Department for
Business, Energy
& Industrial Strategy

Business model for power bioenergy with carbon capture and storage ('Power BECCS')

A consultation seeking views on potential business models for power bioenergy carbon capture and storage

Closing date: 7th October 2022

August 2022

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

Contents

General information

Why we are consulting

The purpose of this consultation is to set out the government's preferred position for a business model to support the deployment of First of a Kind (FOAK) power BECCS project(s). We are seeking views on our early proposals including the main design elements of the business model across electricity generation, payment terms, carbon capture and biomass sustainability and negative emissions requirements.

Consultation details

Issued: 11th August 2022

Respond by: 7th October 2022 at 23:59 hours.

Email: powerbeccs@beis.gov.uk

Consultation reference: Power BECCS business model consultation

Audiences:

We are seeking views from all interested parties, including prospective power BECCS projects, investors, non-governmental organisations and academics.

Territorial extent:

The scope of the consultation is UK-wide but some of the proposals set out in this consultation are based on electricity market structures which do not currently operate in Northern Ireland. We are not currently seeking views on how power BECCS could be deployed in Northern Ireland. The call for evidence therefore applies to Great Britain only. BEIS will continue to work with the devolved administrations as we develop the business models in order to ensure that our policies take account of devolved responsibilities.

How to respond

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

Respond online at: https://beisgovuk.citizenspace.com/energy-strategy-networks-markets/power-beccs-business-model

or

Email to: powerbeccs@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

As set out in the Biomass Policy Statement[1] published in November 2021, the government is working on a business model for power Bioenergy with Carbon Capture and Storage (BECCS) to incentivise verified negative emissions and power generation.

The Net Zero Strategy[2] established the government's intention to develop markets and incentives for engineered greenhouse gas removals (GGR) technologies to support the growth of this emerging industry. In the Net Zero Strategy, we set the ambition of deploying at least 5MtCO_2/year of engineered removals by 2030, in line with Climate Change Committee (CCC) and National Infrastructure Commission assessments. BEIS analysis, conducted at the time of the Net Zero Strategy shows that, to achieve net zero, engineered GGR methods will be required to balance residual emissions from some of the most difficult to decarbonise sectors, such as agriculture and aviation industries. The strategy included a commitment to consult on business models to attract private investment and enable GGR projects to deploy at scale from the mid-2020s. With reference to power BECCS specifically it highlighted that BECCS applications in the power sector could be deployed by the late 2020s, and potentially achieve ambitious contributions to our Nationally Determined Contribution (NDC) target by 2030 and the Sixth Carbon Budget (2033-37).

Therefore, power BECCS is expected to play an important role in helping the UK to achieve net zero through delivering negative emissions, to contribute significantly to the ambition to deliver five million tonnes of GGRs by 2030, whilst also delivering low-carbon power to contribute toward security of supply within Great Britain. Despite the high level of technological readiness[3] in power BECCS, particularly for retrofit biomass projects, there are a number of distinct market barriers preventing the scale up and investment in power BECCS, in addition to more widely understood risks around FOAK carbon capture and storage technologies.

This consultation will consider actions the government can take to enable the deployment of power BECCS at scale, through addressing prevailing market failures, deployment barriers and risks to investment. This consultation will explain the rationale for selecting the current minded-to business model whilst requesting feedback that will inform the detailed design of the business model.

The consultation is structured in three sections. Section 1 sets out the strategic case for power BECCS, and the need for intervention in relation to reaching government's net zero goals. Section 2 explores the research completed to date on business models, the rationale for the minded-to position and an overview of other options considered and the reasons for

[1] https://www.gov.uk/government/publications/biomass-policy-statement-a-strategic-view-on-the-role-of-sustainable-biomass-for-net-zero

[2] https://www.gov.uk/government/publications/net-zero-strategy

[3] Technology readiness levels were stated with reference to the most developed technological concepts within each category of the study. Element Energy and UK Centre for Ecology and Hydrology (2021). Greenhouse gas removal methods: technology assessment report available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1026988/ggr-methods-potential-deployment.pdf

discounting them. Section 3 explores the sustainability and negative emissions related considerations for business model design. For the purposes of gaining further stakeholder feedback, we have analysed a range of potential scenarios. Whilst reading these options, please note that the government has made no final decisions on the integration of Greenhouse Gas Removals into the UK Emissions Trading Scheme (ETS), although we have recently run a Call for Evidence on the future development of the scheme. A separate Greenhouse Gas Removal business model consultation was published in July 2022.

Consultation questions

Section 1: Rationale for developing a power BECCS business model

1. **Have we identified the most important challenges in considering the development of power BECCS projects?**

2. **Are there any other market barriers in addition to those identified?**

3. **Are there any other power BECCS-specific risks that need to be considered? If so, what are your proposals for mitigating them?**

Section 2: The business model proposal and options considered

4. **Do you agree with the overarching objectives of our policy framework for power BECCS?**

5. **Do you agree with the minded-to position of a combined CfD for electricity generation (£/MWh) and a CfD for Carbon (£/tCO_2) under a CfD contract framework? If not, please provide rationale for why not?**

6. **Should the power BECCS project be incentivised to run as baseload or flexibly? Please provide rationale for your answer.**

7. **Are there any alternative methods to setting this that should be considered?**

8. **Are there any risks or concerns around setting the CfDe strike price that have not been mentioned here?**

9. **The CPI indexed strike price option requires the project to bear the risk of biomass costs and is the option in current contracts. Is this an appropriate allocation of risk? Please provide rationale and evidence for your answer.**

10. **Do you agree with the outlined approach to setting the CfDc strike price? If not, are there any alternative methods to setting this that should be considered?**

11. **Are there any risks or concerns around setting the carbon strike price that have not been mentioned here?**

12. **Should the T&S charges be a separate payment?**

13. **Do you agree with a proposed contract length of 10-15 years? If not, why not?**

14. **What are your views on the suggested options?**

15. **Are there any alternative methods to mitigate the biomass price risk that we have not discussed?**

16. **What are your views on the proposed options?**

17. **Where should the T&S charges should be sourced from?**

18. **Should the plant run unabated during periods of T&S unavailability, such as temporary outages?**

19. **Do you have any evidence or thoughts on ways to manage CCUS costs in the event of T&S network unavailability?**

20. **What do you believe is the most appropriate market framework for supporting FOAK power BECCS 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 of the GGR consultation, indicating which option or combination of options would be preferable to achieve the objectives for power BECCS.**

Section 3: Sustainability and negative emissions

21. **Do you agree that a power BECCS project should report against a suitable threshold to ensure that we achieve a minimum level of net-negativity from any power BECCS project is achieved?**

22. **Do you have any evidence to share that could support the determination of a suitable supply chain GHG emission threshold for power BECCS, including by how much they could be strengthened?**

23. **Out of the three options, which option do you prefer for assessing power BECCS? Do you have any other recommendations on an alternative suitable method?**

24. **Of the two options considered (net and gross), which do you think is most appropriate for the reward of power BECCS through an appropriate carbon market?**

25. **Is there any further evidence or arguments we should consider for either taking a gross or net approach in the power BECCS business model?**

Next steps

This consultation will remain open for eight weeks and will close on the 7th October 2022. We intend to publish a response to the consultation and responses will be used to inform the selection of a preferred business model and its design features.

Section 1: Rationale for developing a power BECCS business model

Scope of the consultation

The power BECCS business model and consultation are concerned with the deployment of power BECCS plants within GB only. A definition of power BECCS is provided below.

This consultation is not applicable to any other GGR or BECCS technologies, which should instead look to the GGR business models consultation that was published in July 2022. That consultation is concerned with the business models for GGR technologies that, in addition to power BECCS, could potentially benefit from a GGR business model. These 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.
- 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.

Policy development is also underway in the following areas to support the deployment of specific GGR technologies through the CCUS cluster sequencing programme, including:

- 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 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.

Background to the consultation

What is power bioenergy with carbon capture and storage ('power BECCS') and what are negative emissions?

Power bioenergy with carbon capture and storage (power BECCS) is the process of using sustainable biomass feedstocks to fuel a combustion process to generate electricity in combination with carbon capture and permanent storage. Biomass is mainly plant derived, and so when carbon sequestered in the plant material is captured after combustion and stored underground, this removes CO_2 from the 'active' carbon cycle and creates a net removal of atmospheric CO_2. Through this physical removal of greenhouse gases from the atmosphere, power BECCS is able to deliver negative emissions.

We are undertaking work with the Chief Scientific Adviser to scientifically validate the net-negativity of power BECCS and the sustainability of biomass fuel used. The outcome of this work will be published.

To date, we have signalled intent to pursue BECCS in line with delivering on the net zero targets. The Biomass Policy Statement outlined the rationale for BECCS stating that: *"When undertaken sustainably, BECCS can deliver negative emissions because carbon sequestered in biogenic material is captured and stored after combustion, resulting in a net decrease in atmospheric* CO_2 *overall."*

The forthcoming Biomass Strategy will set out recommendations and principles for deploying BECCS, including an assessment of the sustainability criteria for biomass use in future schemes.

The strategic case for power BECCS: energy security and net zero

In October 2021, government published the Net Zero Strategy outlining the role that engineered greenhouse gas removal ('GGR') technologies would need to play in supporting decarbonisation by 2050. The government is clear that the purpose of GGRs is to balance the residual emissions from sectors[4] that are the hardest to decarbonise to reach full decarbonisation by 2050 and will not be substitutes for ambitious mitigation to achieve net zero. BEIS analysis at the time of the Net Zero Strategy shows that GGR technologies are expected to deploy from none today to 5Mt CO_2/year by 2030; 23 Mt CO_2/year by 2035 and between 75 and 81 Mt CO_2/year by 2050, with higher and lower deployment possible depending on sector-specific and wider economy developments. Specifically, power BECCS is expected to deliver a steady increase of engineered removals between the late 2020s and 2035. This assessment is supported by Climate Change Committee (CCC[5]) and National Infrastructure Commission[6] reports, which both saw a role for power BECCS in contributing to our nearer term 2030 and 2035 targets.

[4] Sectors such as aviation, agriculture and heavy industry
[5] CCC (2020) Sixth Carbon Budget report available at https://www.theccc.org.uk/publication/sixth-carbon-budget/
[6] National Infrastructure Commission (2021). Engineered Greenhouse Gas Removals available at https://nic.org.uk/studies-reports/greenhouse-gas-removals/engineered-greenhouse-gas-removals/

The technological readiness level (TLR) of power BECCS, as well as existing infrastructure in the form of biomass plants that can be retrofitted with CCS technology, means that power BECCS is best positioned to begin delivering on the 5Mt CO_2/year of engineered removals required within this decade. A BEIS study on GGRs[7], gave power BECCS a TRL of 7. Other GGRs were ranked slightly lower; with DACCS scoring 6 and other forms of BECCS, such as BECCS hydrogen being scored 5.

The UK is well-positioned to be a global leader in the development and deployment of GGR technologies, with our world-class research institutions, 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. 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.

With reference to BECCS specifically, the Net Zero Strategy stated that:

'BECCS technologies will include retrofit applications in the power and industry sectors. BECCS applications in the power sector could be deployed by the late 2020s, and potentially achieve ambitious contributions to our Nationally Determined Contribution (NDC) target by 2030. Engineered removals are likely to be located within or near industrial clusters, benefitting from access to CO_2 transport and storage infrastructure, essential to support delivery of net-negative emissions.[8]'

Power BECCS also contributes to the continued efforts to boost system resilience. Standard sustainable biomass combustion for power generation was first used to reduce the UK's reliance on coal power generation. Biomass has since proven to be a reliable source of baseload generation. Adding power BECCS technology to existing or new sustainable biomass combustion power stations would continue to support a source of low-carbon generation into the future that is non-intermittent and can contribute to security of energy supply in a net zero world.

The need for commercial frameworks to deploy power BECCS

In July 2022, the government published a consultation on the development of a GGR Business Model to attract private investment and enable a broad portfolio of GGR projects to deploy at scale from the mid-to-late 2020s. This outlined our intention to introduce a contract-based business model to provide ongoing revenue support for negative emissions, subject to affordability and value-for-money.

We have considered our ability to realise our ambition to remove at least 5MtCO_2/yr by 2030 in the absence of a specific power BECCS business model, and instead relying on a generic GGR business model to support power BECCS projects. This option was not considered to be

[7] Technology readiness levels were stated with reference to the most developed technological concepts within each category of the study. Element Energy and UK Centre for Ecology and Hydrology (2021). Greenhouse gas removal methods: technology assessment report available at https://www.gov.uk/government/publications/greenhouse-gas-removal-methods-technology-assessment-report
[8] Net Zero Strategy, BEIS, p.189 https://www.gov.uk/government/publications/net-zero-strategy

suitable because power BECCS requires a specific framework to ensure correct behaviours are incentivised, both in relation to the grid, and to the wider societal benefit of negative emissions. A FOAK power BECCS business model aims to achieve a framework that addresses these risks collectively, that enables delivery of large-scale project(s), subject to affordability and value for money. Therefore, as outlined in the Biomass Policy Statement and the GGR business models consultation, the decision to develop a bespoke business model for power BECCS is reflective of the advanced technological readiness of this specific technology and the significant co-benefits of both power generation and negative emissions.

Power BECCS will be subject to the established regulatory frameworks in relation to biomass and power generation markets. There will be synergies between the power BECCS business model and aspects of wider negative emissions policy explored in the GGR business models consultation, particularly in relation to the development of carbon markets and frameworks for monitoring, reporting and verification (MRV).

Furthermore, it is worth noting the significance of timing and the current window of opportunity recognised by government. There are biomass plants currently providing bioenergy, with a potential capability of converting to power BECCS projects within this decade by installing carbon capture and storage equipment. By harnessing the opportunity to re-utilise existing infrastructure and expertise, there is potential to accelerate progress in supporting the existing contribution to energy security and the scaling-up of engineered greenhouse gas removals this decade.

Market and technology-based risks to deploying power BECCS

As part of the response to the original GGR Expression of Interest (EoI) (that was launched as part of Phase-2 of CCUS Cluster sequencing process), any prospective power BECCS projects were invited to provide feedback on a report commissioned by BEIS titled 'Investable commercial frameworks for 'power-BECCS'[9] by Element Energy and Vivid Economics. The report explored a number of potential power BECCS business models and made a recommendation based on their assessment of the options. It also outlined key risks for investors aiming to support deployment of power BECCS. In the feedback received from projects, several explicitly mentioned risks common to biomass plants and CCS projects, such as high feedstock price volatility and cross chain risk, that may act as barriers to deployment without a sufficient framework to mitigate some of these risks to a reasonable extent.

BEIS recognises, following research and stakeholder feedback, that there are no current viable alternative investment frameworks that would enable power BECCS to deploy at scale within GB. A specific investment framework is needed that specifically considers what is required to incentivise the optimum dual outputs of electricity generation and negative emissions. Furthermore, independent and internal research note that market-based investment in power BECCS is hindered by a variety of operational and economic challenges common to bioenergy and CCS technology. This is in addition to wider market risks and challenges, which any

[9] Investable commercial frameworks for power BECCS, prepared by Element Energy and Vivid Economics. June 2021. Available: https://www.gov.uk/government/publications/investable-commercial-frameworks-for-power-beccs

commercial framework should seek to address in order to minimise risk to an extent that enables investment for power BECCS deployment at scale. These may include:

- Wholesale electricity price volatility;
- Cross-chain risk with a transport and storage (T&S) network, as part of a CCUS Cluster;
- Biomass fuel price risk: the biomass must be sustainably sourced, and there is a risk of price volatility related to the organisation of supply chains and changing international demand for biomass;
- Current lack of predictable, long-term demand and stable revenue streams to produce negative emissions;
- Immaturity of carbon removal markets and uncertainty around future scales and prices;
- Uncertainty over the long-term policy and regulatory framework for GGRs. The GGR Business Models consultation explores what market infrastructure will be needed to support initial GGR projects over the next decade and how this might evolve over time.
- FOAK technology risk: Whilst carbon capture and storage technologies are still emerging. BECCS projects will benefit from learnings derived from frameworks recently developed for other CCS technologies.

The unique challenge for enabling deployment of a FOAK power BECCS project is addressing these challenges under one framework, at the scale and pace required to achieve the 2030 ambition.

Early government intervention in this sector aims to address the immediate market and technology risks. 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 (once a viable market for negative emissions is implemented). The structure of the carbon payment and participation in any appropriate carbon market will be informed by the responses to the Engineered GGR Business Models consultation and the UK ETS Call for evidence.

Questions:

1. **Have we identified the most important challenges in considering the development of power BECCS projects?**
2. **Do you agree with the market barriers we have identified?**
3. **Are there any other power BECCS-specific risks that need to be considered? If so, what are your proposals for mitigating them?**

Section 2: Potential business models

This section outlines the government's intention to introduce a contract-based business model for power BECCS, subject to affordability and value-for-money. This would address the main investment barriers by providing revenue support for both power generation and negative emissions, within a recognised contract framework that manages the cross-chain risk posed by interactions with the T&S network. This can be done using learnings from the existing biomass Contracts for Difference (CfD), Dispatchable Power Agreement (DPA) and Industrial Carbon Capture business models.

In the report[10], several potential frameworks for a power BECCS business model were identified and assessed. From their initial assessment, several frameworks were ruled out from in depth assessment and a preferred model was identified. This section seeks to briefly summarise our assessment of the models that were considered within the report. During Phase 2 of the Cluster Sequencing Process, an EoI was opened for GGR technologies, who were invited to feedback on the same report. We have considered the feedback and after further detailed analysis, we have reached a minded-to position that the power BECCS business model should consist of a CfD for electricity combined with a CfD for carbon ('CfDe + CfDc') which we will explain in this section.

This work has involved defining assessment criteria, identification, and assessment of options against these criteria, which we have set out below.

Framework and criteria for assessing options

To assess and compare each business model option, the following five key assessment criteria were developed. These were developed through a consideration of BEIS policy objectives for FOAK power BECCS, the report previously mentioned, as well as further analysis carried out by BEIS. These criteria build on the criteria which will be used for assessment of GGR business models, as described in the GGR business model consultation.

The business model should meet the following criteria:

Criteria	Explanation
Affordability	• Incentivise investment, provide the minimum necessary support and have a pathway to reducing support via other merchant revenue routes.

[10] Investable commercial frameworks for power BECCS, prepared by Element Energy and Vivid Economics. June 2021. Available: https://www.gov.uk/government/publications/investable-commercial-frameworks-for-power-beccs

Maximise benefits	• Through appropriate and proportionate incentivisation, maximise negative emissions and electricity generation in proportions that maintain low carbon security of supply and offers decarbonisation for wider societal benefit. • Ensure plants are subject to best practice according to a robust and stringent sustainability criterion, which should aid public confidence.
Minimise costs	• Minimise risk of overcompensation, gaming and creating perverse incentives. • Minimise the subsidy; keep the structure of the business model as simple as possible and keep the costs of administering the business model down.
Investable	• Ensure that risks are allocated to the parties who are best placed to manage them. • Provide sufficient revenue certainty to investors to unlock private sector investment and expertise. • Appropriately apportion risk, relating to wider programme cross chain risk.
Timelines	• Make use of existing precedents where possible to enable the potential for power BECCS participation in the Cluster Sequencing process. • Enable a FOAK power BECCS project to deploy on a timeline that will enable it to provide negative emissions for Carbon Budget 5, 6 and Net Zero and 2030 Nationally Determined Contributions.

Question:

4. **Do you agree with the overarching objectives of our policy framework for power BECCS?**

Business model options and the minded-to position

This section sets out the process used to reach the minded-to position and the reasons behind the discounting of other business model options. We are seeking views on the reasons and process for selecting our minded-to business model, and on the minded-to position itself. The next section will discuss the four options shortlisted from nine identified in the Element Energy and Vivid Economics report. It will then explain the minded-to position and set out the long list of nine options and the reason for their exclusion from the shortlist.

The short listed four options and process for reaching the minded-to position:

The Element Energy and Vivid Economics report began by assessing a long list of nine business model options. From this long list, two of the nine options were recommended: a Contract for Difference for carbon (CfDc) only, or a Contract for Difference for electricity (CfDe) plus a negative emissions payment (NEP). Four variations of these two options were tested further through internal analysis; a CfDc alone; a CfDe with a negative emissions payment; a CfDe combined with a NEP and the Emissions Trading Scheme ('ETS'); and a CfDe and CfDc.

When we analysed these four options, we assessed that they should:

- Involve a contract[11] with a dual payment mechanism;
- Involve private law contract;
- Allocate construction risk to the developer;
- Provide some protection to developers from the risk that market revenues will be insufficient to cover costs;
- Provide an appropriate return on investment; and
- Gain revenue from negative emissions in an appropriate carbon market (at a certain point in time where this is possible).

These options were considered against the assessment criteria and performed as follows:

Affordability:

Options that allow for the project receiving remuneration in part through an appropriate carbon market were considered to be more affordable, as part of the cost of the scheme could be recovered from emitters, which is consistent with the 'polluter pays' principle. It is also noted that a pure **CfDc**, which would not allow for cost recovery from electricity customers, is likely to lead to a greater payment to compensate for costs that may be required for electricity generation.

[11] The proposed terms of any support which may be offered to any Project following a selection process, including the form of the Business Models, are not final and remain subject to further development by government in consultation with relevant regulators and the Devolved Administrations, including in the light of the development and Parliamentary approval of any necessary legislative amendments, and completion of necessary contractual documentation in a way which is considered consistent with subsidy control principles.

Maximise benefits:

The two outputs of the business model are low carbon electricity generation and negative emissions. It is not a minded-to position that projects should be incentivised to run unabated. However, the options that include a **CfDe**, in addition to having a pay-back mechanism under periods of high energy prices, were considered beneficial as they could provide incentives for the plant to continue generating unabated under an outage in the T&S system. This would allow the electricity generation to continue, which may be desirable, given the potential benefits of non-intermittent biomass generation to the system.

Minimise costs:

The **CfDe + fixed NEP** and **CfDe + CfDc** options reduce investor exposure to volatility in both the carbon and electricity markets. The structure of a CfD also mitigates against the risk of overcompensation if market revenues from carbon and energy are high.

Investable:

The CfDe is considered a familiar and effective mechanism for investor confidence. The **CfDe + Fixed NEP + ETS/carbon market and CfDe + CfDc options** stabilise revenues in both the carbon and electricity markets, and therefore provides certainty on return. The **CfDe + Fixed NEP + ETS and CfDe + CfDc options** also protect investors against uncertainty around whether there will be an appropriate carbon market. However, it is recognised that investors may still perceive some residual regulatory and/or delivery risk from the link to an appropriate market for negative emissions within the business model.

Timelines:

The potential integration of negative emissions into an appropriate market for carbon removals adds complexity to the mechanism and may impact timelines. However, this added complexity could be partly mitigated under the **CfDc** only and **CfDe + CfDc options** through the **CfDc** reference price being set at zero or a nominal value until negative emissions are integrated into that market. This could allow investors to progress with the project based on the agreed strike price of the **CfDc** without the certainty of knowing the shape and structure of the future market. Therefore, the **CfDc** and **CfDc + CfDe** options were considered as providing optionality for speed of delivery.

We used the aforementioned assessment criteria to assess and test the suitability of these four options and decide on a preferred one. This table sets out the different options, including the preferred option, and the rationale behind the choice of this business model.

Framework	Current preferred option?	Rationale
Carbon CfDc only	No	Under this option, a CfDc would provide a subsidy paid above the prevailing carbon price for negative emissions up to an agreed strike price (on a £/tCO_2 basis). If negative emissions are not included in an appropriate carbon market, providers could be compensated for the full value of the CfDc strike price. This option was discounted as power BECCS plants would be carrying the wholesale electricity price risk which may increase the CfDc payment and would prevent any revenue payback above a strike price. A payment only on the carbon could create a perverse incentivise for the plant to run inefficiently or during periods of negative electricity prices in order to maximise the carbon payment. This is because the mechanism does not equally value the electricity output. As there would be no CfDe mechanism providing payback for electricity revenues, the project could also gain significant upside under high enough wholesale electricity prices.
CfDe + Fixed NEP + ETS[12]	No	This option includes a CfD for electricity generation (£/MWh), where the generator is paid the difference between a contractually agreed strike price and a market reference price for electricity, combined with a negative emissions payment. The negative emissions payment would be administered as a direct subsidy for each unit of CO_2 captured. The negative emissions would also be traded in the UK Emissions Trading System (UK ETS) or any other appropriate carbon market.

[12] This option has, for the purposes of assessing a potential option, used the ETS as an example market. However, please note that this represents revenue from any other appropriate carbon market. Following the example market, we have considered the risks posed by focusing on ETS integration alone and the challenges that could present.

		In theory, assuming any ETS integration under this option, the level of the negative emissions payment would consider an assessment of projected ETS prices at the time of agreeing the contract and the expected timeline for inclusion of negative emissions in the ETS. This option was discounted because of a lack of flexibility; the fixed negative emission payment would impose a subsidy cost with no exit strategy in sight, regardless of potential negative emission sales revenues. The ETS part of this payment is directly reliant on ETS integration, which is a current uncertainty for power BECCS projects, and limits the ability to gain revenues from bilateral sales.
CfDe + Fixed NEP	No	This option includes a CfD for electricity generation (£/MWh) where the generator is paid the difference between a contractually agreed strike price and a market reference price for electricity, combined with a negative emissions payment. The negative emissions payment (in £/tCO_2) would be administered as a direct payment for each unit of CO2 captured, with the provider excluded from participation in carbon markets. This option has the benefits of the CfDe, however it closes off the opportunity to leverage any form of negative emission sales revenue from investors through the fixed negative emissions payment. This option remains similar to the minded-to position of a CfDe + CfDc, except it has no future facing flexibility and would not allow for participation in any carbon market.
CfDe + CfDc	Yes	This option offers a combination of a CfD for electricity generation (£/MWh) and a CfD for Carbon (£/tCO_2) – intended as a dual payment mechanism under one CfD contract framework.

		This differs from the other options principally due to allowing for flexibility to include negative emissions in any appropriate carbon market in the future. The benefit of this is that it fulfils the ‘polluter pays’ principle, with emitters paying the costs of removals and could reduce the proportion of support payments.

The minded to position rationale summary

Based on this assessment, our minded to position is **CfDe + CfDc[13].** This option was high scoring as:

- This option is the most flexible and allows revenue from any appropriate carbon market;
- The flexibility to adapt to the inclusion of the project within a future carbon market for negative emissions can reduce the scale of support payments;
- By providing a revenue guarantee (where the subsidy payment is linked to the market price and increases or decreases in line with market prices) for both carbon and electricity, the business model minimises investor risk and should reduce the cost of capital as well as mitigate the potential for over-compensation;
- The presence of the CfDe is important for incentivising desired performance around generation when the T&S network is unavailable;
- A key principle of the business model is to value both the electricity output and the negative emissions. The dual mechanism values low carbon power and negative emissions separately, allowing separate cost distribution of these value streams (further consideration of the proportion of payment across both parts needs to be considered);
- A CfDe + CfDc allows us to set a strike price and a pay-back mechanism on both sides of the mechanism; and
- We are still considering the reference price for the CfDc and how it could vary according to whether the project could participate in the UK ETS or another appropriate carbon markets.
- A CfDc alone without CfDe would make the CfDc costs far higher per £/t CO_2 to cover the proposed fuel costs.
- A CfDc alone may not provide an incentive for the plant to run unabated and generate electricity during periods of T&S outage and would not enable any pay-back mechanism during periods of high power prices.

[13] **T&S charges will either be incorporated or treated as a pass-through charge, which we discuss later in this section**.

Why CfDc support?

- A CfDc could transfer part of the costs of power BECCS to emitters, through integration of a BECCS project within an appropriate carbon market option as discussed in the GGR business model consultation and ETS Call for Evidence, or a levy on emitters to pay for the cost of CfDc payments. However, there is uncertainty around the viability of these mechanisms, and considering the expected range of strike prices through BEIS analysis and independent research, we note that the current ETS price alone is unlikely to cover the total costs needing to be recovered by the BECCS plant. The CfDc would provide flexibility to integrate negative emissions sales from an appropriate carbon market and provides enough revenue stability until the carbon price meets the strike price to remain investable.

Why CfDe support?

- The short run marginal costs of running a power BECCS plant are higher than long term trends in baseload electricity prices, which means that a merchant power BECCS plant could only be expected to dispatch in response to high power prices.
- Additionally, wholesale market revenues are highly uncertain, with the market price not correlated to BECCS input cost (unlike for generators combusting gas).
- In addition, there may be constraints on the volume of biomass fuel that can be stored safely onsite to enable running in a dispatchable way.
- Running in a dispatchable manner would also run contrary to the incentive provided by the carbon payment, to maximise negative emissions. This could mean a significantly higher carbon payment might be necessary.
- Exposing the developer to the wholesale price risk may therefore increase the cost of capital for projects and therefore the internal rate of return required.
- Stakeholders have stated that the CfDe is crucial for investability; it has the benefit of incentivising low carbon electricity generation and maximising thermal efficiency.
- It could incentivise a plant to run unabated during periods of T&S unavailability.
- A CfDe also mitigates against a risk of overpayment in the wholesale market if power prices exceed the agreed strike price.

Stakeholder feedback:

In the GGR EoI that was launched as part of the Phase 2 of the Cluster Sequencing Process, stakeholders were invited to give their thoughts on the report and the shortlisted Power BECCS business models. This feedback has been considered in assessing the four shortlisted options. Most respondents, many of whom were prospective projects, favoured a model that paid via both a CfDe for electricity and a payment for negative emissions. Respondents highlighted the following in their feedback:

- The presence of a CfDe to mitigate electricity price risk is crucial for investability. The familiarity of this style contract was also viewed favourably.
- The separation of the cost of the negative emission and electricity, through a CfDe + carbon payment mechanism, would enable these costs to be allocated to different parties if suitable.
- Use of either voluntary markets or a reformed ETS (with the latter preferred) to renumerate part of the carbon payment, reducing cost to government and ensuring the 'polluter pays', should be pursued where possible. However, reform to the ETS to enable this should not delay early deployment of power BECCS deployment.
- Feedstock price is highlighted as a key risk for projects. Clarity is required on sustainability criteria for projects to estimate feedstock cost.
- Management of cross chain risk, particularly with T&S, is key. Other CCS contracts, such as the DPA, provide reasonable mitigations for this risk.
- Expectation that a power BECCS plant will typically run baseload in order to maximise the negative emissions generated.

The long list of options considered

Within the report, nine options were long listed and explored for their suitability in addressing the challenges of a FOAK power BECCS business model as previously discussed. They are explained below:

Option	Rationale for exclusion of frameworks in the shortlist for detailed design
Power Contract for Difference (CfDe): A CfD for electricity generation (in £/MWh) where the generator is paid the difference between a contractually agreed strike price and a market reference price for electricity	• This is an understood business model already in use for other low carbon generation technologies • It does not provide a value for negative emissions, and therefore puts all the burden of the scheme on electricity consumers.
Carbon Contract for Difference (CfDc): A CfD for carbon (in £/tCO_2) under which a subsidy is paid above the prevailing carbon price for negative emissions (such as the UK ETS, a voluntary carbon market or bilateral negative emissions sale) up to an agreed strike price	• This places a value on CO_2 removal which can be recovered from emitters • Developers continue to hold merchant price exposure on the power price which may make the model less attractive to investors, or could increase the CfDc significantly

	• There is uncertainty over the future market infrastructure for negative emissions
Negative Emissions Payment (NEP): Direct government procurement of power BECCS negative emissions via reverse auctions; direct subsidy per negative unit of CO_2; and UK ETS inclusion of negative emissions	• Puts value on negative emissions in simple way that does not rely on integration with any appropriate market for negative emissions • Developers continue to hold merchant price exposure on the power price which may make the model less attractive to investors • Puts significant cost of the scheme on government
CfDe plus NEP: A CfD for electricity generation, combined with a negative emissions payment	• Puts value on negative emissions in simple way that does not rely on integration with any appropriate market for negative emissions • Long-term contract price for power and negative emissions provides revenue confidence for investors and developer • Puts significant cost of the scheme on government
Tradeable Tax Credits: Tax relief for operation in £/tCO_2 removed and capital tax credits	• Does not provide sufficient revenue certainty to mitigate against economic risks faced by investors/developers given the tax credits are not contracted or set over the long term • Limited track record in the UK
Tradeable Carbon Removal Credits with Obligations on Emitters: A new compliance market would be developed and require certain emitters to offset their emissions	• Does not provide sufficient investor certainty • Unlikely to be applicable for FOAK projects and does not align with market-based solutions explored in the GGR business model consultation
Cost Plus Subsidy: An open-book contract which includes direct payments from government covering all incurred	• Mitigates against key risks for FOAK projects and may reduce financing costs

operational costs of the BECCS plant plus an agreed margin	• Allocation of cost risk to government may provide weak efficiency incentives
Full Government Ownership: State-owned enterprise takes complete ownership of project	• Limited track record in the UK and may cause delays to FOAK deployment • Unlikely to drive cost or CO_2 reduction efficiencies
DPA (plus NEP): Direct availability payments (£/MW) and variable payments (£/MWh) for dispatchable power, topped up with an additional negative emissions payment (£/tCO_2) for BECCS plants	• Payment on availability (rather than electricity generated) provides incentive for plant to run flexibly in response to market conditions • Places more value on electricity than negative emissions, whereas we are looking to incentivise the delivery of an optimum level of negative emissions

Question:

5. **Do you agree with the minded-to position of a combined CfD for electricity generation (£/MWh) and a CfD for Carbon (£/tCO_2) under a CfD contract framework? If not, please provide rationale for why not?**

Detailed mechanism design

This section sets out some of the further detailed design decisions that have been considered in relation to the leading option.

Dispatch profile

We have considered the optimum dispatch profile for power BECCS and the impacts of running power BECCS as baseload or flexibly. Baseload running means to generate constantly, whereas flexibly implies a level of responsive generation. Given the critical importance and scale of the negative emissions meeting our economy-wide carbon removal ambitions, the policy objective for the power BECCS business model is to design a mechanism that will incentivise dispatch as often as possible to maximise negative emissions. Alongside this objective, consideration of the impact on the electricity system and how to carefully incentivise the best use of biomass is also required.

Baseload generation would enable a greater potential rate of negative emissions. Dispatchable, flexible generation, likely lowers the costs to the power sector, but with a lower rate of negative emissions. However, we are also considering how the dispatch profile could

impact investability. Considering the benefit of negative emissions for Carbon Budgets across the whole economy relative to the additional cost of generation, it could be more beneficial overall to incentivise a power BECCS plant to run as baseload.

Question:

6. **Should a power BECCS plant run as baseload or flexibly? Please provide rationale for your answer.**

Payment streams

The strike prices for the CfDe and CfDc should be set such that the combined revenues of the two payment streams are sufficient to enable the power BECCS plant to recover its lifetime costs over the period of the contract.

We have considered how the various lifetime costs for the plant may best be allocated between the CfDe and the CfDc. A summary of the different power BECCS payments can be found in the figure below. Costs associated with running of a biomass generation plant are to be recovered through the CfDe, while costs associated with adding and operating CCS capability to the plant are to be recovered through the CfDc. A third revenue stream could cover T&S charges, which in turn cover the cost associated with capture, transmission and storage of CO_2, however we have noted elsewhere that this could be part of the first two payment streams, should a third payment stream be deemed impractical.

CfDe strike price

We have identified a range of options for how the strike price for the CfDe could be set:

Wholesale price projections: This would involve use of government or third-party wholesale power price forecasts to set the CfDe payment over the contract life. This would ensure the CfDe acts as a price stabilisation mechanism, with all additional support provided through the CfDc mechanism. We view this option as less optimal because this does not correspond to specific costs incurred by the power BECCS plant. For example, one consequence could be that the agreed strike price were to be lower than the cost of unabated biomass running, the plant may not be incentivised to run on an unabated basis during periods of T&S unavailability.

Cost of unabated biomass generation: This would involve setting the strike price equal to the cost of running the biomass plant on an unabated basis, including unabated fuel costs, network charges, and plant operational and maintenance costs, which is in line with the previous biomass CfD methodology. This would ensure that the plant continues to have an incentive to run on an unabated basis even if the carbon transport and storage network were to become unavailable, supporting short run energy security. This option carries the risk of uncertain future biomass costs, which may need to be the subject of further consideration and policy design. This option is likely to be bilaterally negotiated. This option could potentially involve indexation for fuel price risk, which is explored in the section for biomass feedstock costs.

Comparator technology cost: This would involve setting the strike price at the level equal to the revenue required to build and operate similar baseload low carbon generation technologies. This corresponds to the Levelised Cost of Electricity ('LCOE') which contains all relevant costs faced, including pre-development, capital, operating, fuel and financing costs. This would allocate a level of cost to electricity consumers equivalent to if power BECCS technology could not be deployed. We think this option is undesirable as it does not necessarily incentivise the plant to run on an unabated basis during potential periods of T&S unavailability. This option does not correspond to specific costs incurred by the power BECCS plant.

Questions:

7. **Are there any alternative methods to setting this that should be considered?**
8. **Are there any risks or concerns around setting the CfDe strike price that have not been mentioned here?**
9. **The CPI indexed strike price option requires the project to bear the risk of biomass costs and is the option in current contracts. Is this an appropriate allocation of risk? Please provide rationale and evidence for your answer.**

CfDc strike price

If the CfDe strike price were set equivalent to the cost of generating power from biomass on an unabated basis, the CfDc strike price would therefore need to cover the incremental costs associated with adding carbon capture and storage capability and operating the plant on an abated basis. This could include:

- Capex and financing costs associated with CCS equipment;
- Fixed costs associated with maintaining CCS equipment; and
- Additional fuel cost associated with generation with CCS.

A further cost associated with running the plant with CCUS is the cost of paying for use of the T&S network. T&S charges will comprise of a Flow charge (to recover the variable operational costs of the network), a Capacity charge (to recover fixed capital costs of T&S), and a Network charge (to recover the remainder of the users share of allowed revenue, based on the emitter’s connection size). We are considering if it is the most practical solution to pay these in a separate T&S payment and are open to views on this.

Questions

10. **Do you agree with the outlined approach to setting the CfDc strike price? Are there any alternative methods to setting this that should be considered?**
11. **Are there any risks or concerns around setting the carbon strike price that have not been mentioned here?**

12. Should the T&S charges be a separate payment?

Reference price

The reference price is used to calculate the difference payment to be made under the CfD contract.

CfDe reference price

The current CfD framework sets a market reference price for baseload CfDs (e.g. unabated biomass) based on season-ahead market prices, calculated using a traded volume weighted average based on forward season data received from London Energy Brokers’ Association (LEBA). We are considering if it is suitable for the power BECCS CfDe reference price to be determined on the same basis and are open to views on this.

CfDc reference price

Section 2.5.3 of the GGR business models consultation invites views from stakeholders on approaches to setting the reference price for a carbon CfD. This recognises the challenges presented by the absence of an established market or prevailing market price for negative emissions. The evidence gathered through this work will help to inform thinking in this area and we are open to views on this through either that consultation process or this one.

Contract length

The contract length of the power BECCS business model should facilitate development of power BECCS projects by providing sufficient revenue certainty to make them financeable and investable. A project’s financing costs will be influenced by the term length, with potential revenues for power BECCS projects discounted more highly beyond the term of the CfD – leading to a project requiring a higher strike price over the contracted period.

The contract should also reflect to an extent the expected asset life and commercial operation of the plant. A FOAK project may involve the retrofit of an existing biomass project, in which case the remaining useful life of the plant is likely to be shorter than that of a new biomass plant.

There is precedent among the CfDs and CCUS contracts under development of a contract length of between 10-15 years. The DPA proposed this for gas power CCUS plants, as it offered flexibility for Generators to choose a term length that could offer the best value for money. It is also consistent with the ICC business model, which features an initial 10-year term with the potential for the emitter to be granted a 5-year extension, subject to fulfilling a set of performance and market conditions.

Question:

13. Do you agree with a contract length of 10-15 years? If not, why not?

Biomass feedstock costs

We recognise that biomass feedstock costs are a consideration for the business model and we are keen to hear views on how biomass feedstock costs should be considered within the business model.

We recognise that a potential for increases to feedstock costs over the long term could present a risk for investment, and a risk for consumers; and locking into contracts with high fuel prices may result in high subsidy costs which would fail the overarching criteria of achieving value for money for electricity consumers and/or taxpayers. Under CfD arrangements for existing biomass plants, fuel cost risk resides with plant developers, who received a fixed strike price, indexed to CPI, regardless of changes to the cost of fuel.

We also recognise that there is a ‘do nothing’ option for the power BECCS business model, which would be to follow this existing approach, and not offer protection for future biomass fuel price volatility. Under this option, the risk is allocated to the developer, which could provide an incentive for developers to mitigate this risk by negotiating long-term supply contracts for biomass. However, if there were no protection from the biomass feedstock price risk, we understand that this risk could be a concern for investors and could influence the strike price.

An alternate option to mitigate biomass feedstock price risk could be to index part of the CfDe strike price to an indicator of fuel costs. A fuel cost index could help to reduce developer risk and therefore reduce the CfD strike price which would mitigate the risk of over-compensation for the developer. However, at present there is not an adequately liquid biomass market on which to base a fuel cost index. An indexation process for fuel costs could therefore require developers to demonstrate incurred costs, which could add complexity to the payment mechanism. This option could limit incentives for developers to achieve cost efficiencies or to mitigate this risk by taking contracts for a long-term stable supply of feedstock.

Another option to mitigate fuel cost risk could be to use a cost reopener for fuel costs, or a gain-sharing mechanism. Further work will be carried out to consider whether these are appropriate options for reducing investor risk as well as limiting the potential for over-compensation of developers.

Questions:

14. **What are your views on the suggested options?**

15. **Are there any alternative methods to mitigate the biomass price risk that we have not discussed?**

T&S Charges

Given the uncertainty around initial T&S charges while the network is developed, one option we are considering is allowing T&S charges to pass-through cost to generators as a separate

third payment stream. Another option is for the T&S charges to be part of the payment mechanism if a separate third payment stream ends up being impractical option.

T&S charges could either be covered by the same source of funding as the CfDc (i.e. from emitters) or the CfDe (i.e. from electricity consumers). Recovering costs from the same source of funding as the CfDc is considered advantageous as the CfDc is providing remuneration for the cost of running a biomass plant on an unabated basis. For now, we have considered that the project may run during temporary periods of T&S unavailability due to the value of the electricity to the power system, but we are open to views on this approach.

We are open to views on where the T&S charges should be sourced from across the minded-to CfDe + CfDc (or a separate third T&S charges payment stream). Within this consideration, the funding could be allocated to electricity consumers or the various funding routes considered under the CfDc.

Negative emissions from power BECCS are intended to offset emissions from hard-to-abate sectors in the wider economy, and therefore we are open to views on the merits of subsidy for the T&S charges as coming from the same source of funding as the CfDc.

Under this premise, if the T&S charges were remunerated through inclusion in the CfDc strike price, the payments included in the CfDc could be set annually based on the charging rates set out in the T&S Charges Statement. The recently published Draft CCS Network Codes indicative heads of terms[14] set out how this T&S Charges Statement will be published each year. Further consideration on if this is practicable would be needed once the approach to the CfDc is finalised.

Another option is for the T&S charges to be remunerated through a separate payment stream, this could work through monthly calculations based on the T&S Charges Statement which is published annually. The monthly payment could include both the fixed and variable T&S charges. The Flow charge would vary monthly according to the metered output onto the T&S Network according to the charging rate for Flow charge. The Capacity and Network charges would be fixed monthly based on the booked capacity and the size of connection, according to the charging rates for the Capacity and Network charges respectively.

Questions:

16. **What are your views on the proposed options?**
17. **Where should the T&S charges should be sourced from?**
18. **Should the plant run unabated during periods of T&S unavailability, such as temporary outages?**

[14] Draft Carbon Capture, Usage and Storage Network Code indicative heads of terms were published in June 2022 and are available at https://www.gov.uk/government/publications/carbon-capture-usage-and-storage-ccus-business-models

T&S Outages

T&S outages that are incurred through no fault of the emitter are a recognised part of the cross-chain risks across all other CCS business models. The various risks associated with T&S outages have been mitigated in various ways across the power and industrial business models and we will be considering the merits of these approaches when assessing the most appropriate solutions for the power BECCS business model. Within the mitigations there are range of implementable reliefs and conditions that range from financial to contractual.

Relief for T&S Outages

Under the proposed CfDc (of the minded-to payment mechanism CfDe + CfDc), projects will receive revenues for each tonne of CO_2 injected into the T&S network. This could expose generators to a loss of revenue in circumstances of T&S network outages, constraint events and commissioning delays.

This risk is outside of the generator and government control, and so we are currently considering what proportionate and appropriate level of relief the power BECCS business model should offer to mitigate this cross-chain risk. The aim would be to ensure that power BECCS projects are investible, drawing on precedents from the DPA and ICC business models which address similar risks.

One option would be to follow the approach taken in the ICC model and pay some costs in a mechanism based on a deemed quantity of CO_2 sequestered during a T&S outage or constraint event. In the case of power BECCS, this could be calculated by reference to a level of electricity generated during the T&S outage. In the ICC approach, capex payments, opex payments and the return on capex will continue during T&S Outages (planned and unplanned) and capacity constraints (noting that other loss of revenues are excluded). Payments will be based on the previous 12 months' performance, unless the capture plant is experiencing an outage due to a (continuing) non-T&S event, in which case this cost protection is not applied. If the T&S outage or capacity constraint arises out of or in connection with any act, omission, breach or default of the project or its Representatives (including any breach by the project or its Representatives of an Industry Document), then this 'deemed treatment' is also not applied.

T&S Unavailability Termination

For the minded-to power BECCS business model (CfDe + CfDc) we are considering which termination provisions to include (including for how long a T&S prolonged unavailability event should continue prior to a termination right being triggered), and which termination events require compensation. In the DPA and ICC business models a mechanism of termination for T&S prolonged unavailability events and associated compensation has been proposed to mitigate the risks to both the Generator/Industrial Emitter and the Counterparty of the asset becoming stranded.

Question:
19. Do you have any evidence or thoughts on ways to manage CCUS costs in the event of T&S network unavailability?

Overview of risk allocation within proposed business model

This section considers the overall allocation of risks between the power BECCS plant and government given the choice of high-level business model (CfDe + CfDc) as well as the more detailed design choices outlined in this section.

Risk	Allocation
Technology risks - costs associated with the deployment and running CCS technology	Power BECCS Plant
Construction risks - risk of capital cost overruns	Power BECCS Plant
Fuel cost risks – uncertainty in cost of sourcing biomass fuel stock	Power BECCS Plant (under consideration)
Operating risks - uncertainty in operating costs or capture plant operation	Power BECCS Plant
Cross chain risks - plant is unable to gain remuneration for negative emissions due to T&S network unavailability	HMG
Legal/policy risk around future market infrastructure for negative emissions through which projects can be renumerated	HMG
Price risk - volatility in electricity and carbon pricing driving revenue uncertainty	HMG
Demand risk – i.e. that BECCS does not run due to being "out of merit" in the electricity market	HMG & Power BECCS Plant (where the plant does not gain during periods of negative power prices)

Carbon/negative emissions market options for power BECCS

As we have set out in this Section 2, the business model support will be essential to enable technology developers and investors to bring forward FOAK power BECCS projects at scale. The identified barriers regarding an appropriate carbon market were:

- A current lack of predictable, long-term demand and stable revenue streams to produce negative emissions; and
- Immaturity of voluntary carbon removal markets and uncertainty around future scales and prices.

There is work ongoing on the development of the framework for incentivising negative emissions and consideration of the options for appropriate carbon/negative emissions markets in the GGR business model consultation and wider ETS discussions in the ETS call for evidence. Given the need for a coherent approach, the CfDc carbon payment is intended to align to the developing work in these areas. As stated in the GGR business model consultation, an effective market framework will be essential to leverage private capital for GGR projects through the sale of negative emissions credits, and in turn minimise support costs. Several options are considered, for example integrating engineered GGRs into a market, such as the UK Emissions Trading Scheme (UK ETS), a separate market for negative emissions or a GGR obligation scheme.

In tandem with this work, we are also looking to determine the most appropriate market infrastructure for the power BECCS business model, noting the main challenge of achieving clarity in time for deployment, subject to the outcome of any further assessment and value for money considerations.

Question:

20. What do you believe is the most appropriate market framework for supporting FOAK power BECCS 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 of the GGR consultation, indicating which option or combination of options would be preferable to achieve the objectives for power BECCS.

Section 3: Sustainability and negative emissions

As proposed in our recent consultation on Business Models for Engineered Greenhouse Gas Removals[15], we believe that power BECCS must result in an overall net-negative removal of CO_2 from the atmosphere and must only use sustainable biomass. In the Biomass Policy Statement[16] Government announced that it would develop a BECCS policy that will ensure that BECCS delivers net-negative emissions. This is in parallel with the review of the existing biomass sustainability criteria being undertaken as part of the Biomass Strategy.

The net-negativity of power BECCS will depend on the balance between the supply chain GHG emissions that occur within the system boundaries of the assessment and the final captured and stored quantity of biogenic CO_2. This section sets out the initial work being undertaken to ensure that power BECCS will meet a suitable level of CO_2 removal.

All biomass used for power BECCS will be required to meet sustainability criteria that relate to relevant GHG and non-GHG aspects of sustainability, including land use, biodiversity, and social impacts, which will be detailed further in the Biomass Strategy. We would also expect all power BECCS operators to comply with all relevant air quality regulations.

Setting a threshold for the supply chain Greenhouse Gas ('GHG') emissions for power BECCS

The UK has strict sustainability criteria in place for biomass use supported by government incentives across the heat, electricity, and transport sectors. The UK only supports biomass which complies with these criteria, irrespective of where the biomass is sourced from. The sustainability criteria include requirements under the land criteria and GHG criteria.

The land criteria take into account a range of social, economic, and environmental issues, including protecting biodiversity and land use rights. The Biomass Policy statement set out that the sustainability criteria are to be reviewed and strengthened where possible, and the recommendations will be set out in the forthcoming Biomass Strategy.

The Renewables Obligation (RO) and Contracts for Difference (CfD) Schemes require that the supply chain GHG emissions from biomass-generated electricity does not exceed a set GHG threshold, target or ceiling. The supply chain emissions must be calculated according to a life cycle assessment approach, meaning that all GHG emissions (including methane and nitrous oxide emissions) of all stages in the supply chain are accounted for, regardless of where they occur (i.e., across international boundaries). For example, this should include the emissions from growing, cultivating (including direct land use change), drying, processing and

[15] https://www.gov.uk/government/consultations/greenhouse-gas-removals-ggr-business-models
[16] https://www.gov.uk/government/publications/biomass-policy-statement-a-strategic-view-on-the-role-of-sustainable-biomass-for-net-zero

transporting biomass. These thresholds are currently set in place to demonstrate that a minimum significant (50% plus) GHG emission saving has been achieved compared to a set fossil fuel comparator. The calculations must be based on the best available data and should be independently audited as part of the regulation and verification process. Subsidies can be revoked where evidence fails to meet the sustainability criteria, such as exceeding the GHG threshold or not meeting other conditions explained in the land-use criteria.

Our evidence shows that retrofitting a CCS plant to a biomass power station, that meets current GHG supply chain thresholds and other sustainability criteria, will result in net-negative CO_2 emissions overall. Under current IPCC accounting rules, all captured CO_2 can contribute to our national GHG inventories, as the supply chain emissions are accounted for in the sectors where they occur. Despite this, our minded to position is that we will continue to set a maximum threshold, at least, for power BECCS supply chain emissions to ensure that power BECCS results in a minimum level of net-negativity. The details of the supply chain thresholds are yet to be determined; the following questions will help gather evidence on the refinement process.

Question:

21. Do you agree that a power BECCS project should report against a suitable threshold to ensure that we achieve a minimum level of net-negativity from any power BECCS project is achieved?

Setting the supply chain threshold for power BECCS

As power BECCS is a new system, a robust calculation methodology and suitable GHG emission threshold should be developed. We are building our evidence base on what these should be and have outlined some of the key considerations being made.

Strengthening the baseline

The current GHG supply chain emission thresholds under the RO and existing CfD contracts are based on a cradle-to-grave assessment of unabated biomass electricity systems, and therefore are not currently suitable for power BECCS (Table 1). However, our analysis indicates that if a power BECCS plant (capturing a suitable level of CO_2) did comply with the current thresholds for unabated biomass it would lead to net negative emissions after supply chain emissions are considered, and easily meet the 8.1 gCO_2/MJ requirement for new builds under the CfD.

However, it is the intention to strengthen the existing sustainability criteria for biomass where possible and take this opportunity to increase the GHG emission mitigation potential of biomass use. There is evidence, from the reporting data provided by the regulator Ofgem[17],

[17] Latest sustainability dataset available here: https://www.ofgem.gov.uk/cy/publications/biomass-sustainability-dataset-2020-21

that many generators that report on supply chain emissions often achieve a lower GHG emission than the threshold or target under the relevant schemes.

We recognise, however, there may be trade-offs and implications on having too low a threshold, which may limit the diversity of potential biomass feedstocks that can meet those thresholds. This may place an over-reliance on particular biomass feedstocks that have a limited sustainable supply as they are a waste or by-product of other industries (e.g., waste wood, agricultural or forest residues). For example, the Ofgem data shows that the GHG supply chain emissions from some specific feedstocks (e.g., perennial energy crops such as Miscanthus) appear to be higher than more commonly used feedstocks such as wood pellets from forest and sawmill residues, and agricultural residues such as oat and sunflower residues, although this is based on a relatively small sample size. We therefore want to understand the potential trade-offs from setting the GHG emission threshold too low, which could mean that certain feedstocks cannot meet it. Therefore, we are seeking evidence on how much further the existing thresholds could be reduced without severely limiting the pool of suitable feedstocks.

In the Renewables Obligation ('RO') and CfD schemes, the supply chain thresholds decrease over time at intervals (Table 1). Taking a similar approach to the power BECCS business model would encourage a continuous incentivisation to decrease supply chain emissions, however there may be other mechanisms to encourage this (e.g., taking a net-approach- see page 4242). In theory any reductions should at least reflect a trajectory of decarbonisation of other sectors, although to some extent this may be outside of the control of the operator. We also welcome views and evidence on how and if thresholds could be strengthened over time.

Table 1 Current GHG emission thresholds for biomass supply chains in the CfD

<table>
<tr><td colspan="3" rowspan="2">Contracts for Difference

(Biofuel limits, not bioliquids)</td><td colspan="2">GHG Threshold (gCO_2/MJ)</td><td rowspan="2">GHG Ceiling (gCO_2/MJ)</td></tr>
<tr><td>Dedicated Biomass with CHP</td><td>Not Dedicated Biomass with CHP</td></tr>
<tr><td rowspan="3">Investment Contract, Allocation Round 1 & Allocation Round 2</td><td>Start of Term</td><td>31/03/2020</td><td>66.7</td><td>79.2</td><td>79.2</td></tr>
<tr><td>01/04/2020</td><td>31/03/2025</td><td>55.6</td><td>55.6</td><td>75</td></tr>
<tr><td>01/04/2025</td><td>End of Term</td><td>50.0</td><td>50.0</td><td>72.2</td></tr>
<tr><td rowspan="2">Allocation Round 3 &</td><td rowspan="2">Start of Term

01/04/2020</td><td>31/03/2020</td><td colspan="2" rowspan="2">8.1</td><td>79.2</td></tr>
<tr><td>31/03/2025</td><td>75</td></tr>
</table>

Allocation Round 4	01/04/2025	End of Term		72.2

Question:

22. Do you have any evidence to share that could support the determination of a suitable supply chain GHG emission threshold for power BECCS, including by how much they could be strengthened?

Determining the final unit of measurement for the supply chain GHG threshold

As stated, the current GHG thresholds for biomass in power are measured on a 'grams of CO_2 per MJ electricity generated' basis (gCO_2/MJ). Therefore, the original threshold would have been set against an appropriate baseline conversion efficiency and system boundary for unabated biomass, which may be different for power BECCS. As a power BECCS system is intended to produce both low carbon electricity and negative emissions, it is necessary to determine what a suitable final unit of measurement will be and set an appropriate threshold against this.

It has been noted in literature[18] that there is an expected impact on plant efficiency when retrofitting CCS to a given plant. This is due to the parasitic load requirements to run the CCS and compress the CO_2. This will mean greater quantities of biomass will be required to generate a given unit of electricity, and the relative impact on the supply chain emissions must be considered when setting an appropriate threshold.

It is likely that the system boundaries of the assessment will be different for power BECCS compared to unabated biomass electricity generation, though this may depend on the final unit of measurement. In conventional biomass the final assessment point is the delivery of unit of electricity (MWh). This could also apply to power BECCS; however, it would not consider the rate of CO_2 capture. If this is considered, the final assessment point could be the point at which CO_2 enters the T&S network.

There are three options currently under consideration for the final unit of measurement for the supply chain GHG threshold, and a summary of the advantages and disadvantages of each is below in Table 2. It is the intention that the threshold should be relatively easy to monitor and verify. Therefore, the proposed options below are identified as they should not require significant changes to the way data is currently reported.

Option 1 (Electricity basis)

This option applies a conventional GHG threshold on the biomass-generated electricity, as is done currently. The electricity will be assessed on a per-unit basis (e.g., gCO_2/MJ electricity),

[18] Watson, J., Broad, O., & Butnar I. 2021. The role of bioenergy with carbon capture and storage in the UK's net-zero pathway, UCL.

and there will be an emission limit that the generators must not exceed. The GHG emission limit will only consider emissions from the supply chain and will not consider the stored biogenic carbon (though this is explored in Options 2 & 3). The threshold will be set so that overall, after accounting for a suitable rate of carbon capture, there is a minimum net-negativity from the power BECCS project. Following this approach, if the generated electricity meets the GHG threshold (and other sustainability criteria), all stored biogenic carbon would also be deemed sustainable. This option is the simplest option but less well adapted to power BECCS.

Option 2 (Carbon basis)

This option sets a GHG threshold on the stored carbon, which will be based on a per unit basis (e.g., gCO_2/tonne of CO_2 stored). This could be assessed to the point at which the CO_2 enters the T&S network. This option would also likely need some averaging mechanism to allow for permitted T&S outage periods (or other types of T&S network unavailability), as if the T&S is not available the plant will not be able to meet any threshold. Like Option 1, the threshold will be set so that overall, after accounting for a suitable rate of carbon capture, there is a minimum net-negativity from the power BECCS project. Following this approach, if the captured carbon meets the GHG threshold (and other sustainability criteria), all generated (biomass-derived) electricity would also be deemed sustainable. It is noted that there will be some complexities associated with this option, and it would not take into account of plant conversion efficiency.

Option 3 (Combined option)

This option combines the two options above. It would set a single combined limit on the supply chain emissions per unit of electrical output which considers the stored biogenic carbon (i.e., a negative supply chain threshold in gCO_2/MJ electricity). This means that the project will have to meet a supply chain emissions threshold that could be affected by both the electrical conversion efficiency and carbon capture efficiency. This could reduce the chances for any perverse incentives that could arise from setting thresholds on one output and not the other directly, reflecting the policy position of valuing both outputs from the power BECCS plant. On balance of the advantages and disadvantages displayed in Table 2, this option could be preferable, yet it is noted that there will be some complexities associated with this option that relate to T&S outages (or other types of T&S network unavailability) and how that affects the determination of the GHG threshold.

Table 2 Advantages and disadvantages of each threshold option currently being reviewed.

Option	Advantages	Disadvantages
Electricity-basis (current approach)	Established method already used by industry. Considers plant conversion efficiency. Not impacted by T&S outage	Does not take account of plant CO_2 capture rate.
Stored Biogenic Carbon	Approach could be compatible with other routes for BECCS or other engineered GGR technologies. Takes account of plant capture rate.	Does not consider plant conversion efficiency. Complexity of dealing with T&S outages.
Combined Negative Threshold	Takes into account of both the energy output and the stored biogenic carbon, and the associated efficiencies of each.	A negative threshold would be unconventional. Complexity of dealing with T&S outages.

Question:

23. Out of the three options, which option do you prefer for assessing power BECCS? Do you have any other recommendations on an alternative suitable method?

Payment for capture storage, and atmospheric removal of biogenic CO_2: net and gross optionality

Outlined above are the merits and possible approaches of setting a maximum threshold for power BECCS supply chain emissions to ensure that project achieves a minimum level of net-negativity.

Another factor which requires consideration, in particular for business model design purposes, is whether to reward a power BECCS facility on what is often referred to as either a 'net' or a 'gross' basis.

In simple terms, this reflects the choice of whether to:

- reward the total volume of carbon stored – after ensuring that a net-negative threshold has been reached (gross), or
- to take a granular approach and only reward each unit of permanently stored negative carbon, 'discounting' the stored carbon that is deemed to be above the set net negativity threshold (net). This option would still require the net-negative threshold to be met.

Both approaches pose merits and disadvantages, and we would welcome stakeholder views on these, some of which we outline below.

The main benefit of taking gross approach is that it may be relatively simple and more closely aligned with national GHG reporting. Under this, all captured CO_2 from biomass capture will be reported as a negative emission against the sector and territory in which they are removed (e.g., energy). Other emissions associated with the supply chain of will be reported against the sector and territory in which they occur. Also, the T&S system provides permanent storage for absolute tonnes of CO_2 and will charge fees based on the gross CO_2 stored irrespective of the net-negativity of a project.

Whilst there may be benefits to aligning to this approach, it may be more advantageous to align with how negative emissions are traded in carbon markets. For example, voluntary markets currently use a net approach and therefore a gross approach could make market compatibility and integration more complex. This may be important when considered in the wider GGR context as taking a gross approach could make it more complex to compare removal credits and ensure they are equivalent due to the differing supply chains of different technologies.

A main benefit of taking a net approach is that it could provide a continual incentive to decrease supply chain emissions and maximise 'net-negativity', i.e., net carbon removed from the atmosphere, compared to just meeting the minimum threshold required. This could have a wider benefit of reducing GHG emissions from other sectors, including outside of UK territory. It could also provide an incentive to increase CO_2 capture rates. We have heard from stakeholders that a framework based on a net approach could benefit public confidence in the scheme, as only net-removal would be rewarded. Based on these benefits, a recent research project on policy mechanisms for engineered GGRs made a tentative recommendation that net

removals be used as the basis for rewarding negative emissions[19]. A noted risk of a net-negative approach for power BECCS may mean some biomass feedstocks with relatively higher supply chain GHG emissions (but still meeting the minimum net-negative threshold) would be less attractive, which could have the impact of reducing the diversity of feedstock supply.

Research[20] suggests that the difference in payments between a gross and net basis are likely to be small, therefore the incentive to reduce supply chain emissions under a net basis is potentially modest. This research also suggests that to maintain an investable proposition, a power BECCS plant will require the same level of support regardless of the approach taken. However, we are looking to expand our evidence base on the merits of either approach and identify the potential implications for the business model design and payment mechanism.

Questions:

24. **Of the two options considered (net and gross), which do you think is most appropriate for the reward of power BECCS through an appropriate carbon market?**

25. **Is there any further evidence or arguments we should consider for either taking a gross or net approach in the power BECCS business model?**

[19] http://www.element-energy.co.uk/wordpress/wp-content/uploads/2022/06/BEIS-Engineered-GGR-policies-FINAL-REPORT.pdf pg 29-31
[20] https://www.gov.uk/government/publications/investable-commercial-frameworks-for-power-beccs

List of acronyms

Acronym	Definition
power BECCS	Power bioenergy carbon capture and storage
CfD	Contract for Difference
CCS	Carbon capture and storage
GGR	Greenhouse gas removal
CCUS	Carbon capture, usage and storage
CPI	Consumer price index
ETS	Emissions Trading Scheme
EOI	Expression of Interest
DACCS	Direct Air Capture with Carbon Capture and Storage
$MtCO_2$/year	Million tonnes of carbon dioxide per year
ICC	Industrial carbon capture
NEP	Negative Emissions Payment

Definitions

Term	Definition
Cluster	T&S Network (incorporating the onshore and offshore network and offshore storage facility) and an associated first phase of carbon capture Projects.
Cross Chain	All elements of the Cluster including development, delivery and operation of all Generators/Emitters as well as Onshore, Offshore and storage infrastructure.
Capex	Capital expenditure
Engineered Greenhouse Gas Removal (GGR)	Projects that ultimately achieve atmospheric CO_2 removal through geological storage. This includes DACCS and BECCS Projects and excludes other engineering-based Projects such as enhanced weathering.
Opex	Operational expenditure

This consultation is available from: www.gov.uk/government/consultations/business-model-for-power-bioenergy-with-carbon-capture-and-storage-power-beccs

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