in a way that meets our policy objective to deploy low carbon hydrogen at scale.

We will consider a range of characteristics of different low carbon production methods when identifying and evaluating potential business models including the parameters and challenges outlined in the consultation. We will also consider the:

- Capacity to deliver low carbon hydrogen at scale in the 2020s.
- Role of different production methods in supporting our net zero target.
- Ability of the models to drive cost reductions over different methods over different timescales; and

- Ability of the models to encourage competition and to consider how support might be competitively allocated, taking into account the different technology readiness levels of low carbon production methods.

Challenges a hydrogen business model needs to address and approaches to address them

Additional cost of hydrogen in comparison to high carbon alternative fuels

We agree with the view of respondents that the cost gap between low carbon hydrogen and counterfactual, high carbon alternatives is a significant challenge and that will remain a key focus of our ongoing work on developing a hydrogen production business model. There are a number of system wide costs that need to be considered in understanding the cost gap, and the carbon price is unlikely to be sufficient to address the cost gap in the near term.

Our Hydrogen Supply Chain Evidence Base work developed our understanding of value chain costs[30] and we will continue to develop our evidence base.

Ensuring hydrogen is deployed where it has the greatest decarbonisation value, rather than where it commands the highest market price

We recognise respondents' concerns around designing a model that takes a prescriptive approach to managing the flow of low carbon hydrogen to end users. Our view remains that different end uses need to be considered in the design of the model including through assessment of other business models across the value chain. We are exploring a range of options that could address this challenge, including market-based mechanisms, alongside understanding how hydrogen may flow in the energy system under different business model options.

Ensuring that hydrogen production facilities are an investable proposition

We agree that ensuring there is a clear investable case for low carbon hydrogen is important, including tackling demand risk. Given the range of uncertainty around the shape and scale of demand for low carbon hydrogen, we will seek to develop a model that is flexible to different end users, with a focus on key markets – industry and heavy transport. We also recognise the system balancing value of energy storage, which may be crucial to help balance supply and demand for projects.

We recognise the need to encourage demand for low carbon hydrogen alongside supply. We will work to explore policies and instruments that could incentivise new low carbon hydrogen demand.

How to take account of the avoided carbon price

There are a range of options for taking account of the carbon price, and we note that some respondents indicated their preference for stable carbon price in the business model. This option could provide a carbon price signal and could be adjusted as technologies mature and deployment of low carbon hydrogen increases over time.

[30] Element Energy (2019), Hydrogen Supply Chain Evidence Base: https://www.gov.uk/government/publications/hydrogen-supply-chain-evidence-base

We will consider how carbon pricing can be accounted for in the level of support provided by the business model, as well as any potential interactions with end use sectors where the carbon price may be a factor during the next phase of our work.

Potential business models

We are considering further the options for a business model for low carbon hydrogen production and have commissioned work on this. This work includes identifying and assessing in further detail potential business models such as the CfD, obligation, RAB, direct grant, tax credit and end use business model options. Separately, we are closely following international developments, noting recent work undertaken by the Netherlands and Germany on hydrogen business models.

The RTFO does currently provide support for hydrogen production from renewables in some circumstances, although this framework is not designed to support hydrogen production for use outside the transport system. As such it is unlikely to fully meet our objectives. While we welcome views on end use support frameworks, our current view is that focusing on production, with an understanding of how models interact with distribution and end use support frameworks, is likely to be the most effective approach to enabling the option of low carbon hydrogen playing a role in the UK's decarbonisation ambitions.

Next steps

Since publishing the consultation, the focus of our work has been on:

- continued stakeholder engagement through the launch of the Hydrogen Expert Group;
- working with external consultants to conduct research on hydrogen business models, with a view to understanding potential business models that can be taken forward for further analysis;
- establishing a ministerial-led Hydrogen Advisory Council of industry representatives to help inform future policy decisions.

Drawing on the responses to this consultation we propose to:

- further evaluate the options for a business model for the deployment of low carbon hydrogen production;
- progress our strategic approach to developing hydrogen as a decarbonised energy carrier;
- consider electrolytic and CCUS enabled production methods in scope for the next phase of work;
- focus efforts on addressing hydrogen production costs whilst considering the interaction with the wider value chain;
- design a model focused on deploying low carbon hydrogen during the 2020s, including sufficient flexibility to adapt as the market grows and changes over time.

We aim to:

- publish an update on our assessment of potential business models to deploy low carbon hydrogen by the end of 2020;

- consult on a preferred business model in 2021;
- finalise a hydrogen business model in 2022.

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