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Briefing

Does the UK need BECCS to reach net zero?

February 2024

Summary

As well as reducing greenhouse gas emissions, the UK will have to remove carbon from the atmosphere and store it to reach net zero emissions by 2050. UK greenhouse gas removal (GGR) policy has so far relied on the future large scale deployment of bioenergy with carbon capture and storage (BECCS), with a particular focus on converting power stations such as Drax in Yorkshire, known as 'power BECCS'.

But the use of biomass for power has been criticised for its impact on the environment. Our analysis suggests other GGR options could reach a similar scale and cost effectiveness as power BECCS. We recommend that the government avoids locking in large scale power BECCS deployment now, and instead supports the rapid development of other GGR options. Doing so would reduce the risks around delivery and the environment in the medium term.

If the government chooses to go ahead with power BECCS it must ensure the sustainability of biomass used, including avoiding damage to biodiversity and long carbon payback periods. It should use the leverage provided by the other available options to demand that concerns about the sustainability of biomass used for BECCS are resolved and that it provides good value for money.

Greenhouse gas removal needs to grow fast

To reach a net zero carbon economy by 2050, which the government has agreed is necessary to avoid the worst impacts of the climate crisis, a range of greenhouse gas removal (GGR) options need to be rapidly deployed and scaled up in the UK and globally.

GGR is needed to balance the leftover emissions from sectors, such as agriculture, aviation and waste, which cannot completely eliminate them by 2050. After 2050, removing excess CO_2 from the atmosphere to a 'net negative' level will be necessary to reach safer levels for the planet.

The UK Climate Change Committee (CCC) estimates that engineered GGR capacity (excluding the organic carbon locked up in trees and soils) will need to reach around 60MtCO_2 a year by 2050.[1]

The government's carbon budget delivery plan aims for engineered removals reaching 75-81MtCO_2 by 2050.[2] For context, in 2020, total emissions from UK power stations was around 50MtCO_2.[3] Engineered GGR is virtually non-existent in the UK, mostly consisting of small scale pilots, the largest being enhanced rock weathering (explained below) being tested at kilotonne scale.

Our analysis suggests it would be possible to reduce the need for engineered GGR to 32MtCO_2 per year by increasing carbon storage in woodland and other semi-natural habitats while decreasing emissions from agricultural activity and peatlands.[4] This approach would also be cheaper, channel more funding towards farmers and be more beneficial for wildlife than relying on greater amounts of engineered GGR.

Power BECCS dominates GGR policy but has environmental risks

Under current plans, it is assumed that most GGR will be achieved through a method known as 'bioenergy with carbon capture and storage' (BECCS). BECCS involves recovering energy from biomass, such as wood pellets, crop residues or food waste, while capturing and storing the CO_2 released in the process. There are several different types of BECCS (see annex one), and the most high profile is power BECCS which involves burning biomass in a power station and capturing the CO_2.

The Climate Change Committee's (CCC's) balanced net zero pathway assumes there will be 53MtCO_2 a year removed through BECCS by 2050, of which 19MtCO_2 is achieved by power BECCS. This has led the government to fast track support for power BECCS deployment, singling it out over other GRR methods and giving it its own business model development process.[5] The company Drax has received planning consent to convert two of its biomass burning units in Yorkshire to BECCS. The government is now consulting on extending subsidies for biomass power stations beyond 2027 to allow time to develop and deploy BECCS.[6]

But power BECCS is controversial. The Drax plant burns wood pellets which has raised the following concerns.

- BECCS is treated as carbon negative at the point of burning the wood, but it is actually only carbon negative once trees regrow which can take decades or even hundreds of years before they reach full maturity (known as the 'carbon payback period').
- Harvesting forest biomass for burning in power stations can cause long lasting and potentially permanent damage to biodiversity.[7]

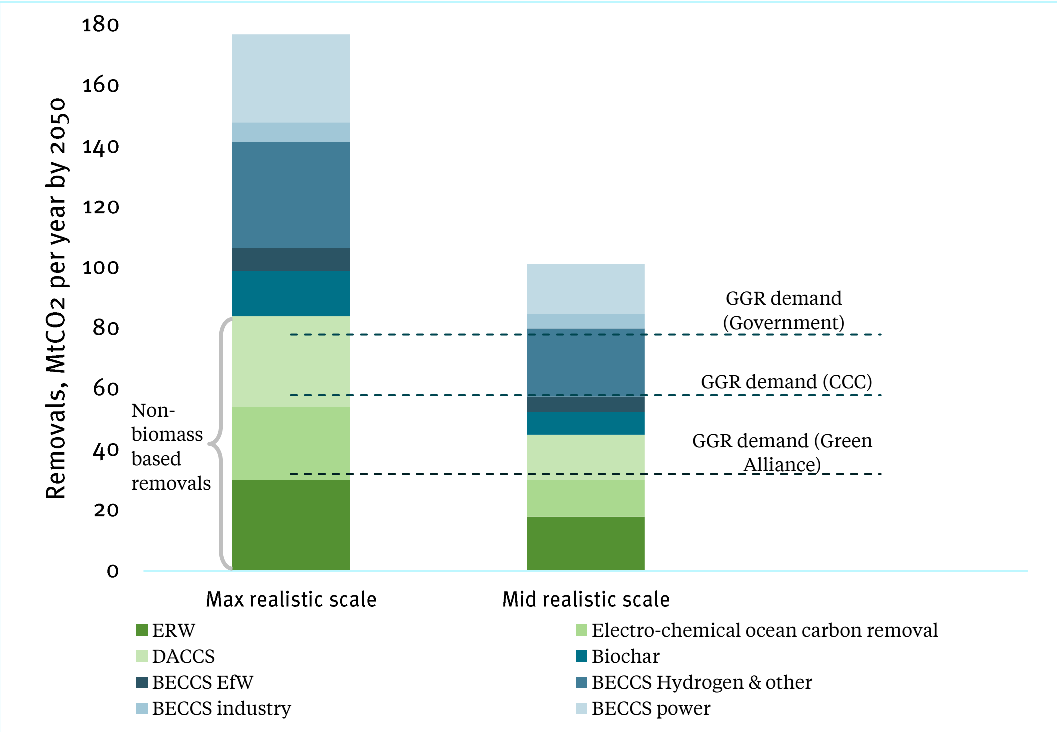
- Power BECCS in the UK will have to rely on imported biomass, not domestic supplies, leaving the country exposed to significant uncertainty around future supply and costs.
- BECCS competes with other land uses, such as agriculture, with total land needed for it globally in Intergovernmental Panel on Climate Change scenarios (which also rely heavily on BECCS rather than other GGR options) ranging from 25-80 per cent of current global crop land.[8]

Power BECCS isn't vital to reach net zero

New developments in other engineered GGR options, such as enhanced rock weathering (ERW) and electrochemical ocean carbon removal, make it increasingly likely that the UK would be able to meet its GGR goals without resorting to power BECCS.

If it was considered desirable, it could be possible to avoid using BECCS altogether once these options reach their maximum realistic potential (see below). Reducing the need for engineered GGR, along the lines we propose, increases the likelihood that power BECCS will not be needed.[9]

Potential GGR capacity and demand in different scenarios



[See annex one for details and sources]

We focus on ERW and electrochemical ocean carbon removal in our assessment because they are highly scalable, provide lasting carbon storage, do not add significant additional pressures to the use of land and are particularly well suited to using resources available in the UK, rather than relying on imports (ie a large amount of agricultural land and sea, significant offshore infrastructure and proximity to renewable energy). They are also likely to be cost competitive with BECCS (see annex one).

ERW and electrochemical ocean carbon removal are not as technologically ready as BECCS, but they are advancing very quickly.

ERW has moved from the experimental proof of concept stage in lab conditions (TRL 3) to being validated in a real setting (TRL 5) in the past five years, and it is already being deployed at a scale of tens of thousands of tonnes by private companies.

Electrochemical ocean carbon removal, which was not assessed in a UK government commissioned review of GGR options, is estimated to be at TRL 5-6 stage (validated and demonstrated in a relevant environment) and is also in the process of being commercialised.

There are still uncertainties about these technologies which are being investigated in pilot facilities and field trials, including the best way to measure and validate how the carbon is removed and stored, and the wider impacts they might have on the environment.

Other options should also play a role in a diverse GGR portfolio to maximise the chances of the economy reaching net zero carbon by 2050 and then becoming net negative. Our table below (annex one) gives an overview of some of the main GGR methods.

Two viable GGR alternatives

Enhanced rock weathering

Enhanced rock weathering (ERW) involves accelerating the natural process of silicate rocks reacting with CO_2 in rainwater (carbonic acid), by spreading crushed silicate rock on open land. The resulting carbonates are stable and capable of storing the CO_2 over long time periods (over a thousand years).

ERW is already being deployed in the voluntary carbon market in the UK. For example, the company UNDO have spread enough crushed rock, including on UK farmland, in 2023-24 to sequester an estimated 37,500 tonnes of CO_2.[10] Spreading crushed silicate rocks on farmland is also good for farming, reducing excess soil acidity, enhancing the availability of nutrients and reducing the release of nitrous oxide (a powerful greenhouse gas and air pollutant).[11]

The UK government is supporting the development of ERW through a UKRI demonstrator project looking into the rates of carbon sequestration and impacts on agriculture and biodiversity in different settings. However, the government's GGR business model only applies to technologies using CCS (eg piping CO_2 underground for storage) so it currently sits outside this framework.

Electrochemical ocean carbon removal

Electrochemical ocean carbon removal takes CO_2 out of seawater and stores it underground, as with BECCS and direct air capture and carbon storage (DACCS). The sea then absorbs more CO_2 from the atmosphere to reach equilibrium. It is a similar process to DACCS, but requires less energy because CO_2 is present in much higher concentrations in water than air.

The technical potential of this technology to remove and store CO_2 is enormous, with the only real limits being the speed at which processing plants can be built and the availability of renewable electricity to power them.

Electrochemical ocean carbon removal is not being deployed at a large scale yet, but it is being used at demonstration scale in voluntary carbon markets. For example, Captura is testing a 100 tonne per year plant, including studying impacts on the marine ecosystem, and has plans to build a 1,000 tonne per year plant in 2024.

The UK is well suited to electrochemical ocean carbon removal because it can utilise decommissioned North Sea oil and gas platforms, using renewable electricity from offshore wind when supply is high. The UK government is supporting an electrochemical ocean carbon removal pilot project in phase 1 of its Direct Air Capture and Greenhouse Gas Removal programme.

The government should keep its options open

The range of scalable and permanent carbon removal and storage options available to the UK mean that power BECCS is increasingly unlikely to be required to meet the government's GGR goals. Instead, it could be one option amongst many. On this basis, the Department for Energy Security and Net Zero (DESNZ) should take the following approach to BECCS and GGRs:

1. Invest to bring more GGR options to commercial readiness

Technologies like ERW and electrochemical ocean carbon removal are developing fast in voluntary carbon markets. Targeted government support to bring them rapidly to the same readiness as BECCS would provide more diversity of options for the country to achieve net zero in the most sustainable and cost effective way.

2. Avoid locking in large scale BECCS too early

In February 2024, the government is consulting on options for maintaining biomass power capacity after 2027 when current subsidies end, as well as finalising its proposals for a BECCS business model to help biomass power plants like Drax convert to BECCS. It should place a time limit on any post 2027 subsidy for biomass power so there is time to assess whether power BECCS is the right option for the UK and, if not, to put an end date on biomass subsidies and avoid large ongoing public costs (by 2023, Drax power station had received £6.5 billion in subsidies for burning biomass).[12]

3. Demand high sustainability standards and value for money

It may be that BECCS still has an important role to play in the UK power system; for example, providing a power generation option at times when renewables cannot meet demand due to unpredictable weather.

The relative merits of this should be weighed up against other options for fulfilling this role in the power system, such as gas with CCS and hydrogen power. If the government chooses to deploy power BECCS as a priority, it must use the fact that there are other GGR options to demand it is done sustainably and delivers value for money. We have previously suggested that replacing imported wood pellets from forests with UK-based waste would be a more sustainable option, provided this is done in accordance with the waste hierarchy (ie to prioritise minimising waste first) and the 'cascading use principle', prioritising bioresources for use in materials such as chipboard first and energy recovery only as a final stage.

At a minimum, sustainable biomass deployed for power BECCS should:

- have a short carbon payback period;
- avoid putting additional pressure on natural habitats and biodiversity;
- avoid competing with food production;
- avoid increasing the UKs overseas environmental footprint.

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Annex one: GGR options compared

	Minimum realistic potential scale 2050 ($MtCO_2$ per year)	**Maximum realistic potential scale 2050 ($MtCO_2$ per year)**	**Cost estimate (£ per tonne CO_2)**	**Technology readiness level**	**Limiting factors**
BECCS power	4	29	£30-£170	7	Land competition and availability of sustainable biomass
BECCS industry	3	6.5	£40-£300	7	Proximity to transport and storage infrastructure; availability of sustainable biomass
BECCS EfW	2.5	7.5	£50-£110	7	Proximity to transport and storage infrastructure; biogenic proportion of waste
BECCS Hydrogen & other	10	35	£30-£100	5	Land competition/ availability of sustainable biomass; demand for hydrogen
DACCS	0	30	£70-£250	6	Build rate and energy demand
Enhanced rock weathering	6[13]	30[14]	£100-£160[15]	5[16]	Transport distance from quarry to suitable farmland; availability of silicate rock
Biochar	0	15	£14-£130	5	Land competition/ availability of suitable biomass (free from potential contaminants eg heavy metals)
Electrochemical ocean carbon removal	0	24[17]	£60[18] (estimated operating cost per tonne CO_2)	5-6[19]	Build rate and energy demand

[All the figures above are taken from Element Energy and UK CEH, 2021, except where otherwise referenced.[20] Other GGR options are also being developed which are not included in this comparison.]

Endnotes

[1] Climate Change Committee (CCC), 2020, *The sixth carbon budget: the UK's path to net zero*
[2] HM Government, March 2023, *Carbon budget delivery plan*
[3] Department for Business, Energy and Industrial Strategy (BEIS), 31 March 2022, 'Provisional UK greenhouse gas emissions national statistics 2021'
[4] Green Alliance, 2023, *Shaping UK Land Use*
[5] Department for Energy Security and Net Zero (DESNZ), March 2023, *Power bioenergy with carbon capture and storage*
[6] DESNZ, 18 January 2024, 'Open consultation: transitional support mechanism for large-scale biomass electricity generators'
[7] See for example, BBC Panorama, 8 October 2022, 'The green energy scandal exposed'
[8] M Fajardy, A Koberle, N Mac Dowell and A Fantuzzi, January 2019, 'BECCS deployment: a reality check', Imperial College London Grantham Institute
[9] Green Alliance, 2023, op cit
[10] UNDO, 20 December 2023, 'UNDO's year in review: expansion, evolution and excellence'
[11] E Kantzas et al, 2022, 'Substantial carbon drawdown potential from enhanced rock weathering in the United Kingdom', *Nature Geoscience*, vol 15, pp 382-389.
[12] DESNZ and National Audit Office, 24 January 2024, *The government's support for biomass*
[13] E Kantzas, 2022, op cit
[14] Ibid
[15] Ibid
[16] Enhanced rock weathering has been tested and demonstrated on agricultural land in the USA (see I Kantola et al, 17 August 2023, 'Improved net carbon budgets in the US Midwest through direct measured impacts of enhanced rock weathering', *Global change biology*, vol 29, pp 7012 – 7028) and is undergoing academic field trials on agricultural land in the UK. It is also being deployed and tested at scale by a private company.
[17] Scale estimate based on 1MtCO_2 per year plant deployed on 25 per cent of oil and gas platforms expected to be decommissioned in the UKCS up to 2025.
[18] Cost estimate based on SeaCURE, 'Phase 1 public facing final report', assets.publishing.service.gov.uk/media/6281f4948fa8f55622a9c82b/university-exeter-seacure-phase-1-report.pdf
[19] R Sharifian et al, 2021, 'Electrochemical carbon dioxide capture to close the carbon cycle', *Energy & Environmental Science,* vol 14, pp 781-814
[20] UK Centre for Ecology and Hydrology and Element Energy, October 2021, *Greenhouse gas removal methods and their potential for UK deployment*