Department for
Business, Energy
& Industrial Strategy

Business Models for Engineered Greenhouse Gas Removals

A consultation on accelerating investment in engineered carbon removals

Closing date: 27 September 2022

July 2022

Any enquiries regarding this publication should be sent to us at: GGR.BusinessModels@beis.gov.uk

Contents

General information

Why we are consulting

The purpose of this consultation is to set out the Government's initial proposals for a business model to support deployment of engineered Greenhouse Gas Removal (GGR) projects. We are seeking views on our early proposals, the main design elements of the business model, and options for developing a market for negative emissions in the UK.

Consultation details

Issued: 5 July 2022

Respond by: 27 September 2022

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Consultation reference: Business Models for Greenhouse Gas Removals (GGRs)

Territorial extent:

The scope of the consultation is UK-wide and responses are invited from all parts of the UK. Depending on the specific GGR process in question, however, certain aspects of the proposals may be in areas that are devolved in Scotland, Wales and Northern Ireland. BEIS will continue to work with the devolved administrations as we develop the business model in order to ensure that our policies take account of devolved responsibilities. Where proposals are suited to implementation on a UK or GB-wide basis, working with the devolved administrations will facilitate the successful deployment of the business model and consistency with devolved policy.

How to respond

We are inviting responses to the consultation online via Citizen Space.

Respond online at: https://beisgovuk.citizenspace.com/nzs/business-models-engineered-ggrs

Respondents are strongly encouraged to respond via Citizen Space. However, we will also accept responses via email to: GGR.BusinessModels@beis.gov.uk

When responding, please state whether you are responding as an individual or representing the views of an organisation.

Your response will be most useful if it is framed in direct response to the questions posed, though further comments and evidence are also welcome.

Confidentiality and data protection

Information you provide in response to this consultation, including personal information, may be disclosed in accordance with UK legislation (the Freedom of Information Act 2000, the Data Protection Act 2018 and the Environmental Information Regulations 2004).

If you want the information that you provide to be treated as confidential please tell us, but be aware that we cannot guarantee confidentiality in all circumstances. An automatic confidentiality disclaimer generated by your IT system will not be regarded by us as a confidentiality request.

We will process your personal data in accordance with all applicable data protection laws. See our privacy policy.

We will summarise all responses and publish this summary on GOV.UK. The summary will include a list of names or organisations that responded, but not people's personal names, addresses or other contact details.

Quality assurance

This consultation has been carried out in accordance with the government's consultation principles.

If you have any complaints about the way this consultation has been conducted, please email: beis.bru@beis.gov.uk.

Executive Summary

Greenhouse Gas Removal (GGR) technologies will play an important role in the UK's approach to reaching net zero – balancing residual emissions from hard-to-decarbonise sectors while providing new economic opportunities as part of our Green Industrial Revolution. The Net Zero Strategy established the Government's intention to develop markets and incentives for engineered GGR technologies to support the growth of this emerging industry. This included a commitment to consult on business models to attract private investment and enable GGR projects to deploy at scale from the mid-to-late 2020s.[1]

As set out in the Net Zero Strategy, the Government's long-term ambition is to deliver a competitive market for GGRs where the cost of deploying these technologies is borne by polluting sectors to compensate for their remaining emissions. This will require integrating engineered GGRs into a market, such as the UK ETS or a separate market for negative emissions. However, we recognise that business model support will be required in the near-term in order to overcome some of the immediate financial barriers to deployment and provide investors with confidence to bring forward early projects.

Since publishing the Net Zero Strategy in October 2021, we have progressed work on the development of a GGR business model to deliver on that commitment. This has included regular engagement with stakeholders, as well as commissioning a study from Element Energy, E4tech and Cambridge Econometrics on possible support mechanisms to stimulate early GGR deployment in the UK.[2]

This consultation sets out the Government's intention to introduce a contract-based business model for early GGR projects, seeking views on which contract mechanism would be most appropriate to enable a suite of technologies to deploy. The aim of the business model is to overcome one of the key barriers to investment in GGRs, namely the absence of a predictable revenue stream for negative emissions. The business model will therefore focus on providing revenue certainty for negative emissions in order to create an investable proposition for technology developers and investors.

The consultation is structured in six sections. Section 1 describes the background to the consultation and the rationale for developing a business model for engineered GGRs, setting this in the wider policy context. It outlines the Government's overarching vision for GGR deployment and the scope of the policy framework we are developing.

Section 2 explores a range of potential supply-side support mechanisms for GGRs and establishes the case for introducing a contract-based business model, subject to affordability and value-for-money. We examine three leading options for a contract-based business model – a Negative Emissions Contract for Difference (CfD), Negative Emissions Payment, and

[1] HM Government (2021): Net Zero Strategy
[2] Element Energy (2022): Policy Mechanisms for First of a Kind Direct Air Carbon Capture and Storage (DACCS) and other Engineered Greenhouse Gas Removals (GGRs) (access online)

Negative Emissions Guarantee – and invite views from stakeholders to enable the Government to decide on a preferred approach. It also includes initial considerations on the key design features of the business model.

Alongside business model support, Section 3 outlines the reasons why a well-functioning negative emissions market will be essential to leverage private capital and advance the Government's objectives for GGR deployment. It explores a range of potential market structures for engineered removals, and invites views from stakeholders on the most appropriate market framework for supporting initial GGR projects over the next decade and how this may evolve over time.

Section 4 sets out the importance of accounting and sustainability frameworks to ensure that GGR technologies deliver verifiable and permanent removals of CO_2 from the atmosphere, and proposes a set of principles for determining the 'legitimacy' of a negative emission. It considers some of the main challenges and research gaps in relation to the monitoring, reporting, and verification of GGRs, as well as the variety of existing standards initiatives in the sector. In addition, it reaffirms our commitment to achieve high levels of environmental protection when deploying these technologies.

Section 5 considers the applicability of the proposed GGR business model across different technologies, and how it might interact with other policies and business models under development.

Finally, Section 6 describes our next steps following the publication of this consultation. We intend to provide a response to the consultation and set out the Government's detailed proposals on the design and implementation of the business model in 2023.

Introduction

In April 2022, a major report from the Intergovernmental Panel on Climate Change (IPCC) made it clear that removing carbon dioxide from the atmosphere is "unavoidable" to achieve net zero and limit global warming.[3] There is now a robust scientific consensus that emissions reduction alone will not be enough to deliver the aims of the Paris Agreement, and greenhouse gas removals (GGR) will be required to counterbalance residual emissions from sectors that are unlikely to achieve full decarbonisation by 2050.

Nature-based methods such as afforestation, habitat restoration, and soil carbon sequestration will be essential to remove and store carbon dioxide at scale while delivering a range of additional environmental benefits such as biodiversity gain, air quality and soil health. However, due to factors such as land constraints and timescales for sequestration, the evidence demonstrates that nature-based GGRs must be complemented by engineered solutions such as Direct Air Carbon Capture and Storage (DACCS) and Bioenergy with Carbon Capture and Storage (BECCS) to remove CO_2 at the speed and scale needed to meet our targets.[4]

The UK is well-positioned to be a global leader in the development and deployment of GGR technologies, with our world-class engineering expertise and access to geological storage sites. In 2021, the National Infrastructure Commission highlighted that engineered GGRs could become "a major new infrastructure sector for the UK" worth billions of pounds per year by 2050.[5] The Government intends to capitalise on this opportunity and seize the economic benefits of this emerging sector, which could provide new export opportunities and high-quality green jobs across the UK. This could transform places with more carbon-intensive industries – such as Scotland, Wales and the North East – and support the Government's Levelling Up mission for pay, employment and productivity to have risen in every area of the UK by 2030.

The Net Zero Strategy outlined the importance of engineered GGRs to our net zero pathway and committed to supporting GGR projects to deploy at scale over the next decade, in line with advice from the Climate Change Committee[6] and the National Infrastructure Commission[7]. The Government's ambition is to deploy at least 5 $MtCO_2$ of engineered removals per year by 2030, potentially rising to around 23 $MtCO_2$ annually by 2035 to meet our indicative pathway for Carbon Budget 6.[8] As well as supporting our near-term climate objectives, early GGR deployment will help to prime the sector for further scaling-up in the 2030s and 2040s through learning-by-doing, efficiency improvements, and supply chain development. Analysis for the

[3] IPCC (2022): Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change
[4] BEIS (2021): Greenhouse Gas Removal Methods Technology Assessment Report
[5] National Infrastructure Commission (2021): Engineered greenhouse gas removals
[6] Climate Change Committee (2020): The Sixth Carbon Budget, The UK's path to Net Zero
[7] National Infrastructure Commission (2021): Engineered greenhouse gas removals
[8] HM Government (2021): Net Zero Strategy

Net Zero Strategy suggests that 75-81 $MtCO_2$ of engineered removals will be required annually by 2050 to cost-effectively reach the UK's net zero target.

The Government is already investing £100m in research and development to spur innovation and enhance our understanding of GGR technologies. Building on this early-stage support, we recognise that a policy framework is needed to enable a broad portfolio of GGRs to deploy at commercial scale. Based on extensive stakeholder engagement – including a call for evidence launched in December 2020 – it is clear that a major policy barrier to investment in GGRs is the absence of a mature market or predictable revenue streams for negative emissions. This creates revenue uncertainty for technology developers and investors, increasing costs of finance and discouraging investment in high-cost first-of-a-kind projects.

To address this prevailing market barrier, the Net Zero Strategy committed to consulting on business models that could enable GGR projects to deploy at scale in the next decade. That is the subject of this consultation, which marks an important milestone in our policy development and sets out the Government's early-stage plans to attract private investment in these technologies.

The consultation outlines the Government's intention to introduce a contract-based business model for GGRs to provide revenue support for negative emissions while markets are in their infancy. This aims to leverage private finance by reducing exposure to market risks and providing investors and technology developers with greater certainty around return on investment. It examines three leading options for the business model – a Negative Emissions Contract for Difference (CfD), Negative Emissions Payment and Negative Emissions Guarantee – and invites views from stakeholders to enable the Government to decide on a preferred approach. We are also seeking views and evidence in relation to the key design features of a GGR business model, which will inform our policy development and the detailed design of the scheme.

Given the embryonic stage of the global GGR sector, there remains considerable uncertainty regarding the future costs and scale-up potential of individual technologies. The Government therefore aims to support a broad portfolio of GGR technologies to commercialise in order to allow the most effective solutions to emerge, reduce reliance on any single technology, and enable a future competitive market which allows us to meet our targets at the lowest cost. To advance this ambition, we intend to design the business model on a technology-neutral basis as far as possible.

Alongside business model support, the Government is committed to taking steps in the near-term to build a robust market for negative emissions. This will be essential to leverage private sources of finance and provide a clear pathway to achieving the Government's long-term vision of a competitive and self-sustaining market for carbon removals in which GGR technologies are commercially viable without business model support. The consultation explores a range of market options for engineered removals, complementing the recent call for evidence on the role of the UK ETS as a potential long-term market for GGRs.[9] The Government will consider

[9] UK ETS Authority (2022): Developing the UK Emissions Trading Scheme (UK ETS), Chapter 8

views and evidence received from stakeholders in response to both publications as we undertake further work to establish the most appropriate market infrastructure for engineered GGRs and how this may evolve over time.

As emphasised in the Net Zero Strategy, robust systems for the monitoring, reporting and verification (MRV) of negative emissions will be paramount to ensure that GGR solutions provide permanent, verifiable and sustainable removal of CO_2 from the atmosphere. The establishment of reliable MRV standards is necessary to underpin business model support and future negative emissions markets, both in order to guarantee the environmental integrity of GGR technologies and to instil confidence in their legitimacy among investors and civil society. In this consultation, we therefore also set out the Government's approach to MRV for initial GGR deployment.

Section 1: Rationale for developing business models for GGRs

This section describes the background to the consultation and the rationale for developing a business model for engineered Greenhouse Gas Removals (GGRs), setting this in the wider policy context. It outlines the Government's overarching vision for GGR deployment and the scope of the policy framework we are developing.

1.1 Background to the consultation

The Net Zero Strategy recognised that large-scale deployment of engineered GGRs will play a vital role in achieving the UK's net zero target. While there is uncertainty around the exact mix of technologies that will be feasible and cost-effective to deploy at scale, BEIS analysis suggests that 75-81 $MtCO_2$ of engineered removals will be required annually by 2050 in order to balance residual emissions from hard-to-abate sectors that are unlikely to achieve full decarbonisation.[10]

Engineered GGRs such as Direct Air Carbon Capture and Storage (DACCS) and Bioenergy with Carbon Capture and Storage (BECCS) are not currently deployed in the UK and there are very few GGR projects operating globally. Government policy to date has focused on research and innovation in order to support the development of emerging technologies and inform future policy development. This includes the £70 million Direct Air Capture and other GGR innovation competition, launched in November 2020, which is supporting the construction of pilot plants for a range of promising technologies to help them achieve commercial realisation.[11]

As GGR technologies progress through the research and development phase, it is necessary for the Government to establish a policy framework that can enable projects to deploy at scale. There are several projects in the UK approaching commercial readiness, and we are committed to pursuing early opportunities to support deployment in order to grow the sector while accelerating the decarbonisation of our economy.

Early deployment over the next decade will be essential to delivering the UK's near-term climate goals, including the Sixth Carbon Budget (2033-37). Modelling conducted for the Net Zero Strategy suggests that at least 5 $MtCO_2$ of engineered removals will be needed annually by 2030, rising to around 23 $MtCO_2$ by 2035. Gaining early experience of constructing and operating a range of GGR plants will also help to realise technical improvements, bring down costs, and prepare the sector for rapid scaling-up through the 2030s and 2040s in order to meet the levels of deployment we are likely to require by 2050.

[10] HM Government (2021): Net Zero Strategy
[11] Direct Air Capture and other Greenhouse Gas Removal technologies competition (link)

Achieving the scale of GGR deployment needed over the coming decades will require significant and sustained private investment. In the Net Zero Strategy, the Government therefore committed to developing business models to address prevailing market barriers and unlock investment in GGR technologies in the 2020s. This is the subject of the present consultation, which explores our preferred mechanisms to bring forward investment in early GGR projects and place the sector on a credible pathway to net zero.

Access to CO_2 transport and storage (T&S) infrastructure will be critical for engineered GGR technologies that rely on long-term geological storage of captured CO_2. The Prime Minister's Ten Point Plan established a commitment to deploy carbon capture usage and storage (CCUS) in at least two industrial clusters by the mid-2020s, and a further two clusters by 2030.[12] The Net Zero Strategy reaffirmed this commitment and set an ambition to capture 20-30 $MtCO_2$ per year across the economy by 2030. In October 2021, the HyNet and East Coast Clusters were announced as Track-1 clusters to deliver in the mid-2020s, with Acorn announced as an additional reserve cluster.[13]

Geological GGR projects will need to be located in areas of the UK where it is feasible to gain access to a T&S network, which is likely to require close proximity to a CCUS cluster. This will facilitate the construction of new-build GGR projects as well as retrofitting existing plants to enable the production of negative emissions. We are exploring how early GGR projects could be supported through the CCUS cluster sequencing programme, and we will publish further information in due course.

The Government also recognises the importance of remote projects in dispersed sites being able to access CO_2 transport and storage networks. We consider that the capacity for T&S networks to be able to accept CO_2 from dispersed sites and international sources, either transported by ship, road or rail (non-pipeline transport), will be vital for achieving our carbon budgets and net zero. We are continuing to develop the licence conditions and business model arrangements so that non-piped sources of CO_2 can be accommodated by the Transport and Storage Regulatory Investment (TRI) model.

The UK is well-positioned to be a global leader in the development and deployment of GGR technologies. As well as our world-class academic and engineering expertise, our assets include a rapidly developing CCUS sector and access to abundant geological storage sites. We intend to capitalise on these advantages and seize the economic benefits of growing a GGR sector in the UK – including inward investment, high-quality green jobs, and new export opportunities.

With the right policy framework in place, GGRs can become an important sector for the UK economy – supporting thousands of green jobs while helping to deliver our climate goals. Beyond this consultation, we will continue to work in partnership with industry, academia, and other organisations in order to realise these opportunities.

[12] HM Government (2020): The Ten Point Plan for a Green Industrial Revolution
[13] BEIS (2021): 2021 update: Track-1 clusters confirmed (link)

1.2 The case for a GGR business model

1.2.1. Barriers to deploying GGRs

Investment in GGRs is constrained by a variety of market barriers. These barriers are wide-ranging and consist of technology-specific barriers as well as general barriers that are relevant to a range of GGR technologies. The Summary of Responses to the Call for Evidence on GGRs, published in October 2021, provides a comprehensive overview of the deployment barriers that have been highlighted to government by stakeholders.[14]

In summary, the main barriers to deploying engineered GGRs include:

- a lack of predictable, long-term demand and stable revenue streams for the production of negative emissions;
- high capital and operating costs, coupled with difficulty obtaining finance due to uncertain return on investment;
- immaturity of voluntary carbon removal markets and uncertainty around future scales and prices;
- current absence of CO_2 transport and storage infrastructure;
- technology and construction risks for 'First of a Kind' projects;
- absence of widely recognised and accepted monitoring, reporting and verification (MRV) frameworks to provide assurance around the quantity and permanence of carbon removals; and,
- uncertainty over the long-term policy and regulatory framework for greenhouse gas removals.

A number of policy interventions will be necessary to overcome these barriers and enable GGR projects to deploy over the next decade and beyond. Some barriers are already being addressed through existing government programmes, such as the development of CO_2 transport and storage networks through the CCUS cluster sequencing programme.

Aside from the absence of physical infrastructure, the barrier most commonly cited by stakeholders is the fact that there is currently no stable price incentive for negative emissions. Existing climate policies do not provide a direct incentive for polluting industries to invest in carbon removals in order to counterbalance their emissions, and the cost of engineered GGR technologies is significantly higher than credit prices on voluntary carbon markets. As a result, GGR developers do not have confidence that there will be sufficient market demand for their product to justify investment in large-scale projects. This consultation is primarily concerned with these financial barriers to GGR deployment and the related issue of the absence of robust MRV frameworks.

[14] HM Government (2021): Greenhouse gas removals call for evidence: summary of responses and next steps

In March 2022, the UK ETS Authority launched a call for evidence on the role of the UK Emissions Trading Scheme (UK ETS) as a potential long-term market for GGRs as part of the 'Developing the UK ETS' consultation.[15] If GGRs were included in the UK ETS, depending on scheme design, participants would be able to offset a portion of their emissions by purchasing negative emissions credits. This would allow emitters, and ultimately the ETS market as a whole, to find the most cost-effective option between abating their emissions or purchasing negative emission credits or other allowances. The responses to the call for evidence will inform the UK Government and Devolved Administrations' future policy in relation to the possible future inclusion of GGRs in the UK ETS.

Alongside the UK ETS, voluntary carbon removal markets are likely to play an important role in helping GGRs to deploy and reducing support costs to government. Corporate net zero commitments have so far been driving demand for carbon credits and have supported early demonstration projects in recent years, including high-profile credit purchases from large corporations such as Microsoft, Stripe, Shopify and Swiss Re.[16]

In the early stages of GGR deployment, however, market-based policies alone are unlikely to be sufficient to unlock private sector investment in large-scale projects due to unpredictable levels of demand and the risk of low and volatile market prices, resulting in uncertain return on investment. Government intervention will therefore be essential to stimulate the growth of the GGR sector at the pace and scale needed to achieve our ambitions over the coming decade. This should aim to unlock private capital by providing technology developers with an investable proposition and mitigating their exposure to market risks.

1.2.2. Delivering a portfolio of GGR technologies

The Government has considered whether existing policies could be sufficient to meet our strategic objectives, without the need for additional policy interventions to stimulate investment in GGRs. In particular, policies are currently in development that could support the deployment of specific GGR technologies through the CCUS cluster sequencing programme. This includes:

- **Power BECCS Business Model:** As set out in the Biomass Policy Statement published in November 2021, the Government is working on a business model for Power BECCS to incentivise verified negative emissions and power production. This is reflective of the advanced technological readiness of this specific technology and the significant co-benefits of both power and negative emissions

- **Industrial Carbon Capture (ICC) Business Model (including Waste):** The Government is developing the ICC business model to support the initial deployment of CCUS in UK industry and the waste management sector through the Track 1 CCUS clusters. This could deliver negative emissions by enabling the capture and permanent storage of biogenic CO_2. The business model is being designed to incorporate

[15] UK ETS Authority (2022): Developing the UK Emissions Trading Scheme (UK ETS), Chapter 8
[16] Element Energy (2022): Policy Mechanisms for First of a Kind Direct Air Carbon Capture and Storage (DACCS) and other Engineered Greenhouse Gas Removals (GGRs) (access online)

payments for captured biogenic CO_2 (as well as payments for fossil CO_2) and will integrate potential future markets for negative emissions.

- **Hydrogen Business Model:** The Government is developing a business model to stimulate private investment in new low-carbon hydrogen products. The model is designed to be applicable to a range of hydrogen production technologies and operating patterns. While the Hydrogen Business Model does not explicitly incentivise or reward negative emissions, it will support both the capture plant and hydrogen production plants for CCUS-enabled hydrogen producers. It may therefore provide sufficient policy support for Hydrogen BECCS routes such as biomass gasification with CCS, delivering negative emissions through the capture and permanent storage of biogenic CO_2.

These policies will support early deployment of certain GGR technologies including Power BECCS, Waste BECCS, and potentially Hydrogen BECCS and Industrial BECCS – delivering negative emissions alongside other services such as industrial decarbonisation and low-carbon energy.

However, these policies alone will not achieve the Government's ambition to pull through a sufficiently diverse portfolio of innovative GGR technologies. Given the limited scale of GGR deployment globally, conclusive evidence is not yet available on the scalability, costs and commercial potential of each technology. However, it is likely that a broad suite of technologies will be needed to sequester the magnitude of CO_2 that will be needed to reach our climate objectives. By pursuing a wider approach and catalysing investment across a range of technologies, we aim to maximise competition and value-for-money in the GGR sector in the longer-term and support the delivery of our objectives at the lowest cost to businesses and the taxpayer. There is also a significant market opportunity for countries and companies able to deliver the most competitive GGR solutions, providing future investment and potential export opportunities.

We therefore intend to develop a business model for GGRs that provides a technology-neutral framework for rewarding negative emissions across a diverse suite of technologies. The business model will focus exclusively on the negative emissions component of a GGR project. We recognise that some GGR projects will deliver co-products and services in addition to negative emissions, such as low-carbon energy. If further policy support is required for those co-products and services, this could be delivered through other policy regimes in the relevant sectors, subject to compliance with subsidy control principles and compatibility with a GGR business model. This is explored further in Section 2.5.6.

Technologies that could potentially benefit from a GGR business model include, but are not limited to:

- **Direct Air Carbon Capture and Storage (DACCS):** the capture and storage of CO_2 from the ambient air using separating agents that can be regenerated using heat, water or both.

- **Bioenergy with Carbon Capture and Storage (BECCS):** the capture and storage of CO_2 from biomass which is used to produce low-carbon energy – particularly in sectors such as biofuels, anaerobic digestion, biomethane, and energy-from-waste that are not supported by other mechanisms such as the ICC and Power BECCS business models.
- **Carbon-negative concrete:** the production of zero-carbon lime, which delivers negative emissions by naturally absorbing CO_2 from the atmosphere after it has been used as a building material.
- **Seawater CO_2 removals:** the capture and storage of CO_2 from seawater via chemical or electrochemical means.

The above list is not exhaustive and the Government recognises that novel approaches could emerge in the coming decade that have potential to remove greenhouse gases cost-effectively and at scale. Among stakeholders who responded to the Government's call for evidence on GGRs, there was widespread agreement that GGR business models should be technology-agnostic as far as possible in order to create a level playing field and encourage investment in a diverse range of approaches. The Government recognises the rapid pace of innovation in the GGR sector and does not intend to 'pick winners' while the sector is in its infancy. We also recognise that developing bespoke business models for each technology would be inefficient and would entail a considerable administrative burden for the Government, given the breadth of GGR technologies that are currently in development.

Question 1: Do you agree that the Government should develop a GGR business model to enable a diverse portfolio of GGR technologies to deploy at scale in the next decade?

Question 2: To support a portfolio approach to GGR deployment, do you agree that Government policy for incentivising negative emissions should be technology-neutral as far as possible?

1.2.3. Risks of policy inaction

We have considered a 'do nothing' option where the Government does not develop business model support for GGRs, and instead relies on existing policies and the growth of voluntary carbon removal markets. As described in further detail in Section 5, policies such as ICC Business Model and the Power BECCS Business Model will enable BECCS projects to deploy in certain sectors. However, the targeted scope of these policies mean they will not be sufficient to commercialise a broad portfolio of GGR solutions. In the absence of further business model support, developers of other technologies (and their investors) would be required to bear the full commercial and market risks of bringing forward early GGR projects. This is likely to represent an unacceptable level of risk, particularly for large-scale projects, given the uncertainty around how the scale and prices of voluntary carbon removal markets will evolve over the coming years.

As a result, we do not believe that a 'do nothing' approach would provide sufficient investment signals to meet our deployment objectives for the 2030s. This view is supported by advice and insights we have received from a broad spectrum of stakeholders across industry, academia and third sector organisations, including the National Infrastructure Commission in their 2021 report to government.[17] A failure to attract the required levels of investment in GGRs over the next decade could risk undermining progress towards Carbon Budget 6 and our overall trajectory to net zero. Furthermore, it would put the UK in a weaker position to capitalise on the economic benefits of a strong domestic GGR sector.

Finally, we recognise the possibility that certain GGR technologies could be deployed at lower cost in other countries. This could present opportunities for the UK to support negative emissions activities overseas at a lower cost than supporting domestic projects. Nevertheless, we are committed to incentivising GGR deployment in the UK to contribute to the UK's decarbonisation strategy while delivering benefits to the economy. While the global GGR sector remains in its infancy, it would not be desirable or prudent to rely on deployment in other countries. The Government has previously set out its intention to meet the UK's targets through domestic action, while reserving the right to use international emissions reductions or removal units under Article 6 of the Paris Agreement.[18]

1.3 The Government's approach to GGR deployment

The Government has developed a set of overarching guiding parameters that will guide our approach to deploying GGRs in the UK. These parameters have been developed in consultation with stakeholders, including through the recent GGRs call for evidence.

1. Enable GGR projects to **deploy from the mid-to-late 2020s at the speed and scale required to support delivery of the UK's Carbon Budgets**, particularly Carbon Budgets 5 and 6 (2028-37).

2. Position the UK as a global pioneer in the development and deployment of GGR technologies – providing **green jobs and export opportunities as part of our Green Industrial Revolution**.

3. Incentivise negative emissions to **balance emissions from hard-to-decarbonise sectors**, ensuring that GGRs are not deployed as a substitute for emissions reduction and do not reduce the pressure to decarbonise.

4. Provide sufficient certainty to investors and project developers to **unlock private sector investment**, ensuring that projects are financed primarily by the private sector with the government providing the minimum necessary support.

[17] National Infrastructure Committee (2021): Engineered greenhouse gas removals
[18] HM Government (2021): Net Zero Strategy p.307

5. Ensure that any **direct government support is proportionate, provides value-for-money for the taxpayer,** and is compatible with subsidy control rules.

6. Facilitate a **transition towards a market-based framework** for negative emissions, providing a clear pathway to reducing government support over time and allowing the most cost-effective route to achieving net zero.

7. Provide a route to market for **a diverse portfolio of GGR solutions** – allowing a suite of different technologies to commercialise in order to reduce reliance on any single technology.

8. Guarantee that GGR projects deliver **permanent removal of CO_2 from the atmosphere based on a full lifecycle assessment** and robust standards for monitoring, reporting and verification (MRV).

9. Deploy GGRs in a responsible manner which **avoids unintended consequences for the environment or other perverse incentives**, ensuring that all GGR projects are subject to stringent environmental regulations and sustainability criteria.

10. Incentivise **continued innovation, reduced costs and supply chain emissions**, and improvements in process efficiency.

1.4 Scope of the consultation

The GGR business model will be designed to support a broad range of engineered GGR technologies that can deploy at scale in the coming decade, establishing a strong domestic GGR sector and contributing to the delivery of the UK's Sixth Carbon Budget (2033-37).

Technologies that could be eligible for the business model are described on pages 16-17 in Section 1.2.2. However, this list is not exhaustive. The policy is being designed on a technology-neutral basis in order to provide a route to market for other innovative approaches that can deliver permanent, sustainable and cost-effective negative emissions in these timescales. Technologies that remove non-CO2 greenhouse gases from the atmosphere – including methane, nitrous oxide and F-gases – are also in scope.

Full eligibility criteria will be developed in due course as we continue to design the business model. This will include proof of compliance with environmental regulations, and robust protocols for the monitoring, reporting and verification of negative emissions to ensure that projects adhere to high standards of environmental integrity.

The consultation is <u>not</u> applicable to the following activities:

- Nature-based solutions such as afforestation, soil carbon sequestration, or habitat restoration.

- Timber in construction, which is being explored through the England Trees Action Plan.[19]

- Ocean fertilization, as such activities are banned under the London Convention and Protocol on environmental grounds.

- Biochar and enhanced weathering. The Government recognises the potential for these methods to support our greenhouse gas removal ambitions, and we are committed to continuing to support their research and development. However, further work is needed to build an empirical evidence base around the benefits and risks of these methods, particularly in relation to their permanence and impacts on local ecosystems when deployed at scale.

- Carbon capture and utilisation (e.g. in sustainable aviation fuels or beverages). This does not provide permanent removal of CO_2 from the atmosphere and is therefore not considered to be a form of greenhouse gas removal. Bio-based plastics and bio-based chemicals are similarly considered to provide only a temporary store of biogenic carbon.

[19] Department for Environment, Food & Rural Affairs (2021): England Trees Action Plan 2021 to 2024 p.19

Section 2: A contract-based business model for negative emissions

This section outlines the Government's intention to introduce a contract-based business model for engineered Greenhouse Gas Removals (GGRs), subject to affordability and value-for-money. This would address one of the main investment barriers by providing revenue support for negative emissions. We examine three leading options for a contract-based business model – a Negative Emissions Contract for Difference (CfD), Negative Emissions Payment, and Negative Emissions Guarantee – and invite views from stakeholders to enable the Government to decide on a preferred approach. Finally, it sets out early considerations on the key design features of the business model.

2.1 The case for supply-side support for GGRs

The Government's long-term ambition is to achieve a competitive and self-sustaining market for carbon removals in which GGRs are commercially viable without government support. As indicated in the Net Zero Strategy, it is appropriate that the cost of GGRs should ultimately be borne by hard-to-abate industries that require negative emission credits in order to compensate for their remaining emissions. This is in line with advice from organisations including the National Infrastructure Commission.[20]

Market demand for negative emissions will increase over time as abatement in these sectors becomes more challenging to deliver. While market prices may not be sufficient to sustain novel GGR technologies in the near-term, the Government envisages that competition will drive cost reductions and enable target levels of negative emissions to be met through the most cost-effective and scalable GGR technologies. It is expected that a combination of lower negative emissions credit prices, reduced abatement options, and a more stringent carbon price will create sustained levels of demand for GGRs out to 2050.

However, government intervention will be essential in the near-term to support the growth of the sector and enable GGR technologies to eventually participate in a competitive market. Section 1 explained that a key barrier to deploying GGRs in the UK is the absence of stable remuneration for negative emissions. While there has been a notable increase in voluntary corporate purchases of negative emissions credits that have helped to support early demonstration projects, global carbon removal markets remain in their infancy and it is uncertain how the scale and prices of these markets will evolve in the coming decade. This results in a weak incentive for technology developers and investors to bring forward large-scale projects due to uncertain market revenues and return on investment.

[20] National Infrastructure Committee (2021): Engineered greenhouse gas removals

Two policy approaches are available to government in order to address this barrier:

- **Demand-side interventions**: policies that stimulate demand for negative emissions from the private sector, providing a source of revenue for GGR projects.
- **Supply-side interventions**: policies that provide direct government support to individual GGR developers to enable commercial viability.

Given our long-term ambitions for the GGR sector, there is a clear need for the Government to start building a market for negative emissions in the UK. This will require action to stimulate the demand-side of the market – ensuring that the right market infrastructure and incentives are in place to attract private capital, support the growth of the sector in the 2020s and 2030s, and reduce support costs to government.

Market frameworks and options for attracting customer capital are explored in detail in Section 3. This considers two broad approaches to market creation: voluntary approaches, which incentivise corporate actors to purchase negative emissions on a non-mandatory basis to support delivery of voluntary carbon-neutrality goals; and compliance approaches, in which demand for negative emissions is created by the need to comply with a regulatory target or emissions cap. Options for a compliance market for GGRs include a Carbon Takeback Obligation (requiring obligated companies to compensate for a fixed percentage of their remaining emissions through the purchase of negative emissions certificates) and the inclusion of negative emissions credits in the UK Emissions Trading Scheme (UK ETS) (creating an integrated market for negative emissions and abatement).

While action to stimulate demand for credits will help to leverage vital private capital and support the transition towards a market-based framework for GGRs, it will not in itself provide the guaranteed revenues that financiers and developers require to justify high-cost investments. The challenges of relying on market-based approaches alone are summarised below (and explored further in Section 3):

- The future scale and prices of voluntary markets are inherently difficult to predict and are unlikely to provide a reliable financial incentive to deploy large-scale plants. Based on engagement with technology developers, Element Energy's report for BEIS highlights that securing corporate interest in engineered removals at large scale is challenging due to limited levels of customer demand and the high cost of credits, which are expected to trade at significantly higher prices than credits from nature-based projects.[21]
- Integrating negative emissions in the UK ETS could present several opportunities – for instance, sending a clear market signal to investors while providing additional liquidity and decarbonisation options for hard-to-abate sectors as the allowance cap falls over time. However, key considerations include the differential between GGR and UK ETS

[21] Element Energy (2022): Policy Mechanisms for First of a Kind Direct Air Carbon Capture and Storage (DACCS) and other Engineered Greenhouse Gas Removals (GGRs) (access online)

prices and the need to ensure that the potential inclusion of negative emissions credits does not weaken the incentive to decarbonise. The potential role of the UK ETS as a market for GGRs has been explored through a call for evidence published by the UK ETS Authority, which closed in June 2022.

- A GGR obligation scheme would create demand for negative emissions credits by requiring major emitters to compensate for a portion of their emissions. However, BEIS' research suggests that in the very early stages of deployment, it will be challenging to design an obligation market that can support the commercialisation of a mix of technologies at different price points, mitigate price volatility, and provide the required level of revenue certainty for project developers. Element Energy's study noted that while an obligation scheme would create demand for negative emissions credits, it does not directly guarantee the supply of credits due to the risk that obligated parties can 'buy out' of the scheme or supply might outstrip demand.[22]

The remainder of this section explores supply-side policies that could unlock investment in large-scale GGR projects from the mid-to-late 2020s. It lays out the Government's view that a contract-based revenue support scheme for negative emissions would provide the optimal level of risk-sharing between government and the private sector, and outlines early considerations for the design of such a scheme. The Government will consider further how any supply-side policies would be funded. This will take into account the impact on the fiscal position, affordability for businesses and developers, as well as ensuring a fair distribution of costs.

While a revenue support mechanism is needed to achieve our deployment objectives in the near-term, we expect reliance on supply-side support to reduce over time as the GGR sector matures. Our policy will aim to facilitate that transition through a combination of market development and cost reductions. Early deployment of large-scale plants will help to accelerate technology cost reductions through learning-by-doing, efficiency improvements, supply chain growth, and technology de-risking leading to lower costs of finance.

Furthermore, it is not clear which technologies hold the greatest promise for the future, and we recognise the possibility that technologies that are less developed and more expensive now may prove to be more cost-effective and desirable in the longer-term. The action we take today to support a portfolio of technologies will therefore help to enable a future competitive market which allows us to meet our targets at the lowest cost.

2.2 Principles for policy design

The Government has developed a set of key design principles which we have used to assess the strengths and weaknesses of supply-side policy options for GGRs. These principles reflect

[22] Element Energy (2022): Policy Mechanisms for First of a Kind Direct Air Carbon Capture and Storage (DACCS) and other Engineered Greenhouse Gas Removals (GGRs) (access online)

our priorities for negative emissions policy in the near-term, taking into account the respective needs of project developers, investors, and the Government.

These principles are linked to our policy objectives for GGR support, and will also inform and guide policy decisions on the detailed design of our preferred scheme.

Principle	**Description**
Revenue Certainty	The policy should provide sufficient revenue certainty to enable investors and project developers to make investment decisions.
Value for Money	The policy should deliver its objectives in a way which minimises the cost to government, adheres to subsidy control rules, and does not lead to excessive returns for developers.
Deliverability	The policy should be feasible to implement in the mid-2020s and avoid unnecessary complexity and undue administration costs.
Competition	The policy should promote innovation and encourage competition between suppliers.
Market Development	The policy should incentivise project developers to seek private buyers for credits and support the growth of a robust market for negative emissions.
Technology Neutral	The policy should be sufficiently flexible to support a range of different technologies to commercialise, recognising that the capital and operational expenditure (capex/opex) requirements of producing negative emissions will vary significantly between projects, and should not create an enduring advantage for technologies that are less expensive today.
Reduced Support	The policy should allow for government support to reduce over time (both within the contract life and across different rounds of contract awards) as costs fall and the market for negative emissions matures.
Compatibility	The policy should be compatible with other policy incentives and support mechanisms for co-products and services, provided that subsidy control rules are adhered to, and it can be demonstrated that there is no double-subsidisation of the same process costs.
Reaching GGR targets	The policy should offer reasonable certainty of delivering the quantity of removals the government is aiming for.

Question 3: Do you agree with the Government's principles for policy design?

2.3 Options for supply-side policy support

The Government has considered a range of supply-side policy interventions that could address the key policy and market risks that impede the delivery and scale-up of GGRs. Four leading options have been identified: contract schemes, tax credits, competition funding, and Regulated Asset Base models. Each of these options is discussed in turn below.

Overall, the Government's view is that a contract-based revenue support scheme for negative emissions will be the most appropriate supply-side intervention to support early GGR deployment.

2.3.1 Contract schemes

Description of policy

There are several possible variants of a contract scheme for negative emissions, as discussed below in Section 2.4. However, the basic principle involves the Government and project developer entering into a private-law contract for the provision of negative emissions at a guaranteed price (per tonne of CO_2).

A contract scheme provides risk-sharing between the private and public sector – mitigating the risk to project developers that market revenues will not be sufficient to cover costs and providing an appropriate return on investment. This could involve a fixed payment per tonne of CO_2 removed, or supplementary payments from government when market revenues fall below an agreed level.

Advantages	**Disadvantages**
• Increases investor confidence and improves access to finance by mitigating market risks and providing predictability over long-term revenues. • Private law contract safeguards against political risks e.g. future changes in policy. • Lower familiarisation costs for investors given the use of contract-based business models for other low-carbon sectors. • Provides government with certainty with regard to quantity of negative emissions supplied. • Competitive auctions for GGR contracts could drive down technology costs over time. • Preferred policy approach across a broad range of stakeholders (as expressed through the recent call for evidence and the Government's wider stakeholder engagement)	• Places a significant share of the commercial risk and financial burden on the Government if market demand for negative emissions is low. • Potential high payments for first of a kind (FOAK) projects due to high costs and technology risks (e.g. around long-term performance). • Lack of an established market or prevailing market price for negative emissions may create challenges in contract design or delay implementation if contract is linked to market revenues.

Government's position

Based on extensive engagement with project developers, the financial community, academics and other stakeholders, we consider that a contract mechanism is likely to deliver the most appropriate intervention to provide ongoing revenue certainty for negative emissions given the unique challenges facing early GGR projects. This would attract private investment while ensuring that financial, technology and policy risks are appropriately shared between government and the private sector. Our view is consistent with advice from the National Infrastructure Commission[23], who have recommended 'contracts for revenue' as an optimal way for the Government to support the initial deployment of GGRs at scale before the transition towards a mature competitive market.

As well as providing confidence around return on investment and minimising exposure to market risks, a contract mechanism is a flexible instrument that could support a diverse portfolio of technologies in the short-term. Furthermore, the Government has a strong track record in supporting deployment of nascent low-carbon technologies through contract schemes in sectors where revenue forecasts are highly uncertain. In the renewable electricity sector, the use of Contracts for Difference has delivered a substantial increase in deployed capacity alongside a fall in the price per unit generated. Building on this success, contract-based revenue support schemes are currently in development in other sectors such as industrial CCUS and low-carbon hydrogen.

2.3.2 Tax credits

Description of policy

Project developers may receive a financial incentive for negative emissions in the form of tax credits (i.e. a deduction from their total tax liability). Two types of tax credits could be awarded:

- Investment tax credits equivalent to a specific percentage of total capital investment; and/or
- Production tax credits awarded on the basis of a fixed rate per tonne of net removed CO_2 (£/tCO_2).

Rates may be set differently for each technology in order to support a broad suite of GGR solutions. Although a tax credit scheme does not involve direct public expenditure, the cost would be borne by the Exchequer through reduced tax revenues.

[23] National Infrastructure Committee (2021): Engineered greenhouse gas removals

Advantages	Disadvantages
• Tax credits covering both operational and capital costs may provide a strong incentive for project developers if the credit level is sufficient. • Does not require a direct funding stream. • Government may set different incentive levels for different technologies, and reduce credit values over time to reflect and incentivise cost reduction. • Successful track record in supporting CCUS deployment in the USA (45Q scheme) – may provide some familiarity to international investors.	• Challenge of setting tax at the right rate. Risk of over-compensating projects that do not require full credit value or under-incentivising projects whose costs exceed the credit value. • Tax credits may not directly benefit all businesses, for example smaller companies with low / zero tax liabilities. • Burden on the Exchequer through reduced tax revenues. • Tax credits alone may not be sufficient to enable high-cost projects to deploy – 45Q tax credits have been used in conjunction with other incentives and markets to support project viability (including CO_2 utilisation). • Uncertainty over longevity of tax credits and risk of policy change could reduce investor confidence. • The UK does not have a history of using tax incentives to encourage deployment of high-cost low-carbon technologies.

Government's position

In the USA, the 45Q tax credit has been widely credited with supporting carbon capture and storage (CCS) projects to deploy (particularly when used in combination with other incentives), and has been expanded in recent years to include DACCS technology. A similar scheme could potentially support our deployment objectives in the UK if the credit was set at a sufficient level.

However, there are various reasons why a tax credit scheme may be less suitable for the UK GGRs context. Unlike the USA, where tax incentives have also been used in other decarbonisation sectors (e.g. renewables), the UK does not have a history of using tax credits to commercialise emerging low-carbon technologies. As well as lacking familiarity in the domestic context, investors have also indicated that a tax credit scheme for GGRs is unlikely to provide certainty over the required time horizon due to the risk of policy changes.

Tax credits could be a complex mechanism for incentivising GGRs and may not benefit all businesses. This could mean they are difficult to deliver in the short term. Overall, the policy was not widely supported by stakeholders through the Government's recent call for evidence, and we consider that a contract scheme would be preferable due to its greater administrative simplicity and ability to provide investor confidence. The Government keeps all tax reliefs under review, to ensure they provide support to businesses across the economy in a fair way and represent good value for money for the taxpayer.

2.3.3 Competition funding

Description of policy

To support initial demonstration of large-scale GGR projects, direct government funding could be awarded to technology developers through competitions. Applications could be assessed across a range of criteria including scalability, commercial potential, value-for-money, economic benefits, and co-products and services.

The UK has a strong track record of competitions and grant funding for innovation purposes, complementing private investment in research and development (R&D) to support the commercialisation of emerging low-carbon technologies. Similar policy levers could be used to deploy a range of first-of-a-kind GGR plants at scale. This would require significant levels of direct government funding, but could be designed with requirements for projects to obtain a minimum proportion of funding from the private sector.

Advantages	**Disadvantages**
• Flexible mechanism which can support deployment of a range of FOAK projects – applicable to smaller projects as well as larger and more expensive technologies. • Good track record in the UK for supporting early stage decarbonisation technologies. • Scheme can be targeted to pull through specific technologies which deliver additional co-benefits. • Competitions would incentivise cost-competitiveness between FOAK GGR projects and increase value-for-money. • Competitions or grant funding schemes can readily be delivered in the 2020s.	• Funding for multiple large-scale projects will require significant government expenditure including high upfront payments to cover capital costs. • Challenge of setting grants at the right level in the early stages of the scheme – may represent poor value for money if set too high. • Does not offer long-term revenue certainty since the incentive is paid upfront. • Does not directly support the growth of a market for negative emissions or provide a clear exit route for government support. • Administrative burden of evaluating proposals could be significant if demand is high.

Government's position

Competitions awarding funding are widely used by the Government to support innovative technologies to develop, as demonstrated by BEIS' Direct Air Capture and other GGRs Innovation Competition and the Industrial Energy Transformation Fund.

However, a competition or grant-based approach is considered to be more appropriate as a means of incentivising pilot projects or technological innovation, rather than supporting a portfolio of large-scale commercial plants. This would involve a high initial cost to the Exchequer due to the high upfront payments that would be needed to compensate for a lack of

revenue certainty throughout the lifetime of the project. Furthermore, the mechanism would not offer a clear transition to a market-based framework and is unlikely to be feasible for supporting a mature GGR sector.

For these reasons, we do not believe that competitions or grant-funding would be appropriate for achieving our strategic objectives over the coming decade. Nevertheless, we recognise that there could potentially be a role for the Government to provide capital support for FOAK projects alongside ongoing revenue support. This is considered in Section 2.5.7.

2.3.4 Regulated Asset Base (RAB)

Description of policy

A Regulated Asset Base (RAB) model is a tried-and-tested method to finance large-scale infrastructure assets such as water, gas and electricity networks in the UK. Under this model, an economic regulator awards companies a licence to charge a regulated price to consumers in exchange for providing essential infrastructure. This enables investors to share some of the project's construction and operating risks with consumers, helping to lower the cost of capital.

The Government has, following public consultation, introduced the Nuclear Energy Financing Act 2022 which introduces a RAB model as an option to finance future nuclear power projects.[24] Large-scale FOAK GGR projects may have certain similarities to nuclear power; specifically, both are high-cost infrastructure assets with high costs of capital, considerable construction and operating risks, and uncertain return on investment. A RAB model (or variant) could therefore be considered to attract private sector investment and enable delivery of large-scale GGR projects.

Advantages	**Disadvantages**
• RAB models have been used successfully in the UK to finance large-scale infrastructure projects (e.g. the £4.2bn Thames Tideway Tunnel sewerage project). • Reduces the cost of capital by reducing construction risks and the risk of the project failing, and by giving confidence to investors due to the increased role of government. • Allows funds to be raised during the construction process (often through consumer bills), helping to further reduce the cost of finance.	• Places considerable administration risk on the Government (or regulator), and increases the length of time projects will receive government support. • Unlike water or energy assets, GGRs do not have a direct customer base, making it difficult to determine how funds will be raised. • Key differences between GGRs and nuclear could make the policy less applicable – e.g. smaller size, shorter construction periods, lower capex requirements. • GGR projects have varied financial structures which is difficult to capture with RAB models.

[24] BEIS (2022): Nuclear regulated asset base (RAB) model: statement on procedure and criteria for designation

Advantages	Disadvantages
• Guarantees a longer rate of return and reduces the risk on investment for capital-intensive projects.	

Government's position

We do not consider a RAB policy model to be suitable for financing a portfolio of GGR projects. This is because RAB models are best-suited for projects that require high capex, large-scale construction and long-term contracts, for example new nuclear plants. In general, GGRs are expected to have significantly shorter construction periods, lower capex requirements, and shorter lifespans than nuclear and other infrastructure assets typically funded through a RAB model. It may also be desirable to limit the length of time FOAK GGR projects receive government support in order to accelerate the learning curve effect. Furthermore, in contrast to utility and electricity projects, there is no clear route to raising funds for negative emissions projects through customer bills or payments.

Additionally, the FOAK nature of GGR technologies contains inherent uncertainty and adaptability is required. The regulatory nature of using a RAB model with a long-term government contract decided up front may limit the ability to be flexible and adapt as the new business area develops.

2.4 Negative emissions contract options

The Government has identified three leading options for the design of a contract-based support scheme for negative emissions: a Negative Emissions Contract for Difference (CfD), Negative Emissions Payment, and Negative Emissions Guarantee.

There are common advantages and disadvantages across each type of contract mechanism, as outlined in Section 2.3.1. All mechanisms are intended to incentivise investment by giving greater certainty and stability of revenues to project developers, reducing their exposure to market risks. This should enable deployment if the contracted price and contract length are sufficient. Each option also has the potential to evolve to support projects beyond FOAK deployment. Competitive auctions can be introduced to incentivise cost reduction, with technology pots reflecting the cost profiles of various technologies to ensure that only comparable technologies are competing with each other.

However, a policy risk associated with all GGR contract mechanisms is the risk exposure to the Government, which may end up bearing a significant share of the costs of early GGR projects due to high technology costs and limited market demand. Costs to government would be expected to reduce over time as early deployment helps to catalyse supply chain growth, economies of scale, and lower costs, coupled with increased customer demand for negative emissions credits. An associated risk is the challenge of setting an appropriate contracted price

for negative emissions (on a £/tCO_2 basis) before price discovery has been achieved. If the contracted price is set too high, this could lead to early projects being over-subsidised.

Despite similar features, there are some notable differences between the contract options in terms of their design, operation, and implications for (i) the Government, (ii) project developers, and (iii) the development of carbon removal markets. In this section, we explore each of the three policy mechanisms and assess their advantages and disadvantages with reference to the policy design principles outlined in Section 2.2. A number of detailed policy design considerations, such as contract length and reference prices, are explored in Section 2.5.

2.4.1 Negative Emissions Contracts for Difference

Description of policy mechanism

Under a Negative Emissions CfD, project developers would receive a fixed 'strike price' for negative emissions, based on their costs and a return on investment. In the first instance, developers seek to sell their negative emissions credits for the highest price on the open market. Where the 'reference price' (i.e. the market price or achieved sales price) is below the strike price, the Government pays the difference to the project developer through a counterparty. Conversely, where the reference price exceeds the strike price, the difference is paid to the counterparty by the provider. Through this mechanism, the project developer receives a guaranteed price for negative emissions for the duration of the contract, while the burden on the Government diminishes as the market price rises.

Summary of advantages

An advantage of a CfD scheme is the mechanism's track record in UK decarbonisation policy. There are notable examples of CfDs working successfully in low-carbon sectors – most notably renewable electricity, where the scheme has leveraged significant private sector investment by providing a degree of revenue certainty for new projects with high capital costs, long lifetimes but low operating costs. This has so far awarded contracts totalling around 16GW of new low-carbon electricity capacity, including 13GW of offshore wind. The CfD auction scheme has also proved successful at bringing down the per unit price of offshore wind by around 65% since the first auctions were held.[25] CfD mechanisms are currently in development to support industrial carbon capture and low-carbon hydrogen production.

In light of this track record, the principle of a Contract for Difference is familiar to investors and a broad mix of stakeholders have indicated their preference for a negative emissions CfD through the Government's call for evidence on GGRs, including academics, project developers and trade associations.

In contrast to other contract mechanisms, a key feature of a CfD is its explicit inclusion of market revenues. The mechanism is inherently linked to markets, with government payments only required when market revenues fall below an agreed level. The reference price also

[25] https://www.gov.uk/government/news/government-hits-accelerator-on-low-cost-renewable-power

serves to ensure that the burden on government will reduce as the market price for negative emissions increases (due to the lower top-up payment required). In this way, the inherent design of the policy facilitates a gradual reduction in the level of government support and a transition to a market-led framework.

Summary of challenges

Despite the track record of CfDs in low-carbon electricity, policy design must recognise significant differences between the GGR and offshore wind sectors. For instance, offshore wind has high capital requirements but once installed has much smaller operating costs with little fluctuation; in contrast, the GGR sector will generally have higher and more variable operating costs (e.g. energy costs, CO_2 transport and storage costs). Therefore, while the principle of a CfD is familiar to investors, the specific and varied characteristics of GGR technologies will introduce complexity to the detailed design of a negative emissions CfD.

The applicability of a CfD scheme to small-scale GGR projects may also be challenging as the administrative burden on developers will be larger relative to the project value than for larger projects.

2.4.2 Negative Emissions Payment

Description of policy mechanism

A contractual Negative Emissions Payment could provide a guaranteed revenue stream for GGR developers. In this scheme, the Government recognises negative emissions as a public good and provides a fixed payment for project developers per unit of negative emissions produced (on a £/tCO_2basis). The payment level could be agreed with each project via auctions or bilateral negotiations, and should provide sufficient revenue certainty for developers to proceed with the investment (by covering developers' costs and providing a return on investment).

To ensure that the cost of GGR projects is not borne solely by the Government, a Negative Emissions Payment would require a mechanism to minimise overall costs to the taxpayer and support the development of the market for negative emissions. The Government would therefore seek to recover some of the costs of the Negative Emissions Payment by selling credits in a voluntary or regulated market; or by requiring project developers to sell credits on the market, with the proceeds shared between the developer and the Government under the terms of the contract.

We have considered an alternative approach in which the Government directly procures negative emissions from early projects and retires the credits without selling on the market; however, this is considered to be undesirable as it would crowd out private investment, stifle the growth of the negative emissions market, and extend reliance on government support.

Summary of advantages

In practice, a Negative Emissions Payment combined with credit sales on the market will be similar in operation to a carbon Contract for Difference. The scheme would provide project developers with a stable, guaranteed price for negative emissions. While the Government would initially cover the full cost of the negative emission, this cost would be offset by selling credits to private buyers on a voluntary or regulated market (either directly or via project developers). The net cost to the Government will therefore reduce as credit prices on the market increase. This is analogous to the CfD mechanism, in which an increase in the reference price leads to a reduction in the top-up payment from government.

Furthermore, the inclusion of credit sales in a Negative Emissions Payment scheme will support the development of the negative emissions market. This allows the policy to capitalise on demand for credits from private buyers, reducing reliance on government support and facilitating a transition to a market-led framework for negative emissions.

Summary of challenges

Through the mechanism described above, the Government would seek to recuperate some of the costs of the Negative Emissions Payment by selling credits in a voluntary or regulated negative emissions market. This exposes the Government to the risk of low credit prices on the market, particularly in the near-term when the market is at an early stage of maturity. This risk is not unique to a Negative Emissions Payment, however, and mirrors the risk of low market (reference) prices leading to a larger government top-up payment through a Negative Emissions CfD.

If the Government were to assume responsibility for selling credits to private buyers, this would increase the administrative costs of the scheme for government. A registry and trading platform would be required to provide transparent information on certified projects and facilitate credit sales – depending on future policy on negative emissions markets, this could be through existing infrastructure and trading platforms under the UK ETS or the Government could establish a new platform analogous to the Land Carbon Registry.

Alternatively, the Negative Emissions Payment contract could require project developers to sell credits to private buyers after receiving the payment, with a percentage of the market revenues passed back to the Government. While this avoids the need for the Government to intervene directly in the market by selling credits, we have identified two main challenges to this approach.

First, developers may have limited incentive to find the highest price on the market after they have already received the Negative Emissions Payment from government, if this payment is set at a level which covers their costs and provides a return on investment. A key challenge will be to design a clawback mechanism in a way which incentivises market sales (e.g. by allowing developers to retain a share of the revenues) while also minimising overall costs to government as far as possible.

Second, there are concerted efforts at national and international level to ensure the integrity and appropriate use of carbon credits. The Government has welcomed the work of the Voluntary Carbon Markets Integrity initiative (VCMI) and Integrity Council for Voluntary Carbon Markets (IC-VCM) to ensure that voluntary markets for carbon have integrity at their heart and are accessible for all at a global level. It is likely that future standards for voluntary carbon projects generating negative emissions will include rules and standards regarding the 'financial additionality' of credits. This refers to the principle that a project would not have been financially viable without revenue from carbon credit sales. In the case of a Negative Emissions Payment, in which developers receive an initial payment from government toward marginal costs, the level of support from government would need to be considered when determining the additionality of the credits produced. Any impact on the financial additionality of the credit could potentially reduce the efficiency of voluntary carbon markets as a means of recovering the costs to government.

2.4.3 Negative Emissions Guarantee

Description of policy mechanism

A Negative Emissions Guarantee scheme would enable project developers to bid for the option to sell their negative emissions credits to the Government at a guaranteed price at regular intervals (for instance, every 3 years). Having secured this option, developers would then look to sell their negative emissions credits for the highest price on the market. If there is a lack of demand on the market, developers may exercise the option to sell their unsold credits to the Government at the guaranteed price (up to an agreed maximum quantity).

In contrast to the Negative Emissions Payment, the Negative Emissions Guarantee is not likely to include a clawback mechanism to recoup costs to the Government. This is because the scheme would require developers to seek private buyers in the first instance, exercising the option to sell credits to the Government only when there is insufficient demand on the market.

The scheme could be modelled on the Woodland Carbon Guarantee[26], one of the Government's flagship schemes for supporting woodland creation in England. The Woodland Carbon Guarantee enables landowners to sell their carbon credits to the Government at the guaranteed price up to 2055. By providing long-term contracts, this helps to tackle key market barriers including access to finance, low demand, and lack of long-term policy certainty.

Summary of advantages

As a fundamental principle, the scheme is intended to encourage developers to find customers for negative emissions credits on the market, with the Government intervening only as a 'buyer of last resort' if there is insufficient market demand. Project developers are able to exercise their option to sell credits to the Government at multi-year intervals to be defined in the contract. The scheme could be designed with longer intervals to enable more time for markets

[26] https://www.gov.uk/guidance/woodland-carbon-guarantee

to develop before credits are purchased by the Government, in order to leverage private capital as far as possible.

Therefore, an advantage of the scheme is the role of the market as the primary source of revenue for negative emissions, with the Government providing a backstop while markets remain in their infancy. Any unsold credits would be paid for by the Government at the full guaranteed price, in contrast to the CfD model whereby the Government pays the difference between the market reference price and the strike price. However, it is envisaged that the overall volume of credits purchased by the Government would fall as market demand increases.

Summary of challenges

The previous section highlighted that a Negative Emission Guarantee would aim to encourage developers to find private buyers for negative emissions credits in the first instance. However, we are mindful of the risk that a Guarantee could, perversely, hinder the development of the negative emissions market. Once project developers have secured the option to sell their credits to the Government, there may be little incentive for developers to sell credits on the market if market prices are below the guaranteed price. Instead, there may be an incentive for project developers to hold on to credits in order to sell them to the Government to receive the highest price. This is in contrast to a Negative Emissions CfD, in which developers retain an incentive to sell their credits below the strike price.

Furthermore, in a nascent market where there may be limited ability to sell credits on the market, this could create cash flow issues for early projects, potentially increasing financing costs and deterring investment. This could partly be mitigated by allowing developers to sell credits to the Government on an annual basis if there is insufficient demand on the market; however, this could reduce opportunities for market growth and credit sales to private customers, and may therefore increase costs to the Exchequer.

2.4.4 Government's current position

Each of the contract mechanisms described above could provide a feasible option for stimulating GGR deployment. All share the key strength of providing revenue certainty for project developers through a stable price for negative emissions. This should de-risk investment decisions and create a clear incentive for companies to bring forward projects at commercial scale.

However, as explored above, there are differences between the contract mechanisms. This includes the burden and level of risk borne by the Government, the onus on project developers to seek private sources of demand for negative emissions credits, the extent to which they support a transition towards a market-led framework, and the overall complexity of the scheme. It is likely that some of the challenges in each approach can be addressed via the detailed design features of the policy, and we explore these further in section 2.5.

The Government is seeking views from stakeholders on the merits and challenges of the contract mechanisms under consideration. This will inform our policy development and enable us to decide on a preferred support mechanism for GGRs.

Question 4: Do you agree with our overall approach to introduce a contract-based business model for GGRs to provide revenue support for negative emissions?

Question 5: What is your preferred contract scheme of those outlined in the consultation? Please provide arguments to support your view.

2.5 Policy design considerations

At this stage of policy development, the consultation does not outline proposals on the detailed design features of a negative emissions contract. However, we recognise that the detailed design of a contract mechanism will be of paramount importance to technology developers preparing to make investment decisions.

Therefore, the following section sets out some early considerations in relation to the detailed design of a contract scheme, and invites views from stakeholders to help to inform our approach. This explores policy design elements that are common across each of the mechanisms, though policy-specific design considerations are identified and discussed where appropriate.

2.5.1 Allocation process

The Government will develop a process for contract allocation that advances our deployment objectives. We are exploring two main approaches to awarding contracts: (i) reverse auctions, in which developers compete for government support through a sealed bid in a competitive process, and (ii) bilateral negotiations between the Government and developers following an expression of interest.

Reverse auctions have been highly successful in accelerating deployment of offshore wind while achieving significant cost reductions. There is an opportunity to replicate this success in the GGRs sector. As the negative emissions market matures over time, our firm ambition is to deliver a price-based auction mechanism in which projects compete to deliver negative emissions at the lowest cost to the taxpayer and private buyers. Using the renewable electricity Contracts for Difference scheme as a blueprint, this could include technology pots reflecting the cost profiles and characteristics of different technologies in order to ensure fair competition and support a mix of technologies.

However, there are challenges associated with using a reverse auction process in the early stages of GGR deployment:

- **Insufficient competition:** The number of GGRs ready for deployment in the near-term may not be sufficient to drive meaningful price competition between projects. Due to the unique cost barriers facing initial projects, there may also be limited scope for cost reduction until subsequent generations of projects are deployed.

- **Wider deployment priorities:** Our objective is to support deployment of a portfolio of GGR technologies over the coming decade. At this stage, we cannot accurately predict which technologies will offer the greatest scalability, cost reduction, and other strategic benefits in the longer-term, so it is important that innovative technologies that are more expensive today are not 'priced out' of early deployment. To avoid supporting the cheapest existing technologies, it may therefore be appropriate for projects that apply for GGR policy support to be assessed across a range of criteria beyond cost – for instance, deliverability, future scalability, economic benefits, co-product benefits, and innovation. A simple reverse auction, where price competition alone is the basis for determining which projects receive support, could therefore undermine our overall objective and limit opportunities to commercialise innovative GGRs that offer wider benefits.

- **Challenges of pot design:** As set out above, it could be possible to mitigate some of the challenges of a reverse auction via pots for different GGR technologies. Whilst this would help projects compete on a more like-for-like basis, it will be challenging to define the number and scope of pots for early auctions given the widely varying characteristics and limited evidence on costs of GGR technologies. Having too many pots will create complexity and diminish competition, while having too few pots could create competition between non-comparable technologies.

For these reasons, bilateral negotiations may be the most suitable allocation process for early negative emissions contracts, with a clear intention to transition to price-based competition (e.g. reverse auctions) once it is practical to do so. We welcome views from stakeholders on the key issues and criteria that the Government should consider when developing its allocation process. The Government will need to consider how to implement an allocation process, including the in-house delivery capability required for bilateral negotiations or the appointment of a delivery body responsible for running an auction.

Question 6: When might it be feasible to introduce an auction mechanism for GGR contracts, and what criteria should the Government consider when developing its allocation process?

2.5.2 Setting the contracted price

Each contract mechanism considered in Section 2.4 involves the agreement of a guaranteed minimum price for negative emissions (on a £/tCO_2 basis) in order to give revenue certainty to suppliers.

- Negative Emissions CfD: the ‘strike price’ represents the guaranteed price developers will receive, with the Government paying the difference where the strike price exceeds the market price.
- Negative Emissions Payment: the ‘payment price’ is the fixed price developers will receive from the Government. Credits may then be sold on the market to recover some of the costs to the Government.
- Negative Emissions Guarantee: the ‘guarantee price’ is the fixed price at which developers can sell credits to the Government if they are unable to find buyers on the market.

In this section, ‘contracted price’ is used as a general term for the price agreed between the Government and developer (the ‘strike price’, ‘payment price’ or ‘guarantee price’ depending on the scheme design).

Finding the appropriate contracted price will be integral to the success of a GGR contract scheme. If the price is set too high, this would lead to overly generous payments from government, excessive profits for project developers, and poor value for taxpayer money. If the contracted price is set too low, this would not provide an investable proposition and projects may not be commercially viable for deployment.

It will be necessary to set the contracted price at a sufficient level to cover the capex and opex costs of producing negative emissions, as well as providing a return on investment. Given the differing technology characteristics of GGRs, the costs to be covered by a negative emissions contract will be specific to each plant, but may include the costs of fuel/energy inputs, installing and operating the capture plant, and CO_2 transport and storage fees. For any given GGR project, the degree of policy support required for the production of negative emissions will depend on a variety of factors – most notably:

- whether the project is a new-build or retrofitting an existing plant
- the type of engineering or process change required to produce negative emissions, and the capital and operational costs incurred

The process for agreeing the contracted price will be inherently linked to the allocation process. As outlined in Section 2.5.1, it may be appropriate to award contracts through bilateral negotiation for early GGR projects. This would require developers and the Government to agree the contracted price on a case-by-case basis, based on transparency around the projected marginal cost of negative emissions in order to ensure any support provided by the Government is proportionate, avoids excessive rewards to developers, and adheres to subsidy control rules. At the same time, we intend to minimise the administrative burden of bilateral negotiations and ensure that developers are rewarded for innovation and cost reduction.

Question 7: How can the Government most effectively reward innovation and cost reduction in early GGR contracts?

2.5.3 Reference price

A Negative Emissions CfD will rely on an underlying market price to serve as the reference price. This in turn requires a decision about the most appropriate market from which to draw the market price. Where the reference price is below the contracted price, the difference will be paid by the Government to the developer; conversely, if the reference price is above the contracted price, the excess revenues will be paid back to the Government. No reference price is required in a Negative Emissions Payment or Negative Emissions Guarantee; though an effective market infrastructure will remain essential to maximise credit sales to private buyers and reduce any requirements on the taxpayer.

Identifying a reference price for a Negative Emissions CfD presents a challenge as there is no established market for engineered removals. Negative emissions credits are traded in very small quantities globally, primarily through private bilateral agreements as opposed to a formal marketplace. Depending on future policy development, negative emissions credits may be sold through voluntary carbon markets, the UK ETS, a separate regulated market for negative emissions, or a combination of these markets. Options for an early negative emissions market are discussed in more detail in Section 3.

Price volatility is likely in the early stages of GGR deployment due to low liquidity in the market, meaning that credit prices are highly sensitive to changes in supply and demand. The emergence of new projects in an illiquid market could significantly increase the overall supply of credits and push prices down. Demand from corporate buyers will also be affected by a range of factors such as innovation that allows for decarbonisation of hard-to-abate sectors, the cost of credits from other countries, and the cost and supply of credits from nature-based solutions.

In the longer-term, it is expected that average negative emissions credit prices could provide a stable reference price for a Negative Emissions CfD, based on a single negative emissions market or a compositional approach. In the near-term, this may not be appropriate due to the absence of an established market, price volatility, and the considerable price differentials between different GGR technologies. For early Negative Emissions CfDs, it could therefore be appropriate to define the reference price as the monthly average achieved sales price for each project.

We are seeking views from stakeholders on the most appropriate basis for setting the reference price for any Negative Emissions CfD awarded to early GGR projects from the mid-to-late 2020s. In particular, we would welcome views on the most appropriate market infrastructure to underpin the reference price.

Question 8: If the Government pursues a Negative Emissions Contract for Difference, what is the most appropriate basis for setting the reference price for initial contracts? Please provide arguments to support your view.

A key design challenge of a Negative Emissions CfD is the weak incentive for project developers to seek the highest possible sales price for negative emissions credits on the market (unless there is an established market price to serve as the reference price). This is because higher market revenues (i.e. a higher reference price) would lead to an equivalent fall in the top-up payment from the Government in order to meet the fixed strike price. An additional mechanism may therefore be required to protect the Government's exposure to very low reference prices and to ensure developers achieve the best possible price for negative emissions credits.

Potential options to incentivise developers to achieve the maximum sales price include:

- Gain-sharing: developers may be permitted to retain a percentage of credit sales, which would be applied as an addition to the strike price; this would directly reward developers for achieving higher market prices but would require higher top-up payments by government.
- A price floor: this would establish a minimum sales price that must be achieved, but would not provide an incentive to sell above that price.
- Benchmarking: the Government could mandate that credits should not be sold below an agreed benchmark, such as average international market prices; however, international market prices will also face volatility and may not provide an appropriate benchmark in the early stages of deployment.

A similar risk is presented by a Negative Emissions Guarantee. As described in Section 2.4.3, a Guarantee scheme may provide developers with little incentive to sell credits to private buyers if market prices are below the guaranteed price.

Question 9: What mechanism could the Government introduce to ensure that project developers achieve the highest possible sales price for negative emissions credits on the market?

2.5.4 Contract length and review mechanisms

A successful GGR business model will rely on an appropriate contract length. If a contract is too short, it may not provide sufficient long-term security for project developers and investors, meaning that some projects will be unable to deploy. Conversely, if a contract is too long, there is a risk that the Government supports a project longer than is necessary or becomes locked into a contract that does not provide value-for-money.

Element Energy's report for BEIS contained a detailed discussion of factors that will influence the optimal contract length for GGR projects.[27] As described in the study, strike prices increase with shorter contract lengths since the project must recover its capital costs in a shorter operational period. However, the strike price increase is likely to be smaller for projects that are dominated by opex costs and have a smaller capex component, because opex costs are not affected by contract length.

The analysis by Element Energy suggests that while shorter contract lengths would increase total costs to government for capex-dominated technologies such as offshore wind, most GGR projects will be opex-dominated and shorter contracts could therefore reduce the burden on government significantly. This would protect the Government against locking itself into supporting expensive or inefficient projects for excessive periods. In addition, shorter contracts could help to accelerate the learning curve effect. As GGRs are expected to experience significant cost reductions after the FOAK stage, there is an economic advantage to enabling new generations of plants to compete against older-generation plants in order to support price discovery. However, we also recognise that longer-term contracts may be more attractive to investors and developers, particularly for FOAK projects given the uncertainty around future market conditions and the commercial viability of projects once contracts expire.

In recognition of market uncertainties and the differing circumstances of each project, it could be beneficial to determine contract lengths for early GGR projects using indicative bids from developers, i.e. negotiated contract lengths. This would enable developers to bid for a term they deem appropriate to enable deployment, within a range of minimum and maximum terms set by the Government. We consider that this may be preferable to setting a fixed or standardised contract length for early GGR projects, and would enable lessons from the initial round(s) of contract allocations to inform future policy. If this is adopted as our preferred approach, the Government will need to consider how to manage the potential difficulty of evaluating bids with different contract lengths.

Question 10: What do you think is the most appropriate option for setting the length of GGR contracts? Please explain your rationale.

The Government is exploring the merits and challenges of building a review mechanism into initial GGR contracts. A principal advantage of a contract-based business model is the certainty it provides to project developers and the Government throughout the duration of the contract. However, given the unique uncertainties and risks facing FOAK GGR projects, it may be beneficial to both parties to include a well-bounded review mechanism in case the contract terms prove to be insufficient or excessively generous once the plant is operational.

To preserve the integrity of the contract and minimise uncertainty, it would be necessary to ensure that the boundaries and criteria of the review mechanism are tightly defined. As

[27] Element Energy (2022): Policy Mechanisms for First of a Kind Direct Air Carbon Capture and Storage (DACCS) and other Engineered Greenhouse Gas Removals (GGRs) (access online)

suggested in the Element Energy study[28], this might allow the strike price to be adjusted upwards or downwards within a clearly-defined range (e.g. +/- 10%) if costs are substantially higher or lower than originally expected. It could also allow terms for early contract termination if mutually-agreed conditions are met.

By mitigating some of the risks and uncertainties associated with FOAK GGR projects, a well-designed review mechanism has the potential to increase investor confidence while maximising value-for-money for taxpayers. However, the Government is also mindful of the risk that a review mechanism could create unwanted complexity and uncertainty. We therefore welcome views from stakeholders on (i) the merits of a review mechanism and (ii) how a review mechanism might be designed in a way that benefits all parties and minimises unintended consequences.

Question 11: Would it be desirable to include a review mechanism in early GGR contracts? If no, please outline your reasons. If yes, please give your views on how a review mechanism might be designed.

2.5.5 CO_2 capture and utilisation

The Government's business model for GGRs will incentivise the production of negative emissions, which is defined as the capture and permanent storage of CO_2 from the atmosphere. In addition to producing negative emissions, it is recognised that GGR projects may potentially generate revenue from carbon capture and utilisation (CCU) activities, such as the sale and utilisation of CO_2 in aviation synthetic fuels, beverages, or greenhouses. While CCU provides important benefits for the economy and decarbonisation efforts, it does not provide permanent removal of CO_2 from the atmosphere. As such, these activities will not be supported by a GGR business model.

Payments through a GGR business model will be paid on the basis of £/tCO_2 stored, so that the Government is not covering the costs of CO_2 utilised. Any capex or opex that is required for both CCU and CCS operations could potentially be pro-rated to the amount of CO_2 that is stored.

2.5.6 Co-products and services

The GGR business model will be designed to incentivise the production of negative emissions by creating a stable value for this service. However, we recognise that many GGR projects will deliver low-carbon co-products and services beyond negative emissions, and we intend to design our GGR business model in a way that enables these projects to be deployed.

Taking into consideration the specific market failure we are seeking to address, the diversity of GGR technologies, and the rapid pace of innovation in this field, it is not feasible or desirable for the Government to develop bespoke business models for each GGR technology in order to account for specific co-benefits. We are therefore exploring the merits of accommodating

[28] Element Energy (2022): Policy Mechanisms for First of a Kind Direct Air Carbon Capture and Storage (DACCS) and other Engineered Greenhouse Gas Removals (GGRs) (access online)

revenue cumulation or 'stacking' – allowing project developers to combine negative emissions support under a GGR business model with existing subsidy schemes for co-products.

In cases where policy support is required for a specific co-benefit, it may be appropriate to allow GGR projects to access different subsidies and support mechanisms relevant to those products and services. However, such an approach must be carefully designed to ensure that access to multiple support mechanisms does not lead to double-subsidisation and/or over-compensation, unnecessary complexity, or other perverse outcomes. We are mindful of some of the challenges of implementing revenue stacking in practice, such as ensuring there is a clear delineation between schemes to demonstrate that there is no double-subsidisation of the same costs, avoiding misalignment between contracts, as well as avoiding excessive administrative costs for both projects and the Government.

The Government is seeking views on the merits of allowing GGR developers to access other support schemes for co-products, how subsidy cumulation could be implemented in practice, and how risks of perverse outcomes could be mitigated. This will help to inform the design of the GGR business model to ensure it is fit-for-purpose and able to support the deployment of multi-product GGRs.

Question 12: Should the Government allow project developers to combine negative emissions support under a GGR business model with other support mechanisms for co-products? Please provide arguments to support your view on whether this could be an effective route to supporting multi-product GGR projects.

2.5.7 Capital support

The Government recognises that some emerging GGR technologies will have high capital costs. These costs may be particularly high for FOAK projects due to a lack of prior learning, less-developed supply chains, and technology or market risks leading to higher costs of finance.

A GGR business model will be designed to provide flexible levels of support depending on the requirements of each project. We envisage that high capital costs may be reflected in the contracted price, providing the revenue stream required to recover capital costs and secure a return on investment. This should provide the necessary policy support to enable capex-heavy GGR projects to deploy.

Nevertheless, Element Energy's study on GGR business models identified that there could be benefits to providing additional capex support mechanisms for FOAK projects – potentially reducing project costs as well as reducing required levels of government support. The study considered four main capital support instruments: grant funding, equity investment, low interest loans, and loan guarantees.[29]

[29] Element Energy (2022): Policy Mechanisms for First of a Kind Direct Air Carbon Capture and Storage (DACCS) and other Engineered Greenhouse Gas Removals (GGRs) (access online)

Our previous stakeholder engagement has not revealed a strong preference for capex support instruments, and the Government notes Element Energy's conclusion that any such measures would be secondary to a stable revenue stream for negative emissions. However, we invite views from stakeholders on whether this should form part of our policy framework for GGRs as a complement to ongoing revenue support.

Question 13: Do you believe that capital support instruments are necessary to complement GGR business models? If so, please outline your reasons and your preferred type of capex support mechanism.

2.5.8 Other design features

The design considerations explored above are not exhaustive. As we progress work on the detailed design of a GGR business model, the Government will consider a range of other issues including, but not limited to, cross-chain risk (particularly in relation to CO_2 transport and storage infrastructure) and the treatment of variable opex costs.

At this stage, we invite stakeholders to briefly highlight wider priorities that the Government should take into account when developing the GGR business model, particularly in relation to issues not directly considered in Section 2.5 of this consultation.

Question 14: What other issues should the Government consider when progressing work on the design of a GGR business model? Please focus your response on issues that are not directly considered through this consultation.

2.6 Next Steps

The Government will use the responses to this consultation to inform the selection of a preferred GGR business model and the detailed design features of the policy. Alongside formal submissions, we recognise the value of maintaining an ongoing dialogue with the sector and this will form an important part of our policy development going forward. We therefore intend to engage with stakeholders through a GGR Business Model Expert Group, which will launch in Autumn 2022 to advise on priorities in relation to the design of the GGR business model. This will complement our wider engagement through bilateral meetings and other forums.

Section 3: Building a market for negative emissions

This Section outlines the reasons why a well-functioning negative emissions market will be essential to leverage private capital and support the Government's objectives for Greenhouse Gas Removal (GGR) deployment. It explores a range of market options for engineered removals, and invites views from stakeholders on the most appropriate market framework for supporting initial GGR projects over the next decade and how this may evolve over time.

3.1 The importance of developing a negative emissions market

As set out in Section 2, the provision of business model support will be essential to enable technology developers and investors to bring forward GGR projects at scale and support the initial deployment of a portfolio of engineered removals. In the early stages of deployment, market-based policies alone are unlikely to be sufficient to unlock private sector investment in large-scale projects due to unpredictable levels of demand and the risk of low and volatile market prices, resulting in uncertain return on investment.

However, the Government's long-term ambition is to deliver a competitive market for GGRs where the cost of these technologies is borne by polluting industries to compensate for their remaining emissions. This will require integrating engineered GGRs into a market, such as the UK Emissions Trading System (UK ETS) or a separate market for negative emissions. Developing a market for GGRs will provide a long-term policy signal to project developers and investors, helping to increase investor confidence and drive down the cost of GGR technologies. In the near-term, an effective market infrastructure will also be essential to maximise private sources of capital for GGR projects through the sale of negative emissions credits, and in turn minimise support costs to government.

As we develop our immediate GGR policy, we are therefore exploring the near-term action needed by the Government to build a robust negative emissions market in the UK. In doing so, we will consider the needs of the three main parties involved in GGR projects: the Government, project developers, and customers in the private sector (including hard-to-abate sectors).

- For the Government, this action should reduce the need for public subsidy for GGRs, provide a clear pathway to reducing government support over time, and accelerate the transition to a competitive market-based framework.
- For project developers, it should offer visibility on the marketplace for their product, improve access to private buyers, and provide a long-term policy signal to boost investor confidence.
- For customers in the private sector (including hard-to-abate sectors), it should provide straightforward access to the marketplace, instil confidence in the quality and integrity of

negative emissions credits, and simplify the due diligence processes that buyers are required to undertake.

3.2 Options for negative emissions markets

There are two main approaches available to government for building a market for negative emissions to support GGR projects over the next decade:

- **Compliance markets**, in which demand for negative emissions is created by the need to comply with a regulatory target or emissions cap.
- **Voluntary markets**, in which actors choose to purchase negative emissions credits on a non-mandatory basis as part of their efforts to meet corporate net zero targets or other sustainability goals.

The following section explores leading options for developing compliance-based or voluntary negative emissions markets. It is emphasised that these options are not considered to be mutually-exclusive: the Government recognises that voluntary and compliance markets may coexist and complement one another, and the balance of voluntary and compliance demand may change over time as the market framework evolves.

3.2.1 Compliance market options

Two possible compliance markets for negative emissions are explored in this section: (1) inclusion of negative emissions in the UK ETS, and (2) the creation of a GGR obligation scheme.

While there are various important differences between these options, they both seek to leverage investment in GGR technologies by creating a source of private sector demand for credits, relieving the burden on the taxpayer by shifting the costs onto hard-to-abate sectors ('polluter pays'). Additionally, as each option would establish a baseline market price for CO_2 removal, they could both complement contract-based policies e.g. by providing a reference price for a Negative Emissions Contract for Difference.

Inclusion of negative emissions in the UK ETS

The Net Zero Strategy identified the UK Emissions Trading Scheme as a possible long-term market for negative emissions. Depending on scheme design, the inclusion of negative emissions credits in the UK ETS would allow participants to offset a portion of their emissions by purchasing negative emissions credits. In its optimal form, this would provide a single compliance market for carbon, allowing emitters to choose the most cost-effective option between abating their emissions or purchasing negative emissions credits or other allowances.

In March 2022, the UK ETS Authority published a call for evidence on the potential role of the UK ETS as a market for GGRs.[30] This explored a range of issues including eligibility criteria,

[30] UK ETS Authority (2022): Developing the UK Emissions Trading Scheme (UK ETS), Chapter 8

accounting requirements, and timings for the inclusion of GGRs in the market. This will inform future policy in this area, which will be developed in collaboration between the UK Government and the Devolved Administrations.

There are several potential opportunities that including GGRs into the UK ETS could provide, for example:

- Sending a market signal to encourage businesses to invest in GGR technologies (providing investors with confidence that there will be sustainable long-term demand for credits).
- Satisfying demand from hard-to-decarbonise sectors such as aviation, in order to help meet the UK's climate targets in a cost-effective way.
- Providing additional market liquidity as the UK ETS allowance cap falls over time.
- Integrating negative emissions in existing market infrastructure and trading platforms.

Any inclusion of GGRs into the UK ETS will need to consider the impact to the functioning and design of the market. As with all market options, it will be important to protect the integrity of the UK ETS market by developing robust monitoring, reporting and verification (MRV) standards. Furthermore, it will be necessary to ensure that the integration of negative emissions in the UK ETS does not undermine the incentive to decarbonise for sectors covered by the scheme.

For any eligible GGRs that could be included earlier in a long-term market, we are exploring different phasing options and policies that could support their deployment and scale-up in a potential market or scheme. The UK ETS Authority recently sought views on phasing and timings of ETS inclusion as part of its call for evidence, which closed in June 2022. The Government will consider responses to the call for evidence alongside the responses to this consultation.

Establishing a GGR Obligation scheme

A GGR obligation scheme (sometimes described as a 'Carbon Takeback Obligation') would require emitters from certain sectors to purchase negative emission credits to compensate for a fixed percentage of their emissions. Where obligated parties do not purchase sufficient negative emissions credits to meet their obligation, they are required to pay a penalty (the buyout price) for each remaining tonne of CO_2.

There are several advantages to creating a GGR obligation scheme. It would leverage private investment in GGR technologies by creating a stable source of demand for negative emissions from hard-to-abate sectors, enforcing the polluter pays principle and relieving the burden on the taxpayer. The level of the obligation could be set in line with target levels of GGR deployment and can be raised over time. The market would encourage competition and drive efficiency. Furthermore, the UK has a track record of using obligation-based schemes to support decarbonisation, such as the Renewable Transport Fuel Obligation (RTFO) and the now-retired Renewables Obligation (RO).

However, while a GGR obligation would create a market demand for negative emissions credits, such a scheme would be very difficult to implement in the early years of deployment and would not directly guarantee the supply of negative emissions credits to meet demand. The main reasons for this were explored in detail by Element Energy, E4tech and Cambridge Econometrics in their study for BEIS[31], and can be summarised as follows:

- Projected cash-flows under an obligation scheme will depend on the market price. This is influenced by the buyout price, which acts as a price ceiling for negative emissions credits. If the buyout price is set too low, more expensive technologies would not achieve a market price that covers their costs and therefore may not be viable.
- Even if the buyout price is high enough to support more costly technologies, developers could still face significant revenue uncertainty due to volatility in the market price for negative emissions credits. When market liquidity is very low, each additional plant may have a significant effect on the total supply of credits; while demand for credits could be affected by wider economic factors or innovation that provides new options for decarbonisation in hard-to-abate sectors.
- As a result, a GGR obligation scheme may not provide the predictable revenue streams that project developers and investors require. Although these challenges could be partly resolved by supplementing the obligation scheme with a negative emissions contract to provide revenue stability, a number of risks and complexities would still remain. This includes the task of setting a buyout price that supports the deployment of a portfolio of GGR technologies with markedly different costs. If a high buyout price is set to incentivise more expensive technologies, this could expose obligated parties to very high compliance costs which may ultimately be passed through to consumers. Price volatility due to low liquidity and the lumpy nature of the supply pipeline may also restrict obligated sectors' ability to forecast compliance costs and undermine confidence in the scheme.
- Additional challenges include determining which sectors and which firms within those sectors will be obligated, as well as setting the level of the obligation (as a share of total emissions). These are complex and sensitive questions that could take considerable time to resolve and may delay the implementation of the scheme.

The design challenges presented by a GGR obligation scheme are not insurmountable. For instance, the Element Energy report suggests potential approaches to reducing price volatility as well as sub-obligations as a possible means of supporting higher-cost technologies. Nevertheless, it is clear that such a scheme would be highly complex to implement in the near-term and it would be necessary for the Government to manage the risks described above. A GGR obligation scheme may be more feasible to implement in the longer-term, when a portfolio of technologies have developed sufficiently to compete with one another on the market and price discovery has been achieved.

[31] Element Energy (2022): Policy Mechanisms for First of a Kind Direct Air Carbon Capture and Storage (DACCS) and other Engineered Greenhouse Gas Removals (GGRs) (access online)

3.2.2 Voluntary market options

Two voluntary market approaches are explored in this section: (1) delivering GGRs through existing voluntary market bodies and verifiers, and (2) establishing a central government-designed market for engineered removals.

In voluntary markets, demand will be comprised of businesses and other actors who choose to purchase negative emissions credits to meet corporate targets and other sustainability goals. However, as voluntary markets by their nature do not require businesses or hard-to-abate sectors to invest in negative emissions, demand for credits is likely to be significantly lower and more uncertain than in a compliance market. This could mean that the taxpayer bears a greater share of the costs of early projects.

Delivering GGRs through voluntary carbon markets

Voluntary carbon removal markets remain in their infancy. To date, voluntary carbon markets have been dominated by emissions avoidance projects and nature-based projects such as woodland credits. Engineered GGR credits have been traded in very small volumes, reflecting the limited deployment of GGR technologies globally.

However, there is a growing focus on engineered negative emissions credits in voluntary markets, with evidence of pent-up demand for credits that provide permanent and verifiable removal of CO_2 from the atmosphere. In the last few years, there have been high-profile examples of multinational corporations announcing purchase agreements and partnerships to support pioneering carbon removal technologies (e.g. Microsoft, Stripe, Shopify, Swiss Re). This has helped to finance a range of early demonstration projects including Direct Air Carbon Capture and Storage (DACCS), Bioenergy with Carbon Capture and Storage (BECCS), and biomass carbon removal.

Several marketplaces specialising in negative emissions credits are emerging, such as Puro Earth and Nori. These platforms currently sell credits for biochar, soil carbon storage, and net-negative construction materials; however, it is expected that these platforms and other voluntary marketplaces may develop frameworks to include DACCS and BECCS credits in the near future.

Historically, there have been concerns around the variable quality and environmental benefits of carbon credits and perceived ‘greenwashing’ practices among businesses. In response to the Government’s call for evidence on GGRs, many stakeholders highlighted the lack of formal regulation of the voluntary market, with some describing it as a ‘wild west’ of varying standards. In particular, respondents noted that there is currently little oversight or standardisation to ensure that carbon removal credits are additional, permanent, and verified to a high standard. It was suggested this could weaken public and business confidence in the integrity of removals, acting as a major barrier to investment.[32]

[32] HM Government (2021): Greenhouse gas removals call for evidence: summary of responses and next steps

The Government has recently welcomed initiatives which aim to support the mobilisation of finance into voluntary carbon markets, by enhancing their legitimacy and incentivising best practice relating to the supply and purchase of carbon credits. This includes:

- The Voluntary Carbon Markets Integrity Initiative (VCMI), which focuses on the claims an entity can make when purchasing a credit through a voluntary carbon market. In June 2022, the VCMI published a provisional Claims Code of Practice on credible voluntary use of carbon credits by companies and other non-state actors and associated public claims. This is intended for public consultation and road-testing by companies in the second half of 2022. The VCMI's intention is to issue a final Claims Code in late 2022/early 2023.[33]
- The Integrity Council for the Voluntary Carbon Market (IC-VCM), which focuses on supply-side standards to increase the quality of credits sold. The Integrity Council's forthcoming Core Carbon Principles (CCPs) and Assessment Framework will set new threshold standards for high-quality carbon credits, provide guidance on how to apply the CCPs, and define which carbon-crediting programs and methodology types are CCP-eligible. This will be issued in Q4 2022, following a public consultation launching in July.[34]

Frontier

Frontier is an advance market commitment, launched in April 2022, that aims to accelerate the development of GGR technologies by guaranteeing future demand. It commits to buying an initial US$925M of permanent carbon removal between 2022 and 2030, signalling to investors and project developers that there is a growing market for engineered removals. The initiative is funded by Stripe, Alphabet, Shopify, Meta, McKinsey and other businesses using Stripe Climate.

Advance market commitments (AMCs) have successfully been used as an innovative funding mechanism to incentivise the development of pneumococcal vaccines for low-income countries. This has helped to spur investment in vaccine research and development where manufacturers have faced uncertain market demand in these countries – saving an estimated 700,000 lives since the AMC was first piloted a decade ago.

The Government welcomes the leadership demonstrated by corporations and other private sector organisations involved in Frontier. This demonstrates the growing corporate interest in GGR solutions that provide permanent, verifiable and sustainable removal of CO_2 from the atmosphere.

Sources: Frontier Climate (link), World Bank (link), Gavi (link)

[33] Voluntary Carbon Markets Integrity Initiative (2022): Provisional Claims Code of Practice (link)
[34] Integrity Council for the Voluntary Carbon Market (link)

In light of ongoing action to strengthen voluntary carbon markets, these markets could play an important role in leveraging private finance for large-scale GGR projects. To provide confidence in the legitimacy of carbon credits, it may be appropriate for the Government to directly endorse carbon crediting programmes that meet high standards of integrity. Any project in receipt of business model support would then be directed to sell credits through an approved marketplace, on the condition that it meets the required monitoring, reporting and verification (MRV) standards and any other eligibility criteria that may apply. Subject to policy design, the achieved sales price through voluntary markets could form the reference price for a Negative Emissions Contract for Difference.

Direct government endorsement of high-quality marketplaces and verifiers could further help to tackle concerns around the legitimacy of carbon credits, give buyers confidence to enter the market, and simplify the due diligence that customers currently need to undertake on GGR projects.

Nevertheless, the Government recognises certain risks associated with this approach. Large-scale GGR projects will typically be different to other projects supported through voluntary markets in important respects; most notably that they are high-cost infrastructure projects of high strategic importance to the UK's climate goals and will potentially be in receipt of government support. As a result, it may be less desirable for the Government to rely on sales through private market platforms that are not subject to formal regulatory oversight. Additionally, initiatives to enhance the legitimacy and integrity of voluntary carbon markets may have a gradual rather than immediate impact on investor confidence. In the short-term, historic concerns around voluntary carbon markets may continue to have an effect on customer demand.

Establishing a government-designed market for engineered removals

To support the growth of the sector and leverage private investment, the Government could establish a government-designed voluntary market for engineered GGR projects. This would require the appointment of a regulatory body responsible for setting and enforcing standards for monitoring, reporting and verification (MRV) and awarding negative emissions credits. A registry and trading platform would also be needed to provide transparent information on certified projects and facilitate credit sales – this could be through existing systems in the UK ETS or the Government could establish new platforms if necessary. Projects receiving business model support from the Government would be invited to register and sell their credits through the market. Demand would initially come from voluntary buyers; however, the Government would have the option to introduce a compliance element to the market over time.

There are several advantages to developing a formal market for engineered removals. Access to a central market with a robust regulatory benchmark could instil confidence in investors and customers, providing assurance that credits are high-quality and approved by the Government. This would reduce the burden on buyers having to navigate through different platforms and standards on the voluntary market. A regulated market would also help to establish a single

market price for negative emissions, which could be used as a reference price for future contracts for difference.

A number of organisations have proposed similar variants of a regulated negative emissions market. For instance:

- In their study for BEIS, Element Energy recommended the creation of a regulated voluntary market that could be linked to the UK ETS over time or provide the market structure for a GGR obligation scheme.[35]
- The Energy Systems Catapult has advocated a centrally accredited GGR marketplace underpinned by rigorous accounting and verification standards, which could link with the UK ETS following a period of technology demonstration and scaling.[36]
- The Oxford Smith School and CO_2RE Greenhouse Gas Removal Hub have considered various approaches to supporting deployment which involve the creation of a government-regulated market for GGRs. Under one option, this market would combine both voluntary and compliance demand for negative emissions credits (with the compliance element potentially taking the form of a carbon takeback obligation). Under another option, there would be no compliance element to the market and demand would come from government purchases and voluntary buyers in the private sector. In both scenarios, the market could be linked with the UK ETS once the differential between GGR and ETS prices has been reduced and GGR technologies have "a track record of safe carbon storage".[37]

A marketplace for engineered GGRs could potentially be modelled on the Land Carbon Registry, which provides a public database of Woodland Carbon Code and Peatland Code projects and a trading platform for certified credits.[38]

Despite these advantages, the creation of a regulated market would impose administrative costs on the Government, and we recognise the risks of placing a new regulated market in possible competition with existing voluntary market bodies and carbon crediting programmes.

3.3 The Government's current position

The Government will undertake further work to determine the most appropriate market infrastructure for engineered GGRs – including the balance between compliance and voluntary markets, and how this may evolve over time to deliver the Government's objective of a strong liquid market for carbon removals. To inform future policy, we welcome stakeholder views on the potential role of the options explored in this chapter. In particular, we are seeking views on the most appropriate market infrastructure to support initial GGR projects that could deploy in the late 2020s and early 2030s, supporting the delivery of the UK's Sixth Carbon Budget (2033-37).

[35] Element Energy (2022): Policy Mechanisms for First of a Kind Direct Air Carbon Capture and Storage (DACCS) and other Engineered Greenhouse Gas Removals (GGRs) (access online)
[36] Energy Systems Catapult (2021). Developing Carbon Credit Markets
[37] Oxford Smith School and CO_2RE (2022). Policy brief: Deployment support for geological Greenhouse Gas Removals (GGR) in the UK (link)
[38] https://www.woodlandcarboncode.org.uk/uk-land-carbon-registry

Furthermore, we recognise that many stakeholders are seeking clarity on rules regarding the international sale of negative emissions credits. The Government's current position is to permit overseas transactions involving negative emissions credits generated by GGR projects within the UK, meaning sales will not be limited to UK customers. However, any overseas sales from GGR projects receiving support through a future GGR business model would not be authorised for use towards any other country's Nationally Determined Contribution (NDC) target or for compliance uses (e.g. CORSIA). In practice, this will mean such removals are permitted for voluntary uses abroad only, whilst contributing towards the UK's own NDC.

Question 15: What do you believe is the most appropriate market framework for supporting initial GGR projects over the next decade, and how might this framework evolve over time? In your answer, please consider the market options outlined in Section 3, indicating which option or combination of options would be preferable to achieve our objectives.

Question 16: What steps should the Government take to stimulate voluntary corporate demand for negative emissions credits?

Question 17: To maximise voluntary private investment in negative emissions credits, would it be preferable for the Government to (i) establish a regulated market for engineered GGRs or (ii) directly endorse voluntary carbon market bodies that meet high integrity and verification standards? Please outline your view of the main benefits and challenges of each approach.

Question 18: Would it be desirable for the Government to establish a regulated market for engineered GGRs to allow for future integration with the UK ETS and/or provide the foundation for a GGR obligation scheme? If so, how could this be achieved?

Section 4: Accounting and sustainability frameworks

This section sets out the importance of accounting and sustainability frameworks to ensure that GGR projects deliver verifiable, permanent and sustainable removals of CO_2 from the atmosphere. It explores key considerations in relation to the monitoring, reporting and verification (MRV) of engineered GGRs, and explores high-level principles that might be applied to ensure their legitimacy. It also considers some of the challenges and research gaps in this area, as well as the variety of existing standards and initiatives that could potentially support early deployment. Finally, it reaffirms our commitment to achieve high levels of environmental protection when deploying GGR technologies, working closely with the Environment Agency and other bodies.

4.1 Monitoring, Reporting and Verification (MRV)

The permanent removal of greenhouse gas (GHG) from the atmosphere is key to reaching net zero. For a GGR approach to be credibly 'net-negative' it must permanently remove more GHG from the atmosphere than it creates.

Monitoring, Reporting and Verification (MRV) is the term often used to describe both the suite of methods for assessing how effective a removal process is, often referred to as its 'legitimacy'. Alongside business model development, MRV is widely viewed as one of the most important challenges to overcome in order to enable large-scale GGR deployment. This is recognised not only within government, but was also a consistent theme from a broad spectrum of stakeholders in response to BEIS's call for evidence, including academics, non-governmental organisations (NGOs), charities, research institutes and technology developers. MRV is also considered essential to building social license for GGRs in the longer-term.

Over 2021, BEIS gathered industry and academic representatives to discuss how the Government should approach this vital area of work. The group reported its recommendations alongside the Net Zero Strategy[39], outlining several long-term priorities for the Government to focus on. These included the importance of permanent CO_2 removal from the atmosphere, understanding and reducing any risk that captured atmospheric CO_2 re-enters the atmosphere (often broadly described as 'permanence') and the need to establish an independent MRV regime.

For some GGR approaches, the amount of carbon captured and stored can be easily measured. In others, establishing this with necessary certainty and verifying that it remains secure will be more challenging. Both land-based storage (e.g., in soil or trees) and geological storage (e.g., subsurface geological formations) are recognised as potential pathways for CO_2

[39] MRV Task and Finish Group (2021): Monitoring, reporting and verification of greenhouse gas removals (GGRs) (link)

removal. However, they vary significantly in terms of permanence of store, associated risk of reversal, and ability to monitor – which comprises accuracy and precision of monitoring, the cost and the frequency of monitoring to verify quantities of CO_2 stored.

In the near-term, our priority is to ensure that approximately 23Mt CO_2 of engineered removals are delivered annually by 2035 through technologies that provide secure and permanent removals of CO_2 from the atmosphere – for instance, through geological storage or the long-term storage of CO_2 in the built environment. The Government's modelling for the Net Zero Strategy suggests that Direct Air Carbon Capture and Storage (DACCS) and Bioenergy with Carbon Capture and Storage (BECCS) could make the largest contribution to the UK's deployment ambitions for engineered CO_2 removals by 2035. This consultation chapter therefore contains a specific focus on MRV challenges for these technologies. However, the core principles of our policy framework for MRV will be applicable across all technologies, ensuring that all GGR projects in the UK meet high standards of integrity and verification.

4.1.1 Approach to MRV for initial GGR projects

The establishment of robust MRV standards will be crucial to underpin any future market for engineered GGRs, both in order to preserve the integrity of the market and instil investor confidence. There will be some particular challenges, such as how to treat removals of different storage durations within the same market. We will also continue to explore the role of an independent function that could be responsible for overseeing an MRV regime, particularly in relation to the future integration of GGRs in a market such as the UK ETS. The Government's overarching ambition is to ensure that removals deployed in the UK can meet an agreed definition of legitimacy and therefore be confidently attributed to our carbon budgets. Our immediate task is to consider how to appropriately define a legitimate removal and to determine the quality of evidence required for ensuring that projects can meet this definition.

As we progress this work, we recognise that there are a growing number of institutional efforts to develop MRV 'standards' for GGRs, notably for enabling their participation in high-quality voluntary carbon markets. A non-exhaustive list of these are outlined in Figure 1. Rather than develop new standards, our current intention is to review the existing landscape, to determine which of these standards, if any, might form the basis of 'MRV eligibility criteria' for business model support in the near-term. We intend to work closely with stakeholders as we approach this work, and welcome views on this overall approach.

We acknowledge that a number of research gaps remain for some aspects of the MRV of GGRs, for example around the permanence of some non-geological removal methods, such as biochar and enhanced weathering, and the role of non-CO_2 Greenhouse Gas Removal technologies. As set out in the 2021 MRV Task and Finish Group report, certain land-based methods pose particular MRV challenges, especially in cases where captured carbon is challenging to track and measure and carries a risk of being re-emitted back into the atmosphere.

NGO	Private Voluntary	Intergovernmental
IC-VCM[40]	VERRA[41]	IPCC Guidelines[42] [43]
ISO Standards[44]	Gold Standard[45]	CORSIA[46]
CCS+[47]	Puro.earth[48]	
GHG Protocol: Land Sector and Removals Guidance[49]		
Oxford Principles[50]		

Figure 1: Non-exhaustive table of GGR standard initiatives considered for future review

Question 19: Do you agree with the government's immediate priority for MRV, including a review of standards that could underpin business model support for initial GGR projects? Please share any views or suggestions that could help to inform our approach.

Question 20: Beyond ensuring the legitimacy of initial projects, what is the appropriate role for the government in developing a robust and enduring framework for negative emissions MRV, compared to the role of other bodies such as those outlined in Figure 1?

4.1.2 Defining GGR legitimacy

A common understanding of what constitutes a high-quality 'negative emission' will be fundamental to any future work on MRV for GGRs. Drawing on the MRV Task and Finish Group's advice, we have identified a set of proposed principles for determining the legitimacy of a negative emission. We would welcome views on these principles, which are set out below.

[40] https://icvcm.org/the-core-carbon-principles/
[41] https://verra.org/project/vcs-program/
[42] https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html
[43] https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html
[44] https://www.iso.org/standards.html
[45] https://www.goldstandard.org/
[46] https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx
[47] https://www.ccsplus.org/
[48] https://puro.earth/
[49] https://ghgprotocol.org/land-sector-and-removals-guidance
[50] https://www.ox.ac.uk/news/2020-09-29-oxford-launches-new-principles-credible-carbon-offsetting

CO_2 source	Carbon must be captured from the atmosphere (directly, or via biological means) to be considered a negative emission.
Net Negativity	Supply chain CO_2 emissions must be lower than the total amount of stored carbon. We propose that we would set requirements to limit the level of supply chain emissions to ensure that GGR technologies achieve a minimum level of negative emissions.
Permanence and usage	Atmospheric carbon, once captured, must be stored for a sufficiently long enough time period to be considered a valid removal. Currently, the longest, or most 'permanent' known form of storage is in geological rock formations and are therefore the most 'useful' at this point in time. Forms of storage with a greater 'risk of reversal' (likelihood of captured carbon being re-emitted into the atmosphere) are considered to be therefore less permanent. Negative emissions (removals) must be treated as a distinct service from avoided emissions. Products made with atmospheric carbon, such as low carbon fuels and chemical products, carry the risk of near-term release back into the atmosphere and are considered to be providing an offset, rather than a removal service.

Question 21: Do you agree with our proposed principles for negative emissions legitimacy?

4.2 Environmental safeguards

The Government is committed to upholding the highest standards of environmental protection, in line with the ambitions of the 25 Year Environment Plan. In developing our plans for GGR deployment, we will minimise the impacts and risks to our environment – air, land and water.

The Government will build environmental considerations into decision-making at an early stage, to allow any potential environmental risks to be effectively managed. In doing so, we will continue to work closely with the Environment Agency, project developers and other partners to ensure that these risks are understood and mitigated, based on site specific risk assessment and enforced through the relevant policy frameworks.

In December 2021, the Environment Agency published signposting guidance on environmental regulations and considerations relevant to GGR technologies.[51] This is intended to support

[51] Environment Agency (2021), 'Greenhouse Gas Removal innovation projects – Signposting to environmental considerations and regulations' (link)

technology developers to understand the regulations applicable to their projects, including environmental permits and licences.

Section 5: Applicability across different GGR technologies

This section considers the applicability of the proposed Greenhouse Gas Removal (GGR) business model across different technologies, and how it might interact with other policies and business models under development.

5.1 Direct Air Carbon Capture and Storage (DACCS)

Direct Air Carbon Capture and Storage (DACCS) is a strategically important technology for the UK's climate ambitions. A major advantage of the technology is its ability to remove carbon dioxide directly from the ambient air, without reliance on sustainable biomass supply or significant land use requirements.[52] It is estimated that at least 18Mt of engineered removals from DACCS will be required annually by 2050 in order to reach net zero, while early deployment at scale will also be required to achieve Carbon Budget 6.

However, DACCS faces a combination of unique risks and challenges which may have implications for future policy. These risks include:

- **Early stage of development:** Despite progress in the development and pilot demonstration of DACCS, the technology remains unproven at large scale and is considered to be at an earlier stage of technology readiness than Bioenergy with Carbon Capture and Storage (BECCS).[53] The world's largest DACCS plant, located in Iceland, is currently capturing 4,000 tCO_2/year.[54]

- **Higher costs:** At least in the near-term, the estimated cost of producing negative emissions via DACCS is likely to be significantly higher than for other technologies, reflecting the earlier stage of development. Modelling by Element Energy suggests a possible first of a kind (FOAK) levelised cost for DACCS of £453 per tonne for hybrid solid DACCS plants and £318 per tonne for hybrid liquid DACCS plants.[55]

- **Energy requirements:** A key benefit of DACCS is that it does not rely on biomass; however, DACCS processes are highly energy-intensive and depends on the availability of large quantities of low-carbon energy. This means that the cost of operating DACCS

[52] Royal Society and Royal Academy of Engineering (2018): Greenhouse gas removals p.71. See also G. Realmonte, L. Drouet, A. Gambhir et al (2019): 'An inter-model assessment of the role of direct air capture in deep mitigation pathways', Nature Communications 10, 3277
[53] BEIS (2021): Greenhouse Gas Removal Methods Technology Assessment Report p.32.
[54] Element Energy (2022): Policy Mechanisms for First of a Kind Direct Air Carbon Capture and Storage (DACCS) and other Engineered Greenhouse Gas Removals (GGRs) (access online)
[55] BEIS (2022): Policy Mechanisms for First of a Kind Direct Air Carbon Capture and Storage (DACCS) and other Engineered Greenhouse Gas Removals (GGRs)

plants is highly sensitive to changes in energy prices, which could have a sizeable effect on the costs of producing negative emissions.

- **Lack of co-product revenue:** Along with negative emissions, BECCS projects provide other goods and services such as low-carbon electricity, hydrogen, biomethane, and waste management. These benefits provide additional revenue streams that would support the economic viability of the plant, and in many cases would be the primary output. However, DACCS does not produce a co-product and the economics of the plant will rest solely on negative emissions revenues.

Given these risks and uncertainties, it may be appropriate to consider adaptations to the negative emissions revenue support scheme or supplementary policy support to increase the confidence of the private sector to invest in large-scale DACCS projects. The Element Energy study considered the following options, noting that these measures may also be appropriate for technologies other than DACCS:

- Higher strike price: Initial DACCS may be supported through a higher strike price to cover high operating expenditure (opex) and capital expenditure (capex costs). This would guarantee developers a higher price per unit of negative emissions to ensure the desired return on investment.

- Energy price risk-sharing: Due to the sensitivity of DACCS to energy prices, contract adjustments may be needed to mitigate the risks of energy price fluctuations. There are two main approaches to provide this risk-sharing. First, higher estimates of the cost of energy could be baked into the strike price to provide protection against above-average rises in energy prices. Second, strike prices may be indexed to energy prices to allow the government to increase or reduce support depending on market conditions. However, it will be important to ensure that the Government does not assume unnecessary risks that should be borne by the private sector.

- Front-loading capex payments: The contract mechanism could frontload support for capex, covering the capital costs in a condensed period. This could also reduce the cost of capital for the project due to the shorter repayment period.

- Capital support: There are potential benefits to providing direct capital support to initial DACCS projects, through instruments such as low interest loans and loan guarantees. As discussed in Section 2.5.7, these instruments have the potential to reduce the costs of finance for developers as well as reducing support costs to government.

Question 22: Are there specific policy requirements for DACCS projects that the Government should take into consideration? Please provide arguments to support your view.

5.2 Bioenergy with Carbon Capture and Storage (BECCS)

When undertaken sustainably, BECCS can deliver negative emissions because carbon sequestered in biogenic material is captured and stored after the energy production process, resulting in a net removal of atmospheric CO_2. BECCS can be deployed in the power, industry, hydrogen, waste and biofuels sectors in support of net zero, delivering essential low-carbon energy vectors alongside negative emissions.

Given the variety of BECCS applications across different sectors, the Government is mindful of the potential interactions between a GGR business model and other policies that are being developed to deliver specific decarbonisation services. In the following sections, we set out the Government's initial view of how our negative emissions revenue support scheme will be applied in the context of specific BECCS technologies.

In addition, we recognise that any deployment of BECCS must be underpinned by robust monitoring, reporting and verification (MRV) protocols to ensure that our policy framework only rewards BECCS routes that deliver genuine net-negative removals of CO_2, while adhering to stringent standards for biomass sustainability.

The forthcoming Biomass Strategy, due to be published later this year, will further detail the Government's position on future biomass use and policies needed to support biomass use across the economy in meeting net zero. The Government's intention is to ensure that biomass is only used where it complies with our net zero and wider environmental goals, and the longer-term ambition is to ensure that biomass is prioritised for use with carbon capture utilisation or storage where feasible. The Strategy will review the amount of sustainable biomass available to the UK and how this resource could be best utilised across the economy to help achieve our net zero greenhouse gas emissions target by 2050 while also supporting the delivery of our wider environmental targets.

5.2.1 Power BECCS

As described in the Net Zero Strategy, Power BECCS is expected to play a major role in delivering engineered removals from the late 2020s. Our ambition is to store at least 5MtCO_2 annually from engineered GGRs by 2030, the majority of which could potentially be met by utilising Power BECCS projects. This is supported by analysis from the Climate Change Committee[56] and National Infrastructure Commission[57].

As set out in the Biomass Policy Statement[58], published in November 2021, the Government has commenced work to develop a bespoke business model for Power BECCS that will reward verified negative emissions while delivering value for money electricity. This is reflective of the advanced technological readiness of this specific technology and the significant co-benefits of both power and negative emissions.

[56] Climate Change Committee (2020): The Sixth Carbon Budget, The UK's path to Net Zero
[57] National Infrastructure Committee (2021): Engineered greenhouse gas removals
[58] BEIS (2021): Biomass Policy Statement

The Power BECCS business model is focused on the co-benefits of power and negative emissions and as such it will be subject to the established regulatory frameworks in relation to biomass and power generation markets. However, there may be common considerations in relation to the negative emissions market frameworks explored through this consultation.

The Government will publish its consultation on a Power BECCS business model later this year.

5.2.2 BECCS in Industry

There is a role for BECCS in the industrial sector, particularly the cement, glass and paper industry, where the use of sustainable biomass combined with carbon capture and storage (CCS) could deliver negative emissions alongside the decarbonisation of these industries. Net Zero Strategy analysis indicates that around 2.2 $MtCO_2$ of negative emissions from BECCS Industry could be needed annually by 2035 in order to achieve the Sixth Carbon Budget.

The Government is developing the Industrial Carbon Capture (ICC) Business Model to enable initial industrial CCS projects to be deployed through the Carbon Capture Usage and Storage (CCUS) Clusters. The ICC contract pays the emitter a payment per tonne of captured and stored CO_2 (covering operational expenses, CO_2 transport and storage fees, and return on capital investment), reducing industry's risk exposure by providing certainty over revenues.

The aim of the ICC model is to support initial deployment of CCUS in UK industry. Given that several industrial processes can utilise biomass feedstocks, the ICC business model is being designed to allow ICC plants to receive payments for both captured biogenic CO_2 and captured fossil CO_2. The business model is also being designed to take into account any future markets for negative emissions and reflect payments accordingly. Projects in receipt of the ICC will therefore have no requirement for additional GGR support to support costs associated with the construction of the capture plant.

Along with from CCS installation, fuel-switching to biomass is essential for fossil-powered industrial plants to convert to 'BECCS' in order to achieve negative emissions. In this space, programmes such as the Industrial Energy Transformation Fund (IETF) provide grant funding for the deployment of deep decarbonisation projects such as the installation of biomass boilers. This scheme is scheduled to conclude in 2025.

5.2.3 BECCS in the waste sector

Residual waste management is a challenging sector to decarbonise. The waste management sector is comprised of a diverse range of technologies with the primary purpose of safe and timely disposal or recovery of waste, such as Energy from Waste (EfW), Hazardous Waste Incineration (HWI) and Advanced Conversion Technology (ACT)/Advanced Thermal Treatment (ATT). Carbon capture and storage (CCS) is the main decarbonisation option for many of these technologies.

Installing CCS within these facilities can result in negative emissions due to the presence of biogenic material in household and commercial waste streams. Municipal Solid Waste (MSW) feedstocks contain a large proportion of biogenic waste, which produces biogenic CO_2 after incineration/gasification in EfW and ATT/ACT plants. As well as generating negative emissions as a result of biogenic CO_2 capture, these processes support fossil CO2 abatement from the waste sector and the production of energy vectors such as electricity, heat, hydrogen, or liquid or gaseous renewable transport fuels.

To facilitate the demonstration of CCS at waste management facilities, BEIS has confirmed that initial waste CCS projects will be eligible to apply for the ICC Business Model for Phase 2 of the CCUS cluster sequencing process, with adaptations to the model being designed to ensure it is appropriate for the waste sector. The Waste ICC model, alongside the ICC model, is being designed to take into account any future markets for negative emissions (reflecting payments accordingly). Therefore, projects receiving a Waste ICC Contract will not require any additional GGR business model support.

5.2.4 Hydrogen BECCS

BECCS Hydrogen is expected to play an important role in supporting the UK's decarbonisation objectives. As well as delivering low-carbon hydrogen for use across the economy, our analysis for the Net Zero Strategy indicates that around 2.7 $MtCO_2$ of negative emissions from BECCS Hydrogen could be needed annually by 2035 in order to achieve the Sixth Carbon Budget.

The Government is developing a hydrogen business model[59] to stimulate private investment in new low-carbon hydrogen projects and help achieve our ambition of up to 10 GW of low carbon hydrogen capacity by 2030, subject to affordability and value for money. The aim of the model is to provide revenue support to hydrogen producers to overcome the operating cost gap between low carbon hydrogen and high carbon counterfactual fuels. It will provide price support through a variable premium which will pay the difference between a strike price reflecting the cost of producing hydrogen and a reference price reflecting the market value of hydrogen. The model will also provide volume support through a sliding scale in which the strike price will be higher if hydrogen offtake falls. The business model is designed to be applicable to a broad range of hydrogen production technologies and operating patterns, including hydrogen BECCS routes such as biomass gasification with CCS.

The hydrogen business model is intended to incentivise low-carbon hydrogen and does not explicitly value negative emissions. However, the model will provide support to cover the costs of installing and operating CCS technology. As negative emissions are generated as a by-product of CCS-enabled hydrogen, the hydrogen business model may provide sufficient policy support to deliver negative emissions through hydrogen BECCS, without the need for additional support from a GGR Business Model.

[59] BEIS (2022): Low Carbon Hydrogen Business Model: government response

In parallel, the Government has developed a Low Carbon Hydrogen Standard[60] ("the standard"), The standard sets a maximum threshold for GHG emissions allowed in the production process for hydrogen to be considered 'low carbon hydrogen' and therefore eligible for certain government funding, such as the hydrogen business model. Hydrogen producers are permitted to account for negative emissions when calculating the carbon intensity of hydrogen production, i.e. by using carbon capture to achieve negative emissions. The Low Carbon Hydrogen Standard does not provide an incentive to deliver additional negative emissions once the threshold has been met.

The Government would welcome views from project developers on the most appropriate means of incentivising the deployment of hydrogen BECCS projects. Negative emissions required to meet carbon budgets, rather than low carbon hydrogen which can be produced in multiple ways, is likely to be the key strategic driver for hydrogen BECCS in the late 2020s and early 2030s. A price incentive for negative emissions may be important to ensure there is a sufficient investment signal to bring forward hydrogen BECCS over the next decade. Further work is required to determine the interaction between the Hydrogen Business Model and a future GGR business model in relation to hydrogen BECCS, and we would welcome views from project developers on the appropriate route to incentivising this technology (see Question 23). The Government is also mindful to avoid overcompensating hydrogen BECCS and perverse impacts in relation to hydrogen policy objectives; for example, by creating market distortions and a competitive advantage for hydrogen BECCS over other low-carbon hydrogen production methods.

Finally, we recognise that the Renewable Transport Fuel Obligation (RTFO) could also provide a potential route to support hydrogen BECCS. The Government recently consulted on proposals to reward biohydrogen with development fuel certificates where it has been produced from qualifying feedstocks via anaerobic digestion with steam methane reformation combined with CCS. The possible interactions between the GGR business model and the RTFO are considered in Section 5.2.5 below.

5.2.5 BECCS Biofuels

The production of liquid and gaseous biofuels could be combined with CCS to deliver negative emissions. Some biofuel production plants (e.g. fermentation processes) already regularly capture CO_2 that would otherwise have been emitted as part of their production process. More advanced and developing technologies, such as gasification, could provide a stream of CO_2 for capture and sequestration.

Renewable Transport Fuels Obligation

The Renewable Transport Fuel Obligation (RTFO) is the main support mechanism for renewable fuels including biofuels. It obligates fuel suppliers to provide a specified percentage of renewable fuels as part of the fuels they supply (by volume), with targets being set on an upward trajectory to 2032 and continuing beyond that date. The RTFO also includes a sub-

[60] BEIS (2022): UK Low Carbon Hydrogen Standard: government response

target for 'development fuels'. These are waste-derived fuels and renewable fuels of non-biological origin of strategic importance - such as drop-in fuels, hydrogen, and aviation fuels.

Under the RTFO, certificates are awarded to eligible fuel suppliers that meet the GHG threshold, and then traded for the purposes of meeting the obligations. In the RTFO, suppliers are currently permitted to use CCS to reduce the carbon intensity of their fuel to meet the GHG thresholds; however, there is currently no financial incentive to exceed the threshold by delivering negative emissions. By rewarding negative emissions that would not otherwise be recognised under the RTFO, a GGR business model could provide a direct incentive for fuel producers to install and operate capture plants. As we develop our policies further, the Government will continue to explore potential interactions between GGR support mechanisms and the RTFO.

SAF Mandate

To accelerate sustainable aviation fuel (SAF) deployment and tackle the barriers faced by developing SAF projects, the Government is introducing a comprehensive programme of interventions aiming to commercialise the domestic SAF industry and deliver carbon savings. On top of over £200m competition funding, we consulted on the introduction of a UK SAF blending mandate[61]. This is expected to replace the support for SAF currently available under the RTFO.

In contrast to the RTFO, the SAF mandate will reward the GHG intensity of produced fuels rather than the volume produced. This obligation will require a set reduction in lifecycle emissions for SAF compared to high-carbon jet fuels. The integration of CCUS in the SAF production process could reduce the GHG emissions intensity of the resulting fuel and provide additional revenue for the plant. Furthermore, integrating CCUS into certain SAF production processes could potentially result in negative emissions.

The SAF mandate is still under development, including the Government's position on how GHG reductions associated with SAF will be rewarded with credits, and further work is needed to determine how the SAF mandate could incentivise CCUS and negative emissions. BEIS and the Department for Transport will continue to work together to explore the potential interactions between the SAF mandate and the GGR business model as we develop our policies.

Finally, the Government also recognises a potential route for the production of SAF using CO_2 derived from Direct Air Capture (DAC) technology. Carbon dioxide captured by DAC and low-carbon hydrogen can be used to produce power-to-liquid fuel, a near-zero emission fuel could achieve significant emissions reductions by displacing the sector's use of fossil jet fuel. The utilisation of DAC derived CO_2 for SAF production could play a valuable role in supporting the commercialisation of Direct Air Capture technology, which could potentially help to reduce the costs of Direct Air Carbon Capture and Storage projects in the future. However, the

[61] Department for Transport (2021): Sustainable aviation fuels (SAF) mandate consultation on reducing the greenhouse gas emissions of aviation fuels in the UK

Government's business model for GGRs will reward CO_2 captured and permanently stored, rather than CO_2 utilised in fuel production.

5.2.6 BECCS Anaerobic Digestion and Biomethane

Anaerobic digestion (AD) is a process whereby organic materials are broken down by microbes in the absence of oxygen to produce biogas, which can be used for local generation of electricity and heat. This biogas can be upgraded to biomethane by removing CO_2 and other gases and adding propane. Biomethane is chemically identical to methane and can be injected into the gas grid as a direct replacement for natural gas.

The use of organic materials/biomass in the production of biogas, when coupled with a capture process for the removal of CO_2 to create biomethane, offers an opportunity to produce negative emissions. Biomethane can be used in several key sectors of the economy such as transport, clean heat and hydrogen production. This section focuses on the production of biomethane and not its usage.

At this time, the industry is supported primarily via the Green Gas Support Scheme (GGSS). This replaces support for biomethane injection under the Non-Domestic Renewable Heat Incentive, which closed to new applicants on 31 March 2021. The scheme provides tariff support for biomethane produced via anaerobic digestion and injection into the gas grid. Producers receive tariff payments for a 15-year lifetime and the scheme is open to new build AD plants.

The GGSS provides revenue certainty for new projects for the production of biomethane. Participants are required to meet a greenhouse gas emissions saving threshold of 70% against its fossil fuel comparator, using a published methodology, which includes consideration of any emission savings from carbon capture and geological storage. However, the scheme offers no incentive for plants to install carbon capture and storage technology to deliver negative emissions. A revenue support mechanism for negative emissions could provide this incentive. This would provide a stable additional revenue stream for AD plants, which could be combined with revenue from the GGSS as the schemes would cover different costs. We will continue to develop our policy position on the interactions between the GGSS and any GGR support to avoid perverse outcomes such as double subsidisation.

5.2.7 Stakeholder comments

The Government would welcome feedback and reflections from stakeholders, particularly project developers, on the applicability of the GGR business model to BECCS projects that are not within scope of the Industrial Carbon Capture or Power BECCS business models.

We are particularly interested to receive views on (i) the best route to incentivising particular BECCS technologies, (ii) interactions with other business models and support mechanisms, and (iii) wider issues that the government should consider in the design of the GGR business model.

Question 23: Do you have views on the applicability of the GGR business model to BECCS projects that are not eligible for the Industrial Carbon Capture or Power BECCS business models?

5.3 Novel GGR technologies

In Autumn 2020, the Government commissioned Element Energy and the UK Centre for Ecology and Hydrology to produce an updated assessment of the costs and deployment potential of GGR methods in the UK. The analysis identified DACCS and BECCS as the engineered GGR technologies that could offer the greatest deployment potential; however, it also acknowledged significant uncertainties in the evidence base and highlighted the need for a portfolio of GGR methods to reach net zero.

This consultation has confirmed the Government's intention to commercialise a diverse mix of GGR technologies and develop a technology-neutral negative emissions market. This will provide a wider range of options for meeting our targets, mitigate the risks and uncertainties associated with each individual solution, maximise competition between GGRs, and allow the UK to capitalise on the economic opportunities of being a world-leader in developing innovative GGR technologies.

To support these objectives, the Government is investing £100m in research and development to spur innovation across a range of GGRs, such as carbon-negative concrete and seawater CO_2 removals. Given our intention to design the GGR business model on a technology-neutral basis, we envisage that this could support innovative GGR technologies (aside from DACCS and BECCS) that are ready for full deployment in the next decade.

The Government would welcome views from technology developers on how the GGR business model could support the full commercialisation of emerging technologies once they have progressed from the R&D stage.

Question 24: Do you have views on the applicability of the GGR business model to novel technologies excluding DACCS and BECCS? Please outline any specific policy requirements or other considerations we should take into account.

Section 6: Next Steps

This consultation will remain open for twelve weeks and will close on 27 September 2022. The responses to this consultation will be used to inform the selection of a preferred business model and its design features.

Alongside the consultation, we recognise the importance of continuing to engage with stakeholders to ensure that future GGR policy meets the needs of a broad range of project developers and investors. To support this aim we intend to launch a GGR Business Model Expert Group in Autumn 2022. This group will advise on the design of the GGR business model, alongside our wider stakeholder engagement. We expect membership to be comprised of a range of experts in the sector including technology developers, academics, and the finance community. Further details will be announced in due course.

We intend to provide a response to the consultation and set out the Government's detailed policy proposals on the design and implementation of the business model in 2023.

List of consultation questions

Section 1: Rationale for developing business models for GGRs

Question 1: Do you agree that the Government should develop a GGR business model to enable a diverse portfolio of GGR technologies to deploy at scale in the next decade?

Question 2: To support a portfolio approach to GGR deployment, do you agree that Government policy for incentivising negative emissions should be technology-neutral as far as possible?

Section 2: A contract-based business model for negative emissions

Question 3: Do you agree with the Government's principles for policy design?

Question 4: Do you agree with our overall approach to introduce a contract-based business model for GGRs to provide revenue support for negative emissions?

Question 5: What is your preferred contract scheme of those outlined in the consultation? Please provide arguments to support your view.

Question 6: When might it be feasible to introduce an auction mechanism for GGR contracts, and what criteria should the Government consider when developing its allocation process?

Question 7: How can the Government most effectively reward innovation and cost reduction in early GGR contracts?

Question 8: If the Government pursues a Negative Emissions Contract for Difference, what is the most appropriate basis for setting the reference price for initial contracts? Please provide arguments to support your view.

Question 9: What mechanism could the Government introduce to ensure that project developers achieve the highest possible sales price for negative emissions credits on the market?

Question 10: What do you think is the most appropriate option for setting the length of GGR contracts? Please explain your rationale.

Question 11: Would it be desirable to include a review mechanism in early GGR contracts? If no, please outline your reasons. If yes, please give your views on how a review mechanism might be designed.

Question 12: Should the Government allow project developers to combine negative emissions support under a GGR business model with other support mechanisms for co-products? Please provide arguments to support your view on whether this could be an effective route to supporting multi-product GGR projects.

Question 13: Do you believe that capital support instruments are necessary to complement GGR business models? If so, please outline your reasons and your preferred type of capex support mechanism.

Question 14: What other issues should the Government consider when progressing work on the design of a GGR business model? Please focus your response on issues that are not directly considered through this consultation.

Section 3: Building a market for negative emissions

Question 15: What do you believe is the most appropriate market framework for supporting initial GGR projects over the next decade, and how might this framework evolve over time? In your answer please consider the market options outlined in Section 3, indicating which option or combination of options would be preferable to achieve our objectives.

Question 16: What steps should the Government take to stimulate voluntary corporate demand for negative emissions credits?

Question 17: To maximise voluntary private investment in negative emissions credits, would it be preferable for the Government to (i) establish a regulated market for engineered GGRs or (ii) directly endorse voluntary carbon market bodies that meet high integrity and verification standards? Please outline your view of the main benefits and challenges of each approach.

Question 18: Would it be desirable for the Government to establish a regulated market for engineered GGRs to allow for future integration with the UK ETS and/or provide the foundation for a GGR obligation scheme? If so, how could this be achieved?

Section 4: Accounting and sustainability frameworks

Question 19: Do you agree with the government's immediate priority for MRV, including a review of standards that could underpin business model support for initial GGR projects? Please share any views or suggestions that could help to inform our approach.

Question 20: Beyond ensuring the legitimacy of initial projects, what is the appropriate role for the government in developing a robust and enduring framework for negative emissions MRV, compared to the role of other bodies such as those outlined in Figure 1?

Question 21: Do you agree with our proposed principles for negative emissions legitimacy?

Section 5: Applicability across different GGR technologies

Question 22: Are there specific policy requirements for initial DACCS projects that the Government should take into consideration? Please provide arguments to support your view.

Question 23: Do you have views on the applicability of the GGR business model to BECCS projects that are not eligible for the Industrial Carbon Capture or Power BECCS business models?

Question 24: Do you have views on the applicability of the GGR business model to novel technologies excluding DACCS and BECCS? Please outline any specific policy requirements or other considerations we should take into account.

Acronyms

Acronym	Definition
£/tCO_2	Price per tonne of carbon dioxide
ACT	Advanced Conversion Technology
AD	Anaerobic Digestion
AMC	Advanced Market Commitments
ATT	Advanced Thermal Treatment
BECCS	Bioenergy with Carbon Capture and Storage
BEIS	Department for Business, Energy and Industrial Strategy
CAPEX	Capital Expenditure
CCP	Core Carbon Principles
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Usage
CCUS	Carbon Capture Usage and Storage
CfD	Contract for Difference
CO_2	Carbon Dioxide
CORSIA	Carbon Offsetting and Reduction Scheme
DAC	Direct Air Capture
DACCS	Direct Air Capture with Carbon Capture and Storage
EfW	Energy from Waste
UK ETS	United Kingdom Emissions Trading Scheme
FOAK	First of a Kind
GGR	Greenhouse Gas Removal
GGSS	Green Gas Support Scheme
GHG	Greenhouse Gas
HMG	Her Majesty's Government
HWI	Hazardous Waste Incineration
ICC	Industrial Carbon Capture
IC-VCM	Integrity Council for Voluntary Carbon Markets
IETF	Industrial Energy Transformation Fund
MRV	Monitoring, Reporting and Verification
MSW	Municipal Solid Waste
MtCO2	Megatonne Tonnes of Carbon Dioxide
NDC	Nationally Determined Contribution
NEG	Negative Emission Guarantee
NEP	Negative Emission Payment
NOAK	Nth of a Kind
OPEX	Operational Expenditure
R&D	Research and Development
RAB	Regulated Asset Base
RO	Renewables Obligation

RTFO	Renewable Transport Fuel Obligation
T&S	Transport and Storage
VCM	Voluntary Carbon Market
VCMI	Voluntary Carbon Markets Integrity Initiative

This consultation is available from: https://www.gov.uk/government/consultations/greenhouse-gas-removals-ggr-business-models

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