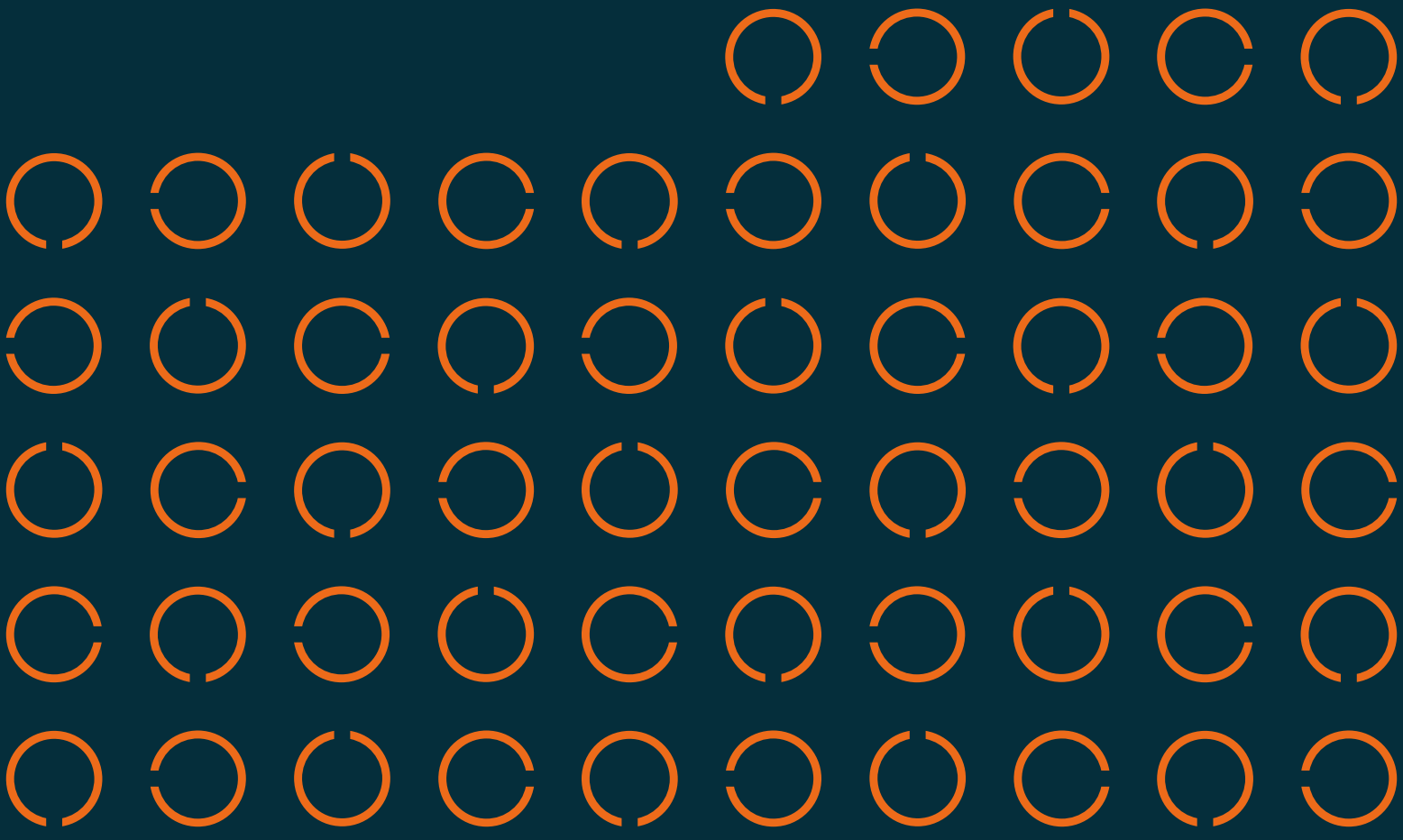
CO2RE THE GREENHOUSE GAS REMOVAL HUB

# The UK State of Carbon Dioxide Removal

July 2025



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This report is led by the University of Oxford's Smith School of Enterprise and the Environment.

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# Executive Summary

Carbon dioxide removal (CDR) refers to activities that capture $CO_2$ from the atmosphere and store it durably. There is a wide and growing range of CDR methods, including forestry (the planting of new woodlands and enhancement of existing ones), bioenergy with carbon capture and storage (BECCS), direct air carbon capture and storage (DACCS), enhanced rock weathering and biochar.

CDR is increasingly recognised as a critical component of climate strategies alongside deep and rapid decarbonisation. To reach net zero greenhouse gas (GHG) emissions, CDR can be used to balance residual emissions from activities that are difficult or impossible to fully decarbonize. Beyond net zero, if it is decided that net removal from the atmosphere is required, CDR becomes essential. Currently:

- All global pathways assessed by the Intergovernmental Panel on Climate Change (IPCC) for staying below 2°C above pre-industrial levels involve some level of CDR. While the precise amount varies widely, on average they indicate a CDR increase of 5 billion tonnes per year from 2020 to 2050.
- For the UK, the Climate Change Committee's (CCC) Seventh Carbon Budget projects that meeting the legislated net zero target will require around 36 $MtCO_2$/year of removals by new technologies in 2050, in addition to around 44 $MtCO_2$/year of removals via land use.

This report provides an overview of the state of CDR development in the UK. It begins with an analysis of the research and development landscape (**Chapter 2**) and the role of UK-based companies in advancing CDR technologies (**Chapter 3**). It then explores voluntary carbon market activity in the UK (**Chapter 4**), followed by an assessment of national policy frameworks and governance structures supporting CDR (**Chapter 5**). The subsequent chapters examine public perceptions of CDR (**Chapter 6**), the current level of CDR deployment in the UK (**Chapter 7**), and the role of CDR in the UK's net zero pathways (**Chapter 8**).

## Research and development

Research and development (R&D) is important for innovating new CDR methods, reducing their costs, increasing the feasibility and accuracy of measuring their effectiveness, and understanding their wider environmental and social effects. The UK Research Councils invested around £62m in CDR R&D in 2021–4, most notably through the £31.5m Greenhouse Gas Removal Demonstrators Programme. Additional direct government support has come from the £60m Direct Air Capture and Greenhouse Gas Removal Innovation Programme, and pilot projects for restoring UK woodlands, wetlands, grasslands and peatlands. The UK's academic output on CDR has grown over sixteen-fold from 12 publications in 2000 to 194 publications in 2022. However, gaps remain in the UK's CDR R&D portfolio, for example in support for marine CDR methods. Funding to maintain the UK's R&D is also uncertain, with both major programmes scheduled to end in 2025.

## Company activity

The UK is home to over 100 companies developing or deploying CDR solutions, spanning a wide array of approaches (**Figure ES.1**). Activity is most concentrated in biochar, DACCS, BECCS, and forestry. Most ventures are small-scale and early-stage, with the exception of Drax piloting BECCS at a large scale. The majority of companies were founded after 2020, reflecting rapid recent growth in the sector.

**Figure ES.1: Visual map and sectoral breakdown of UK CDR companies (2000-2024)**

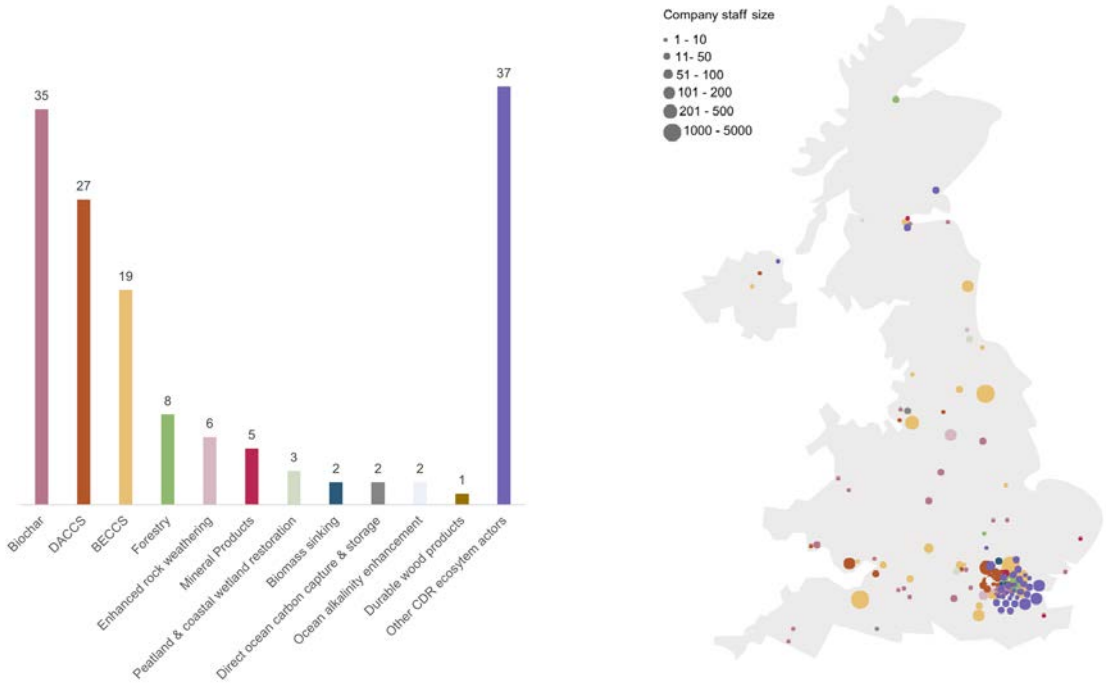



***Figure ES.1*** *Chart and Map of UK CDR companies, according to method and staff size (2000–24)*
*This chart and map are based on a compiled database drawing from public and proprietary sources. Actual figures are likely underestimated due to the fast-evolving nature of the sector and some companies providing CDR (especially through forestry and other conventional land methods) and not identifying as such. (see* ***Chapter 3****).*

## Voluntary carbon markets

Voluntary purchases of carbon removal credits play an important role in supporting CDR development in the absence of government-led commercialisation mechanisms and standards for many CDR methods.

Markets for forestry and peatland restoration credits are operating under government-backed carbon codes. In 2022, around 212,000 tonnes of UK woodland carbon credits were sold at £20/tonne on average, and around 11,400 tonnes of peatland carbon credits sold at £25/tonne on average. Available data suggests market activity declined in 2023.

Credit purchases for a wider array of UK CDR technologies are at a smaller scale but growing rapidly. These occur using different and often proprietary standards, and most purchases are not yet delivered. Around 130,000 tonnes of credits have been sold in total, principally for enhanced rock weathering and mineral products (around 40,000 tonnes each), followed by BECCS (30,000 tonnes), DACCS (around 20,000 tonnes), as well as biochar and biomass burial (1,000 tonnes each). So far, approximately 8,000 of these credits have been actually delivered. UK deliveries stand at roughly 1% of all credits delivered by CDR technologies around the world to date.

## Policy and governance

The UK's approach to CDR is evolving within the broader context of its net zero goal for 2050. The Net Zero Strategy published by the previous government included ambition of at least 5 $MtCO_2$/year of novel removals by 2030, scaling further to 23 $MtCO_2$/year by 2035. Additional commitments were made to increase CDR from land use by planting 30,000 hectares of trees per year from 2025 and restoring 280,000 hectares of peatlands by 2050. Nevertheless, gaps

remain in policy clarity, market design, and long-term support to deliver these.

A summary of current UK policy coverage and gaps across different CDR methods is provided in Table ES.1 (below). While frameworks for measurement, reporting and verification (MRV) of removals are well established for most conventional land-use methods, this is not yet the case for most novel removal technologies. The government has tasked the British Standards Instituted with developing standards for BECCS and DACCS projects, but MRV frameworks for other methods, including biochar and enhanced rock weathering, are not in development either at the project level or at the level of national reporting for climate targets. Another key role for government is in creating commercial mechanisms that reward projects, given CDR is a public good. Currently forestry and peatland restoration are supported by up-front grant schemes, however they provide limited ongoing support, and existence of these grants in England is uncertain beyond 2025. The government has signalled an intention to integrate BECCS and DACCS into the UK Emissions Trading Scheme as a long-term commercial mechanism, supported by carbon Contracts for Difference (CfDs). Support for other CDR methods, including biochar and enhanced rock weathering, is not currently in development. Consequently the UK is off-track to meet its removal targets.

<table>
<tr><th rowspan="2">CDR method</th><th colspan="2">Regulated MRV</th><th rowspan="2">Commercial mechanisms</th><th rowspan="2">Target</th><th rowspan="2">Target on track?</th></tr>
<tr><th>National level</th><th>Project level</th></tr>
<tr><td>Forestry</td><td>Yes</td><td>Yes</td><td rowspan="2">Grant schemes in England, Scotland, Wales & N Ireland; limited in scale and long-term certainty</td><td>Create 30,000 ha per year</td><td>No</td></tr>
<tr><td>Peatland</td><td>Yes</td><td>Yes</td><td>Restore 32,000 ha per year</td><td>No</td></tr>
<tr><td>Soil carbon sequestration</td><td>Yes</td><td>No</td><td>No</td><td>No</td><td rowspan="3"></td></tr>
<tr><td>Durable wood products</td><td>Yes</td><td>Yes</td><td>No</td><td>No</td></tr>
<tr><td>Coastal wetland</td><td>Yes</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td>Biochar</td><td>Basis for development</td><td>No</td><td>No</td><td rowspan="4">Ambition of at least 5 $MtCO_2$ per year by 2030</td><td rowspan="4">No</td></tr>
<tr><td>Enhanced rock weathering</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td>BECCS</td><td>Yes</td><td>In progress (BSI standard)</td><td>In development (CfD + ETS)</td></tr>
<tr><td>DACCS</td><td>No</td><td>In progress (BSI standard)</td><td>In development (CfD + ETS)</td></tr>
<tr><td>Other (DOCCS, mineral products, etc.)</td><td>No</td><td>No</td><td>No</td><td></td><td></td></tr>
</table>

***Table ES.1**, Summary of UK policy elements and gaps*

## Public Perceptions

Public awareness of CDR in the UK is currently low. Nevertheless, recent national public appraisals show a rejection of the notion that there should be no CDR in UK climate policy, and different levels of support for different CDR methods. DACCS is viewed relatively less favourably than other CDR methods in national public appraisals, lower only than BECCS and biochar. Most people surveyed neither support nor oppose enhanced rock weathering. For all these methods most people support small-scale field trials.

Of other CDR methods for which there is quantifiable support, afforestation was a high performing option and peatland restoration was the highest performing overall option in national appraisals. Regional differences in public appraisals do not currently seem to be statistically significant, but show that certain regions could be more or less likely to support or oppose certain CDR deployments

Studies have shed light on the underlying factors determining attitudes towards, and permission for, different CDR methods. Among the strongest factors affecting attitudes are impact on the environment, perceived naturalness, and prior beliefs on climate. Safety, controllability, and low scientific uncertainty are the conditions for deployment with strongest evidence in the UK.

## Current deployment levels of CDR

CDR deployment in the UK remains modest. The vast majority of carbon removals are delivered through forestry and grassland, as recorded in the national GHG inventory. Forestry provides the largest carbon sink, delivering between -21.0 and -17.6 $MtCO_2e$ annually from 2008 to 2023. However, these gains are offset by persistent emissions from degraded peatlands, averaging +15 $MtCO_2e$ annually, and smaller net sources from cropland and settlement land. As a result, the UK's land use, land-use change, and forestry (LULUCF) sector has remained a net emitter, at approximately +0.5 $MtCO_2e$ per year on average between 2008 and 2023.

Novel removal methods, such as BECCS, and DACCS, as well as biochar, remain at the pilot or early demonstration stage. Based on reported deliveries of carbon credits, total novel removals during 2022 to 2025 are estimated at less than 8,000 tonnes.

## Looking ahead: CDR in net zero pathways

The pathway to net zero set out by the UK's Climate Change Committee projects a requirement for approximately 36 $MtCO_2$/year of novel removals by 2050, while, conventional land-based CDR is expected to provide around 44 $MtCO_2$/year, all requiring rapid scale-up before 2030. This includes tree planting at 37,000 hectares per year and peatland restoration at 49,000 hectares per year - exceeding existing government targets. The Carbon Budget sets a recommended emissions cap of 535 $MtCO_2e$ for the period 2038-2042, representing a 87% reduction relative to 1990 levels. While the UK has strong scientific and technical capabilities, current deployment levels remain below these targets.

Other studies presenting pathways to net zero in the UK have been published. The level and mix of CDR in these pathways varies, largely because of deliberate choices in the desired mix of technologies and behaviours, as well as differences and limitations in the modelling tools used. Several studies specifically target futures with minimal CDR, generally indicating the need for even stronger economy-wide reductions in demand for energy and materials than are in the CCC's pathway. With the exception of one study targeting absolute (rather than net) zero, the studies indicate a scale-up of CDR in the range 35-120 $MtCO_2$ per year. This range, and limitations in predicting the future, point to the need for an adaptable approach to CDR deployment alongside deep emissions cuts.

Despite some policy progress and some inherent uncertainty in precise levels of CDR required, it is clear that the current pipeline of CDR in the UK is insufficient to meet the government's 2030 ambition. net zero. The Figure below illustrates the scale of the challenge for novel CDR in particular. Based on all CDR projects eligible for participation in the Track 1 CCUS Clusters (primarily energy from waste BECCS), plus reported sales of future carbon credits from other CDR projects, the UK's current removal pipeline totals just 2.8 $MtCO_2$/year. This is well below the Government's 2030 ambition of 5 $MtCO_2$/year and the CCC's projected requirement of 36 $MtCO_2$/year by 2050. If the Track 1 CCUS projects are not operational by 2030, or if not all future credit sales are delivered, this shortfall will increase further.

By extension it is unlikely that CDR on its current course will scale to the levels that give confidence in meeting the 2050 net zero target. And, given the UK's position globally as a leader in R&D, finance and policy for climate action, this shortfall in domestic progress presents a risk to achieving sufficient levels of CDR globally as well.

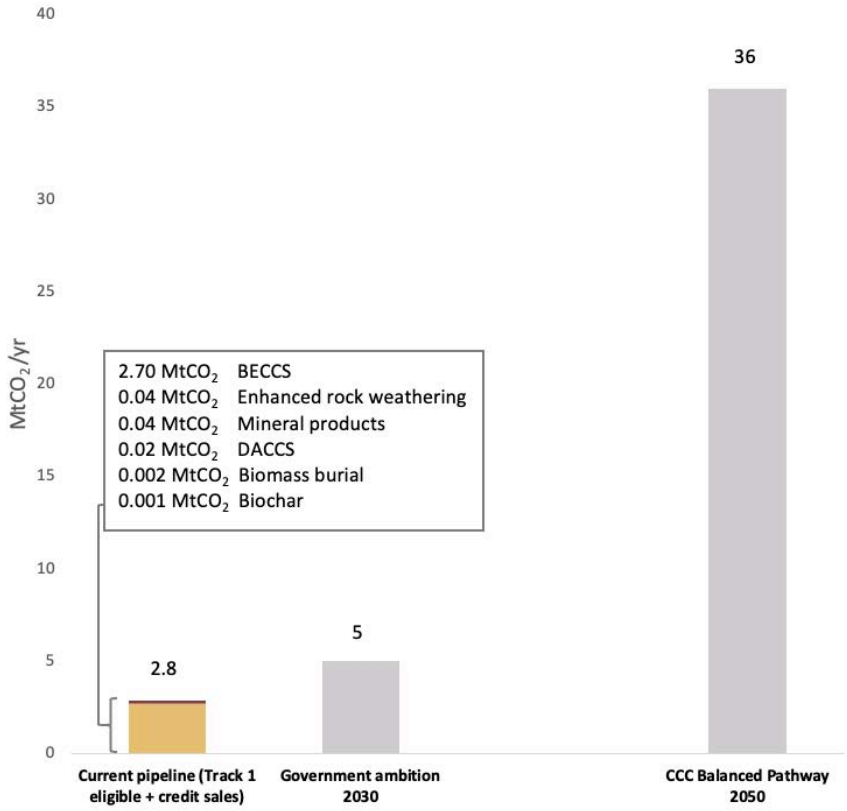



***Figure ES.2:*** *Comparison of current UK novel CDR pipeline and policy targets to CCC's 2050 Net Zero Pathway*

## Key priorities to enable scale are likely to include:

- Continuing research & development to expand the set of viable options, test them through demonstration, improve methods for measurement, and understand wider social and environmental effects;
- Establishing and improving protocols for measurement, reporting and verification. This includes at the project level and for national inventories, which are necessary for CDR methods to count towards emission targets;
- Providing stable and de-risked policy mechanisms that allow projects to become commercially viable according to their ability to deliver effective carbon dioxide removal;
- Delivering enabling infrastructure for $CO_2$ transport and storage;
- Building public trust and legitimacy, including through ensuring safety, wider environmental benefits, and alignment with ambitious emissions reductions;
- Collaborating internationally, to maximise the benefits of R&D in improving effectiveness and bringing down costs, to reduce policy conflicts, and to raise capability in the UK and elsewhere.

*Chapter 1*

# Introduction

# Chapter 1: Introduction

Climate change is being driven by emissions of carbon dioxide ($CO_2$) to the atmosphere. These emissions come from human activities: principally the burning of fossil fuels, land use and industrial processes. Emissions of other GHGs, such as methane and nitrous oxide, are exacerbating climate change further. Carbon dioxide removal (CDR) refers to processes that remove $CO_2$ from the atmosphere and store it away durably. Meeting climate goals at both the international and national level requires both rapid, large-scale reductions in $CO_2$ emissions and increases in CDR.

This report provides a UK-specific assessment of CDR progress and contributes reliable data tailored to the national context. It builds upon the second edition of The State of Carbon Dioxide Removal (2024).[1]

This chapter sets out the motivation for considering CDR within the UK context, explains the purpose and scope of this report, and introduces the key CDR methods.

## 1.1 What is CDR?

This report adopts the definition of carbon dioxide removal used by the Intergovernmental Panel on Climate Change (IPCC) and the global State of CDR report[2]:

*Human activities capturing $CO_2$ from the atmosphere and storing it durably in geological, land or ocean reservoirs or in products. This includes human enhancement of natural removal processes but excludes natural uptake not caused directly by human activities.*

This definition of CDR contains three key principles:

- **Principle 1:** The $CO_2$ captured must come from the atmosphere, not from fossil sources.
- **Principle 2:** The subsequent storage must be durable, such that $CO_2$ is not soon reintroduced to the atmosphere.
- **Principle 3:** The removal must be a result of human intervention, additional to the Earth's natural processes.

It is important to distinguish CDR from other related terms and concepts, such as carbon capture and utilisation (CCU), and carbon capture and storage (CCS). While CCS involves capturing $CO_2$ and storing it underground, it only qualifies as CDR when the captured $CO_2$ comes from the atmosphere, either through direct air capture (DAC) or indirectly through biomass or seawater. Similarly, CCU captures $CO_2$ for use in products, but products such as fuels or carbonated drinks are not durable forms of storage; only when $CO_2$ is incorporated into durable products, such as concrete aggregates or construction timber, does CCU meet the criteria for CDR. Examples of how different activities meet, or fail to meet, the principles of CDR are shown in **Figure 1.1**.

Greenhouse gas removal (GGR) – also known as 'negative emissions' – is a term often used in a UK context. GGR includes CDR alongside the removal of other GHGs from the atmosphere, such as methane ($CH_4$) and nitrous oxide ($N_2O$). Emissions and atmospheric concentrations of these gases are much smaller than for $CO_2$, and methods for their removal are generally at a much earlier stage of development. While they are not currently included in UK pathways to net zero (see **Chapter 8**), the UK does fund some research and innovation around GGR beyond solely CDR.

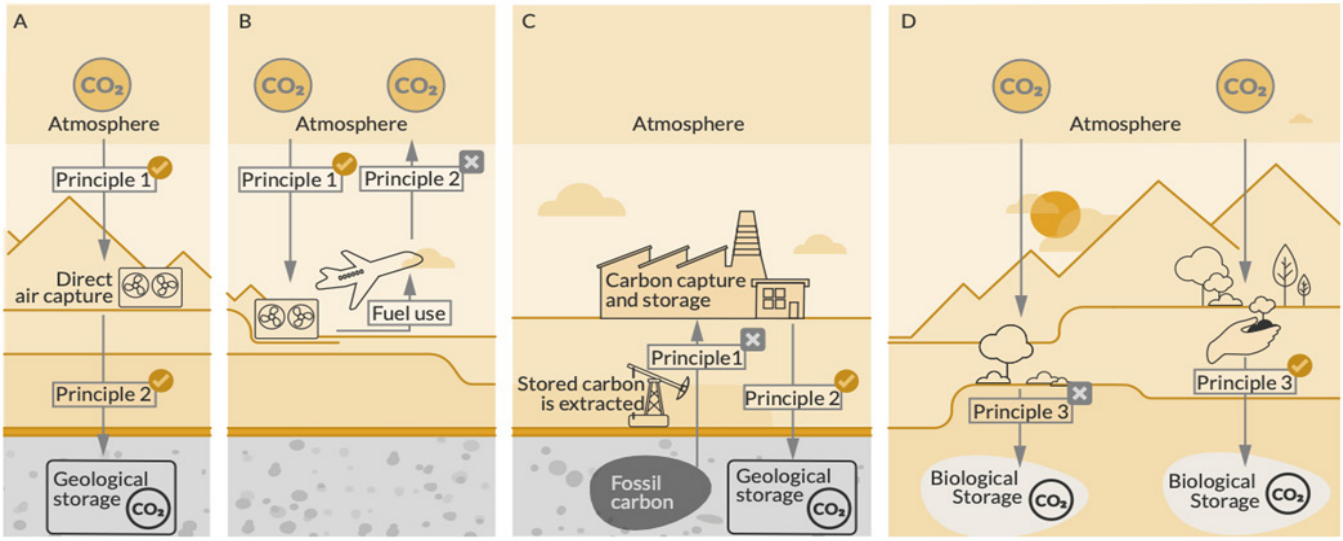



***Figure 1.1*** *What is, and isn't, CDR?*
*To qualify as CDR, a method must capture $CO_2$ from the atmosphere (Principle 1) and durably store it (Principle 2) as a result of human intervention (Principle 3). An example is direct air capture with geological storage (panel A). Several related approaches satisfy only one of these principles, and hence are not CDR. For instance, direct air capture of $CO_2$ for use in short-lived products such as fuels does not meet Principle 2 (panel B). Capture and geological storage from sources of fossil $CO_2$ emissions does not meet Principle 1 (panel C). Natural processes such as tree growth can meet Principles 1 and 2, but they only meet Principle 3 if enhanced through human activity (panel D).*

## 1.2 CDR methods and their characteristics

CDR encompasses a broad range of methods that differ in how they capture and store carbon, their readiness for large-scale deployment, and the durability of their storage. In the UK context, understanding these characteristics is critical, given the country's distinct challenges and opportunities in deploying CDR.

### Categorising CDR methods

**Figure 1.2** provides an overview of the key CDR methods considered in this report. It is not exhaustive, but shows methods that are already being deployed and/or analysed in the research literature. Whenever a specific CDR method is referred to in this report, the associated definitions and characteristics shown in this figure apply. [a] More detailed descriptions of these CDR methods can be found in the **Abbreviations**.

CDR methods are often grouped into categories for ease of reference. One common grouping is to separate "natural" or "nature-based" methods from "technological" or "engineered" methods. This categorisation is contested, however, as well as blurred (a third "hybrid" category is frequently employed to cover methods that fall in between). There are a variety of ways in which CDR methods could be grouped, and there is as yet no universal agreement on classification. The rows in **Figure 1.2** indicate different characteristics that are useful for categorising methods in different contexts.

*a This report broadly follows the categorisation and naming of methods used in the IPCC's Sixth Assessment Report (AR6). See: Babiker, M. et al. Cross-sectoral perspectives. In Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (eds. Shukla, P. R. et al.) 1245–1354. Cambridge University Press. (2022).*

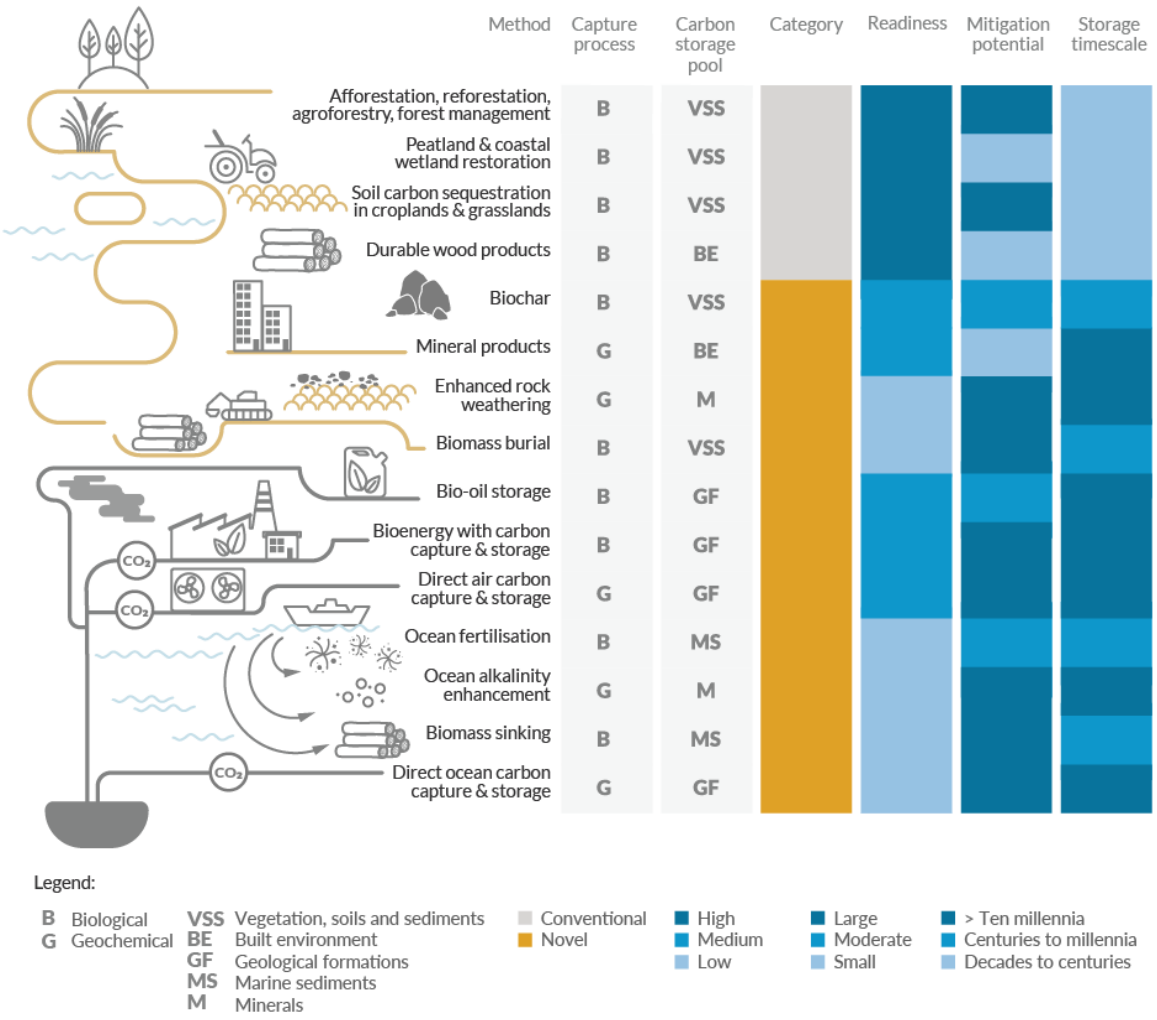



***Figure 1.2*** *Summary of CDR methods, noting their respective capture processes and carbon storage pools, categorisation as 'conventional' or 'novel', their current readiness to scale, maximum mitigation potential (large: >9 $GtCO_2$/year; moderate: 3-9 $GtCO_2$/year; small: <3 $GtCO_2$/year) and characteristic storage timescale. (Based on Babiker et al., 2022; Bustamante et al., 2023; and Cobo et al., 2023.)*

As in the global State of CDR reports, this report groups CDR methods into two categories: conventional and novel. This is based on a broad combination of their current level of readiness for deployment, the scale at which they are currently deployed, and the type of carbon storage they employ:

- **Conventional CDR:** Methods that are well established, already deployed at scale and widely reported by countries as part of land use, land-use change and forestry activities. The methods in this group include afforestation/reforestation; agroforestry; forest management; soil carbon sequestration in croplands and grasslands; peatland and coastal wetland restoration; and durable wood products.

- **Novel CDR:** All other CDR methods, which generally have a lower level of readiness for deployment and are therefore currently deployed at smaller scales **(**see **Chapter 7)**. The captured carbon is stored in geological formations, the ocean or products. Examples of such methods include bioenergy with carbon capture and storage; direct air carbon capture and storage; enhanced rock weathering; biochar; mineral products; and ocean alkalinity enhancement.

## 1.3 The role of CDR

Alongside deep and sustained reductions in GHG emissions, CDR has been widely recognised – by successive governments and other organisations – as essential for meeting climate goals. [3,4,5] It can fulfil three distinct functions within climate strategies over different timeframes:

- In the near term, CDR can help reduce net emissions.
- In the medium term, CDR can be used to counterbalance residual emissions from sectors where decarbonisation is challenging, hence facilitating net zero $CO_2$ or net zero GHG emissions.
- In the longer term, if removals exceed emissions, CDR can help achieve net-negative emissions. If global temperature rise exceeds acceptable levels, sustained net-negative $CO_2$ emissions in conjunction with deep reductions of non-$CO_2$ emissions could reverse at least some of this temperature overshoot at the global level. At a national level, achieving net-negative emissions may be seen as part of the UK's fair contribution towards global action and the Paris temperature goal.

In addition to mitigating climate change, CDR can also have wider benefits. For instance, some methods may generate electricity, fuels or materials as marketable products, while others may improve biodiversity or water quality. Weighed alongside any adverse impacts, these wider benefits are further considerations in determining the role of CDR deployment. All global pathways assessed by the Intergovernmental Panel on Climate Change (IPCC) for staying below 2°C involve some level of CDR. While the precise amount varies widely, they tend to show GHG emission reductions from 2020 to 2050 in the range of 30-40 billion tonnes of CO2-equivalent, alongside a CDR increase of 6-10 billion tonnes per year.[6]

For the UK, the Climate Change Committee's (CCC) Seventh Carbon Budget projects that meeting the legislated 2050 net zero target will require emissions reductions of around 350 million tonnes of $CO_2$-equivalent per year, alongside 36 $MtCO_2$/year of removals by new technologies and around 44 $MtCO_2$/year of removals via land use.

## 1.4 Technology readiness levels and deployment potential of CDR methods in the UK

Drawing on a 2021 report commissioned by the UK Government, **Table 1.1** provides an overview of the technology readiness levels (TRL) and deployment potential for a subset of CDR methods in the UK. This is not a complete set of all methods with potential in the UK – commercial and pre-commercial projects are emerging that involve mineral products and direct ocean carbon capture and storage, for instance – and generating cost and potential estimates for these other methods is a priority.

| CDR Method | TRL | Estimated cost (£/$tCO_2$) gross | | Potential deployment ($MtCO_2$/yr) | |
|---|---|---|---|---|---|
| | | 2030 | 2050 | 2030 | 2050 |
| **Direct Air Carbon Capture & Storage (DACCS)** | 6 | 150–700 (300) | 70-250 (130) | 0-1.3 (0.5) | 0–30 (18) |
| **Bioenergy with Carbon Capture & Storage (BECCS) - Power** | 7 | 70–150 (120) | 30-170 (100) | 0-8 (8) | 4–29 (26) |
| **BECCS - Industry** | 7 | 50–270 (100) | 40-300 (90) | 0-1 (0) | 3–6.5 (3.5) |
| **BECCS – Energy from Waste** | 7 | 60–140 (70) | 50-110 (60) | 0.5-1.2 (0.6) | 2.5–7.5 (5.5) |
| **BECCS - Hydrogen & Other** | 5 | 50–120 (60) | 30-100 (50) | 0-2 (1) | 10–35 (22) |
| **Wood in Construction** | 9 | Uncertain (0) | Uncertain (0) | 0.2-0.6 (0.4) | 0.9–2.8 (1.5) |
| **Afforestation** | 9 | 2–23 (12.5) | 2-23 (12.5) | 3-5 (3.73) | 16–24 (18.6) |
| **Habitat Restoration - Peat** | 9 | 26–48 (34) | 26-48 (34) | 0-1.5 (0.37) | 0–4.6 (1.16) |
| **Habitat Restoration - Saltmarsh** | 7 | 17–35 (23.5) | 17-35 (23.5) | 0-0.3 (0.08) | 0–1.0 (0.23) |
| **Soil Carbon Sequestration** | 8 | 4–20 (12) | 4-20 (12) | 0-12 (3.06) | 0–15 (3.8) |

**Table 1.1** *Overview of the TRL and deployment potential for a subset of CDR methods in the UK context*[b]
*Note: TRL are a type of measurement system used to assess the maturity level of a particular technology – TRL 1 is the lowest and TRL 9 is the highest. Values in brackets indicate the central estimate taken for costs and the scale deployed in the central balanced deployment scenario*
*Source: Greenhouse gas removal methods and their potential UK deployment. Element Energy, & UK Centre for Ecology & Hydrology.* https://assets.publishing.service.gov.uk/media/616ff80ce90e07197b571c95/ggr-methods-potential-deployment.pdf (2021)

## 1.5 Purpose and scope of this report

Interest in CDR has grown significantly among UK policymakers, investors, researchers and environmental groups. This has led to an expanding body of information, including academic research, market activity and policy guidance.

The first edition of the global State of Carbon Dioxide Removal report (2023) provided the first comprehensive global assessment of developments in CDR. It aimed to inform and guide further development of CDR by providing a clear, independent and authoritative assessment of available data. In June 2024, an expanded and updated second edition was published.[7]

To provide a holistic view of the state of CDR, the reports are structured around key elements in a model of innovation (see **Figure 1.3**). In this structure, the development of new technologies and practices depends on processes that interact and feedback with each other. In short, there are processes that affect the supply of technologies and practices (e.g., research and development (R&D), and demonstrations), and processes that affect demand for them (e.g., niche markets, pull-through to mass deployment, and public perceptions). All of these processes are regulated to some degree by policymaking and governance.

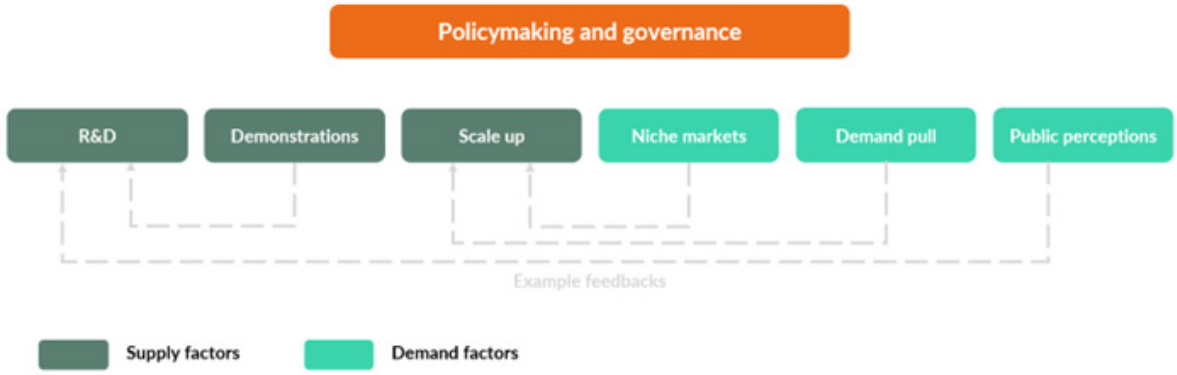



***Figure 1.3*** *The process of innovation on which this report's assessment of the state of CDR in the UK is based.*

The rest of this report follows this model by covering R&D (**Chapter 2**), early-stage scale-up through companies (**Chapter 3**), niche demand creation through voluntary carbon markets (**Chapter 4**), followed by an assessment of policymaking and governance to create demand at scale (**Chapter 5**) and an examination of public perceptions (**Chapter 6**). The subsequent chapters assess current levels of UK CDR (**Chapter 7**) and its role in national net zero pathways (**Chapter 8**).

The underlying data for this report are accessible via the database accompanying this report.

b *BECCS Power refers to carbon capture from biomass combustion in dedicated power plants; BECCS Energy from Waste involves capturing $CO_2$ from incinerating municipal or industrial waste, which contains a biogenic fraction; BECCS Industry applies carbon capture to industrial biomass use, such as in cement, lime or paper production; and BECCS Hydrogen & Other includes capturing $CO_2$ from biomass gasification or other processes used to produce hydrogen, biofuels, or other energy carriers.*

*Chapter 2*

# Research & Development

# Chapter 2: Research & Development

This chapter provides an overview of the UK's publicly funded R&D landscape for CDR. It first considers how R&D efforts align with national climate policy, particularly the legally binding target of reaching net zero by 2050. It then focuses on how the UK has developed its research capability and technical expertise in CDR through a range of funding initiatives, including government agencies, research councils, innovation programmes and demonstration projects. It also outlines how public funding has supported innovation across both conventional and novel removal methods.

## 2.1 Historical evolution of public funding for CDR-specific R&D

The UK's publicly funded CDR research landscape has developed incrementally over the past decade. In 2017, UK Research and Innovation (UKRI) and the Natural Environment Research Council (NERC) launched the UK Greenhouse Gas Removal (GGR) Research Programme. This initial four-year, £8.6 million programme primarily supported desk-based, fundamental research on the feasibility, environmental impacts, and governance of various carbon removal methods.[8] In 2018, the Royal Society Report on Greenhouse Gas Removal provided one of the first comprehensive assessments of CDR's potential within the UK. This report emphasised the need for demonstration projects across a range of CDR approaches, including afforestation, biochar, and BECCS. Its findings helped lay the groundwork for subsequent initiatives, including the Greenhouse Gas Removal Demonstrators (GGR-D) Programme, designed to move from theoretical research toward practical demonstrations of carbon removal technologies.

Building on these foundations, in 2021, the UKRI launched the Greenhouse Gas Removal Demonstrators (GGR-D) Programme with a larger investment of £31.5 million. This phase explicitly shifted focus from research to pilot-scale demonstration. In parallel, the Department for Energy Security and Net Zero (DESNZ) launched the Direct Air Capture and Greenhouse Gas Removal Innovation Programme, with £60 million awarded directly to pre-commercial projects across two phases.[9]

## 2.2 Alignment with policy priorities

Public investment in CDR research and innovation in the UK is directly tied to the country's 2050 net zero target. Both the Net Zero Strategy (2021) and the Net Zero Growth Plan (2023) identify GGR as necessary to address residual emissions from sectors in which full decarbonisation can be technically or economically challenging (see **Chapter 5**).

National R&D priorities are also shaped by the UK's participation in international frameworks. These include commitments under UN international climate negotiations, such as the reporting of emissions and removals and submission of Nationally Determined Contributions (NDCs) under the Paris Agreement, and membership of the EU until 2020. Although the UK is no longer part of the EU, it remains associated to Horizon Europe, which is a large source of R&D funding relevant to EU climate action.

The GGR-D Programme, administered by UKRI, explicitly states that its aim is to assess sustainable routes for large-scale GGR, allowing the UK to make a significant step towards net zero emissions. It also aims to position the UK to benefit from the estimated £400 billion future global market for GGR technologies.[10]

More broadly, public research funding helps de-risk early-stage innovation; supports interdisciplinary collaboration across science, engineering, and social research; and ensures that the UK develops domestic expertise. This strengthens the evidence for future policy decisions, including the portfolio of available CDR methods, and how to integrate them into decarbonisation pathways, and national carbon budgets, as well as regulatory and reporting frameworks.

## 2.3 Major publicly funded CDR research programmes

The UK's publicly funded CDR research and innovation landscape is coordinated primarily through DESNZ and UKRI. Several research councils within UKRI support fundamental research and demonstration across different carbon removal methods. Other government departments and innovation agencies fund applied research, technology demonstration, and commercial readiness initiatives.

### The UK Greenhouse Gas Removal (GGR) Research Programme

The UK GGR Research Programme, running during 2017-21 and funded by NERC, was the first coordinated national research programme dedicated to exploring GGR methods in the UK. This £8.6m programme supported four multi-institution research consortia, focusing on soils-based removals, afforestation and BECCS feasibility, enhanced weathering, and regionally comparative assessments of GGR pathways, respectively. Each consortium combined natural science, engineering and social science research, addressing technical feasibility, environmental impacts and policy requirements.[11] They examined areas such as agroforestry; methane removal; life cycle assessment methods; monitoring, reporting and verification (MRV) methods for GGR; and potential mitigation deterrence effects if removals are relied upon to substitute emission reductions.[12]

The GGR Research Programme advanced the evidence base on GGR for policy and investment decisions. Many researchers involved also contributed directly to the Royal Society's 2018 report on GGR, which highlighted the need to shift towards practical demonstration and deployment.[13] These provided the scientific basis that later informed the development of the GGR Demonstrators Programme (GGR-D), creating a research-to-demonstration pipeline for GGR within the UK's public funding landscape.[14]

### The Greenhouse Gas Removal Demonstrator (GGR-D) Programme

Launched in 2021, the GGR-D Programme represents UKRI's largest CDR investment to date. With £31.5m in funding, it supports five large-scale demonstrator projects (see **Box 2.1**) alongside the establishment of the $CO_2$RE Hub.

The GGR-D Programme was explicitly designed to bridge the gap between academic research and real-world application by funding pilot-scale projects to test technical feasibility, MRV systems, environmental sustainability, and community engagement across a range of removal approaches. It aims to position the UK to benefit from the estimated £400bn future global market in GGR technologies.[15]

**Box 2.1 The five demonstration projects in the GGR-D Programme**

- **The NetZeroPlus Demonstrator**: This project gathers evidence, addresses knowledge gaps and allows decision makers to explore the GGR consequences of different tree-planting interventions. As well as GGR, the project delivers insights on how tree-planting can deliver other benefits such as enhanced biodiversity, water quality, recreation and health, and is pioneering tools for decision making that take into account all the effects of land use change.[16]
- **The Perennial Biomass Crops (PBC4GGR) Demonstrator**: PBC4GGR is investigating the potential for plants like willow and miscanthus to support BECCS in the UK. It demonstrates novel establishment techniques that maximise yield whilst minimising GHG emissions. The project aims to establish the conditions required for farmer uptake and wider societal acceptance, and to investigate costs, benefits and trade-offs for biodiversity and ecosystem services. New field trials have been developed for miscanthus (Bishop Burton College, East Yorkshire) and willow (Myerscough College, Lancashire).[17]

- **The GGR-Peat Demonstrator**: This project works with natural processes to restore and enhance the environmental conditions that lead to peat formation. Simultaneously it is developing innovative approaches to increase rates of CO2 uptake and store it securely for millennia. Three experimental test locations are being established in representative lowland and upland peat settings: South Yorkshire; land owned by the National Trust in the South Pennines; and the Pwllpeiran Upland Research Centre in Wales.[18]
- **The Enhanced Rock Weathering Demonstrator**: The project explores amending soils with crushed calcium and magnesium rich silicate rocks from waste quarry fines to accelerate natural CO2 sequestration. It aims to provide the first integrated whole system assessment of the science, societal and scalability opportunities and challenges of enhanced rock weathering deployment in UK agriculture. Field sites are in Plynlimon (mid-Wales), and Rothamsted Research's North Wyke grassland platform (Devon) and arable research facility (Harpenden)[19]
- **The Biochar Demonstrator**: This project addresses uncertainties around the extent of biochar deployment and its carbon stability, together with quantifying effects on soil health and ecosystem services, economic viability and social acceptability. Field trials are at arable and grassland sites in the Midlands and Wales, an open cast coal mine site in Cumbria, denuded railway embankments, and forestry sites in England and Wales.[20]

The $CO_2$RE Hub is backed by six institution and led by the University of Oxford.[c] It provides scientific coordination across the five GGR-D projects and conducts multi-disciplinary research on CDR policy, governance, public engagement, and economic viability. $CO_2$RE also manages a flexible fund to support smaller-scale exploratory research into emerging CDR techniques not covered by the main demonstrators.[21] The $CO_2$RE Hub also used £0.5m in funding from Innovate UK, through the Undaunted climate accelerator, to support CDR start-ups.[22]

## The DESNZ Direct Air Capture and Greenhouse Gas Removal Innovation Programme

Alongside UKRI-led programmes, DESNZ launched its own Direct Air Capture and Greenhouse Gas Removal (DAC & GGR) Innovation Programme to target novel CDR methods and bring them towards commercial readiness.[23]

The programme was announced in 2021 as part of the government's Net Zero Innovation Portfolio, unfolding across two phases:

- Phase 1 (2021) funded 23 feasibility studies, with a total investment of £5.6m. This phase focused on early-stage design, technical feasibility, cost estimation and environmental impact assessments.[24]
- Phase 2 (2022–25) allocated £54.4m to 15 of the Phase 1 projects. This funding took forward the designs to the construction and operation of pilot plants, the development of bespoke MRV systems, and the assessment of real-world performance.[25]

This programme explicitly prioritises novel removal technologies that are scalable to tackle residual emissions in difficult areas, such as parts of the agriculture and aviation sectors. Many funded projects combine novel and conventional removal methods, such as hybrid systems integrating biochar production with carbon storage, or combining direct air carbon capture and storage (DACCS) with renewable energy deployment.

*c $CO_2$RE's six institutions are Imperial College London, University of Bristol, University College London, University of Edinburgh, University of Manchester and University of Oxford. See $CO_2$RE. Who we are. https://co2re.org/who-we-are/*

## Other UKRI funding initiatives

UKRI and its constituent research councils have supported other CDR-related research through grants, thematic calls and interdisciplinary programmes. [d] Between 2021 and 2024, UKRI invested approximately £62m in research explicitly related to GGR and CDR (see **Table 2.1**), of its total spending of £24.2bn across all fields.[26]

A broader portfolio of GGR-relevant research occurs beyond the GGR-specific programmes. This includes smaller-scale individual projects, as well as programmes and projects which focus on technology elements and issues that contain important overlaps with removals. Among these, the Engineering and Physical Sciences Research Council (EPSRC) has provided over £22m funding since 2012 to the UK Carbon Capture and Storage Research Centre (UKCCSRC).[27] The Land Use for Net Zero (LUNZ) Hub was launched in 2023 with £6.5m of funding, supporting integrated research on land use change for climate mitigation.[28] The Farming Innovation Programme, jointly run by the Department for Environment, Food and Rural Affairs (Defra) and UKRI, has committed up to £30m to support on-farm R&D across England. Several of its projects aim to support sustainable land management, soil health and low-emissions farming practices – areas that can intersect with land-based CDR approaches over time.[29]

| Year | Direct CDR/GGR Funding (£m) |
|---|---|
| 2021 - 22 | 19 |
| 2022 - 23 | 21 |
| 2023 - 24 | 22 |
| **Total (2021 - 24)** | **62** |

***Table 2.1*** *Breakdown of UKRI CDR/GGR investment (2021–24)*
*Source: UK Research and Innovation. UKRI investment and outputs publication. https://www.ukri.org/what-we-do/what-we-have-funded/investment-and-outputs-publication/ (2024)*

Other smaller-scale funding streams within UKRI continue to play a vital role in supporting discovery science, fostering early-stage innovation, and linking research on removals to wider social and environmental priorities.[30] Together, these programmes contribute to a broad innovation pipeline, though there is limited formal coordination. This approach aligns with a portfolio model supporting a basket of CDR options at different stages of maturity, while allowing space for the development and evaluation of emerging techniques through ongoing research. However, there are currently no confirmed or published plans for what will follow these programmes after 2025.

## Other public funding initiatives

Funding for research and demonstration also comes from public bodies beyond UKRI, principally government departments and agencies. In 2021, a £12.5 million pilot programme, "Nature-based Solutions for Climate Change at the Landscape Scale", was launched by Natural England in partnership with Defra and the Environment Agency, with funding from the Treasury's shared Outcomes Fund. It supports large-scale projects to help demonstrate and quantify the carbon removal potential of restoring and enhancing natural habitats such as woodlands, wetlands, peatlands, and grasslands.[31] As part of this initiative, £4.3 million was allocated to six projects in 2023.[32]

The government's £1 billion Net Zero Innovation Portfolio, in addition to including its specific programme on Direct Air Capture and Greenhouse Gas Removal, contains several other programmes which support removal technologies. These include the "Hydrogen BECCS Innovation Programme", allocating up to £31 million to support the development of technologies that combine bioenergy production with carbon capture and hydrogen generation.[33] The Portfolio also includes the CCUS 2.0 Innovation competition, which awarded approximately £1.8 million to three CDR-focused projects: CCm Technologies (Mineral Products), MONET (BECCS), and UK BECCS-MCFC (BECCS). Adding these to

*d Further details on UKRI-funded environmental research can be explored through: Natural Environment Research Council. Grants on the Web. https://gotw.nerc.ac.uk*

the Direct Air Capture and Greenhouse Gas Removal Programme indicates total funding of around £93m for removals technologies across the whole of government's Net Zero Innovation Portfolio.

In 2025, DESNZ funded strategic research into carbon removal deployment through programmes run by the Energy Innovation and Research Office. Delivered by Energy Systems Catapult, recent studies have explored the system integration of DACCS and BECCS in the UK, including siting constraints, cost profiles and contributions to net zero pathways. These projects highlight the role of public funding not only in supporting innovation, but also in assessing the feasibility and system-level impacts of different CDR options.[34]

## 2.4 Building research capacity

A skilled workforce is essential to scaling CDR in the UK, with a key role for education and training in universities and other research institutes.[35] UKRI funds postgraduate research through Centres for Doctoral Training (CDTs), Doctoral Training Partnerships (DTPs), and individual studentships, many of which could support CDR-related research depending on thematic priorities.[36, 37] At least one doctoral training programme, hosted by Aston University's Net2Zero Centre, offers dedicated training in carbon removal technologies as part of its broader focus on industrial decarbonisation.[38]

Early-career researchers can also access support through schemes like the Future Leaders Fellowships (FLF). Launched in 2018, the FLF programme provides up to £1.5 million per fellow.[39, 40] At least three fellows directly focus on CDR-related proposals.[41] The Future Leaders Fellowship represents a flexible route for early-career innovation in the field.

The UK's training and skills development ecosystem for CDR is distributed across several existing UKRI mechanisms, rather than being consolidated into a dedicated removal-focused programme. This approach has successfully supported research across natural sciences, engineering, and social sciences, but the fragmented nature of funding means that interdisciplinary training opportunities, which are critical for removals, can be harder to access. As the UK aims to accelerate the scale-up of CDR technologies, future training programmes could benefit from clearer thematic focus on carbon removal within doctoral and early-career pathways. This could involve targeted calls for removal-specific training grants, or new cross-council initiatives that actively foster the combination of environmental science, engineering, economics, and policy skills required for effective removal deployment.

| CDR method | Fundamental science research | Pilot demons-tration | MRV | Social science research | UK funding source(s) |
|---|---|---|---|---|---|
| **Afforestation / reforestation** | Yes | Yes | Yes | Yes | UKRI GGR-D Programme, Natural England, Forestry Commission, Scottish Forestry, Defra |
| **BECCS** | Yes | Yes | Yes | Yes | DESNZ DAC & GGR Innovation Programme, UKRI GGR-D Programme, BBSRC, EPSRC/UKCCSRC, Innovate UK, BEIS |
| **Biochar** | Yes | Yes | Yes | Yes | UKRI GGR-D Programme, DESNZ DAC & GGR Innovation Programme, Natural England |
| **DACCS** | Yes | Yes | Yes | Limited | DESNZ DAC & GGR Innovation Programme, Innovate UK, EPSRC/UKCCSRC, UKRI |
| **Direct Ocean Carbon Capture and Storage (DOCCS)** | Yes | Limited | Limited | Limited | DESNZ DAC & GGR Innovation Programme |
| **Enhanced rock weathering** | Yes | Yes | Yes | Yes | UKRI GGR-D Programme, NERC, DESNZ DAC & GGR Innovation Programme |
| **Ocean alkalinity enhancement** | Limited | Limited | No | Limited | UKRI, NERC, Defra |
| **Peatland restoration** | Yes | Yes | Yes | Yes | UKRI GGR-D Programme, Natural England, IUCN UK Peatland Programme, Defra, NatureScot |
| **Soil carbon sequestration** | Yes | Limited | Limited | Yes | Innovate UK, NERC, Defra |

***Table 2.2*** *Overview of UK research funding according to CDR methods*

## Trends in academic publications

The volume of UK-affiliated scientific publications on CDR increased from just 12 in 2000 to 194 in 2022 - over a 16-fold increase.[e] There with a noticeable acceleration in the growth of publications after 2008 (see **Figure 2.1**), coinciding with the passage of the UK Climate Change Act (see **Chapter 5**). This trend likely reflects both growing academic interest and the increasing policy relevance of carbon removal in UK climate strategies.

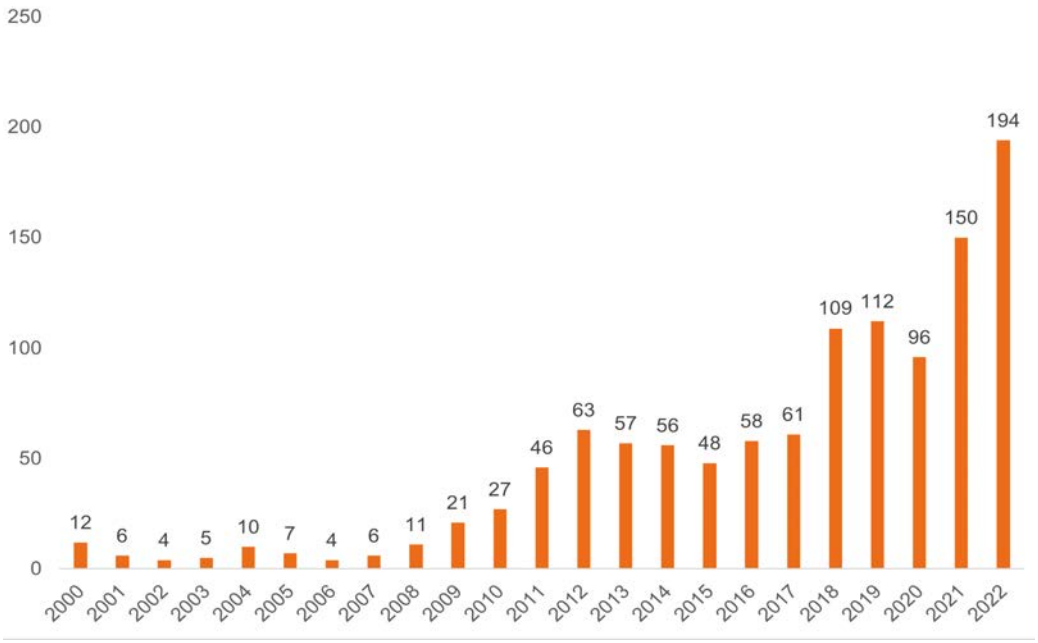



***Figure 2.1*** *Number of UK-affiliated CDR-related scientific publications per year (2000–22)* [f]
*Source: Lück, S. et al. Scientific literature on carbon dioxide removal much larger than previously suggested: insights from an AI-enhanced systematic map. Preprint (version 1) available at Research Square: https://doi.org/10.21203/rs.3.rs-4109712/v1. (2024).*

Publications in the early 2000s focused heavily on afforestation and reforestation: its share of publications peaked in 2002 before gradually declining. From the 2010s, biochar emerged as a dominant topic, alongside BECCS until the 2020s (see **Figure 2.2**). The latter may reflect its inclusion in UK and international decarbonisation pathways and policy scenarios. Soil carbon sequestration has maintained a consistent presence in UK-affiliated research publications. Other methods, such as enhanced weathering, ocean fertilisation and DACCS, appear more sporadically, though several show signs of gradual growth since the late 2010s.

*e "UK-affiliated" refers to publications in which the lead author was affiliated with a UK institution at the time of publication.*

*f This analysis draws on data from a bibliometric database filtered using machine-learning techniques, using both general (e.g., "carbon removal") and method-specific keywords (e.g., "biochar", "afforestation") applied to Scopus-indexed titles and abstracts. The use of "CDR" here reflects formal terminology found in academic publications, rather than capturing all research activities related to carbon storage or land-based sinks. Inclusion criteria differ by method and are outlined in the dataset protocol. The methodology is described in detail in: Lück, S. et al. Scientific literature on carbon dioxide removal much larger than previously suggested: insights from an AI-enhanced systematic map. Preprint (version 1) available at Research Square: https://doi.org/10.21203/rs.3.rs-4109712/v1 (2024).*

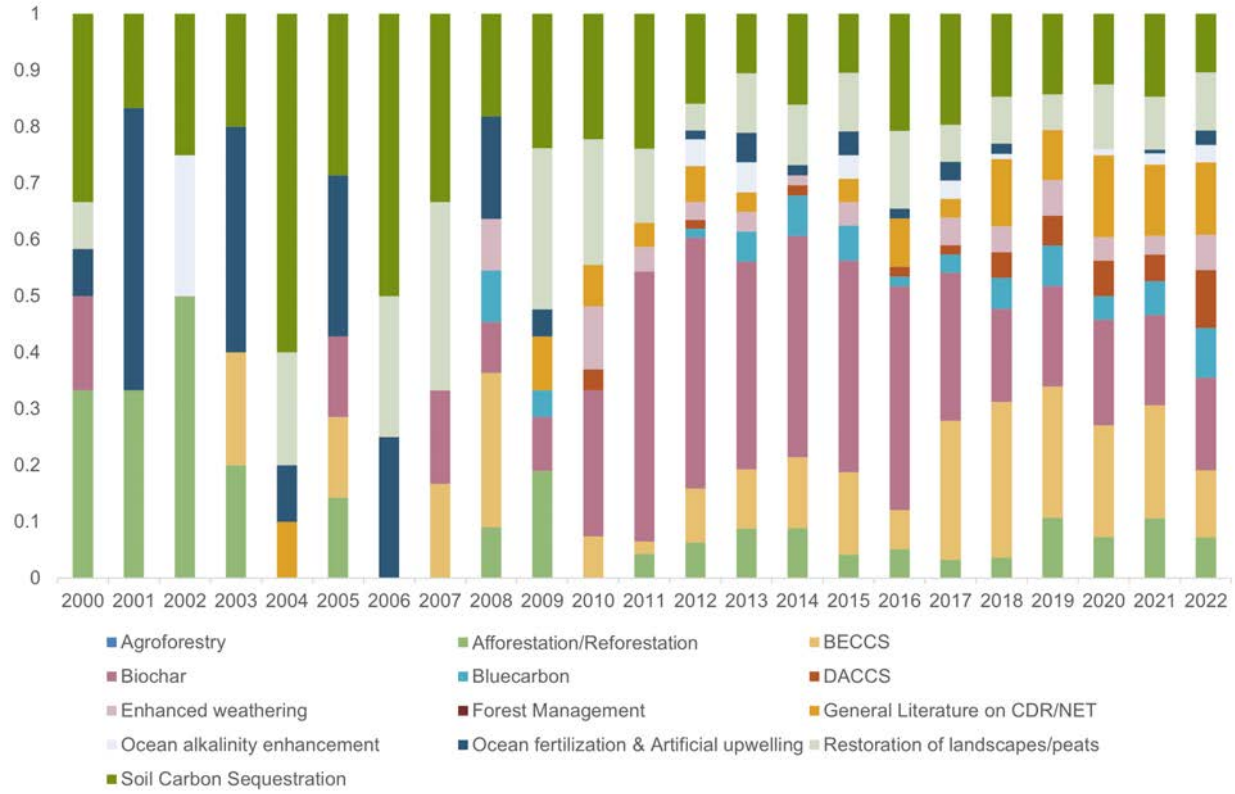



***Figure 2.2*** *Share of UK-affiliated CDR-related scientific publications by method (2000–22)*
*Source: Lück, S. et al. Scientific literature on carbon dioxide removal much larger than previously suggested: insights from an AI-enhanced systematic map. Preprint (version 1) available at Research Square: https://doi.org/10.21203/rs.3.rs-4109712/v1.*

Overall, while the UK's research publication landscape has been historically concentrated on land-based approaches, there is emerging diversification. However, the relative shares by method fluctuate year to year, suggesting that further longitudinal tracking is needed to confirm enduring shifts in focus.

## 2.5 Conclusion

Publicly funded R&D plays a central role in shaping the UK's approach to CDR. Over the past decade, UKRI and the UK Government have built a funding landscape spanning basic research, applied demonstration projects and policy-relevant innovation. This ecosystem reflects the UK's recognition that carbon removal will be essential to achieving net zero by 2050.

The UK GGR Research Programme and GGR-D Programme have provided substantial investments in both conventional and novel removal methods, supporting work from fundamental process research to pilot-scale deployment. Parallel initiatives, such as the DESNZ DAC and GGR Innovation Programme, have focused on scaling novel removal solutions, particularly DAC. Together, these programmes have positioned the UK as a frontrunner in public funding for CDR.[42] Doctoral training and early-career fellowships are building a skilled research workforce, though training on CDR remains largely embedded within broader environmental, engineering, and climate science programmes, rather than being a standalone priority.

Both the GGR-D Programme and DESNZ Innovation Programme are funded until 2025. It is not yet clear what new public R&D programmes will be put in place to ensure that removal methods can continue to progress from research into scalable, commercially viable deployment. While significant research has been funded to date, research gaps remain across CDR methods. Continued coordination between R&D programmes, commercialisation mechanisms, policy targets and pathways will shape the future development of CDR.

*Chapter 3*

# UK Companies

# Chapter 3: UK Companies

The UK's CDR sector has expanded, particularly since 2021. There are 108 CDR companies in the UK, with more in the wider sector, although most have fewer than 50 employees. In addition to the UK's long-standing focus on conventional CDR, such as afforestation and peatland restoration, businesses are emerging for methods such as biochar, DACCS, BECCS and emerging hybrid methods.

## 3.1 Overview of the UK CDR industry

The UK's CDR industry has been shaped by a combination of entrepreneurs, R&D (see **Chapter 2**), developing government support (see **Chapter 5**) and corporate interest in the purchase of carbon removal credits (see **Chapter 4**).

The sector includes a mix of early-stage companies, established firms, and research-led spinouts, with startups dominating the space, highlighting the growing innovation and development of carbon removal technologies. Most companies are operating at the pre-commercial or pilot stage of deployment. There are 108 carbon removal companies based or operating in the UK (see the database accompanying this report).[g] Approximately 50% were founded in or after 2020, suggesting a sharp increase following the UK's net zero commitment in 2019 (see **Chapter 5**) and the strengthening of international ambition under the Paris Agreement (see **Figure 3.1**). The firms established before 2021 show a slightly greater concentration in biochar, afforestation and BECCS activities, which likely reflects the longer history of these approaches and established value chains.

Only a small proportion (6 out of 108) of companies on the list are removals companies headquartered outside the UK (majority BECCS), indicating that the vast majority of removals operations are undertaken by UK-based ventures. Conversely, only 3 out of the 108 UK-registered companies have pilot or demonstration projects located outside the UK, all of which are in either the United States or Canada. These cases pertain to DACCS technologies, likely reflecting the stronger policy incentives and more developed supporting ecosystems available in North America.

In addition to removal-focused ventures, the broader UK CDR ecosystem includes actors such as credit trading platforms, insurance providers and venture capital firms, all of which play a role in supporting the development and scaling of carbon removal solutions.

*g The actual number of companies engaged in CDR is likely to be higher than the estimate in this report, as some companies may not explicitly identify as CDR ventures, particularly those either offering co-benefits or offering removals as co-benefits. This is especially true for conventional approaches such as afforestation and peatland restoration, as well as novel methods like biochar, which had established markets and benefits prior to the formal recognition of carbon removal as a distinct category.*

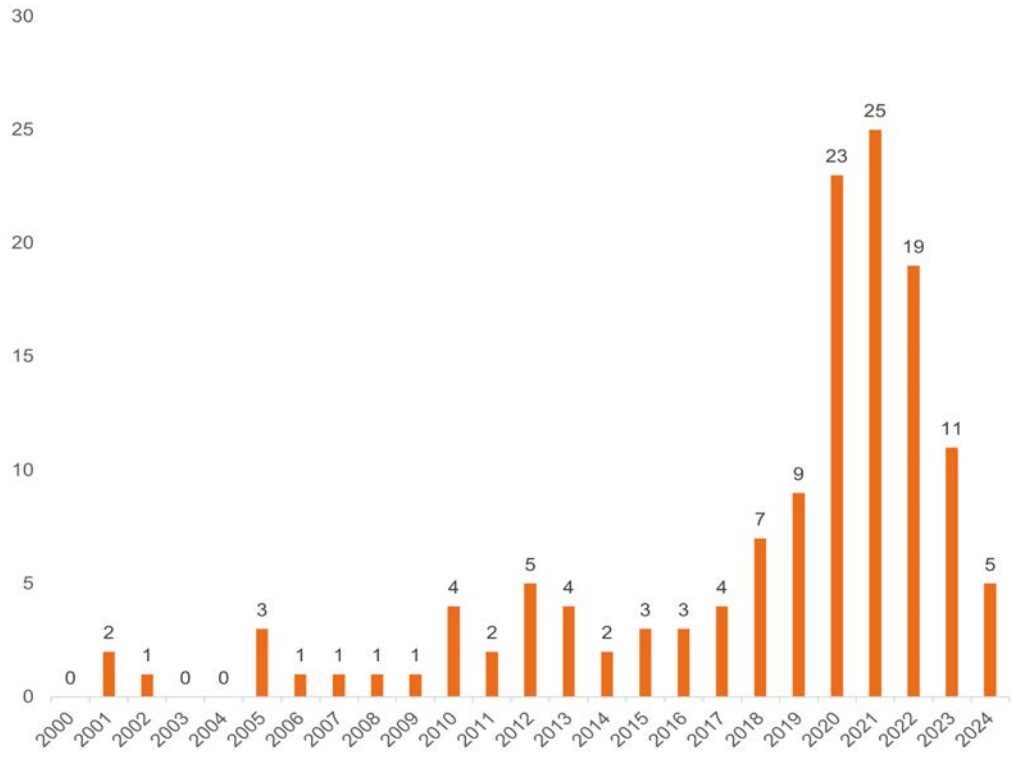



***Figure 3.1*** *Number of UK CDR companies founded (2000–24)*[h]
*Source: Data compiled from multiple sources, including NetZero Insights, PitchBook, CDR.fyi, Kumu, government publications, and general internet searches*

## Company size

More than half (57%) of UK CDR companies have fewer than 10 employees, and over three quarters (77%) have fewer than 50 (see **Figure 3.2**).This demonstrates the early-stage nature of the industry, with firms typically focusing on research, pilot-scale projects, and technology validation in small teams or even as individual entrepreneurs.[ij] Around 10% of the companies are focused on conventional land-based CDR, and are as small as those working on novel approaches. A small number of companies working on biochar, BECCS or operating carbon marketplaces have larger teams, often linked to their origins in established sectors such as bioenergy or environmental services. These firms are exceptions within an otherwise early-stage and low-headcount sector.

*h* *See the database accompanying this report.*
*i* *Out of 115 removal companies, we could trace employee counts for only 83 of them.*
*j* *The 77% translates to 83 out 108 CDR removal companies, whereas 139 is the number of companies (out of 141) that had publicly available data for the staff size.*

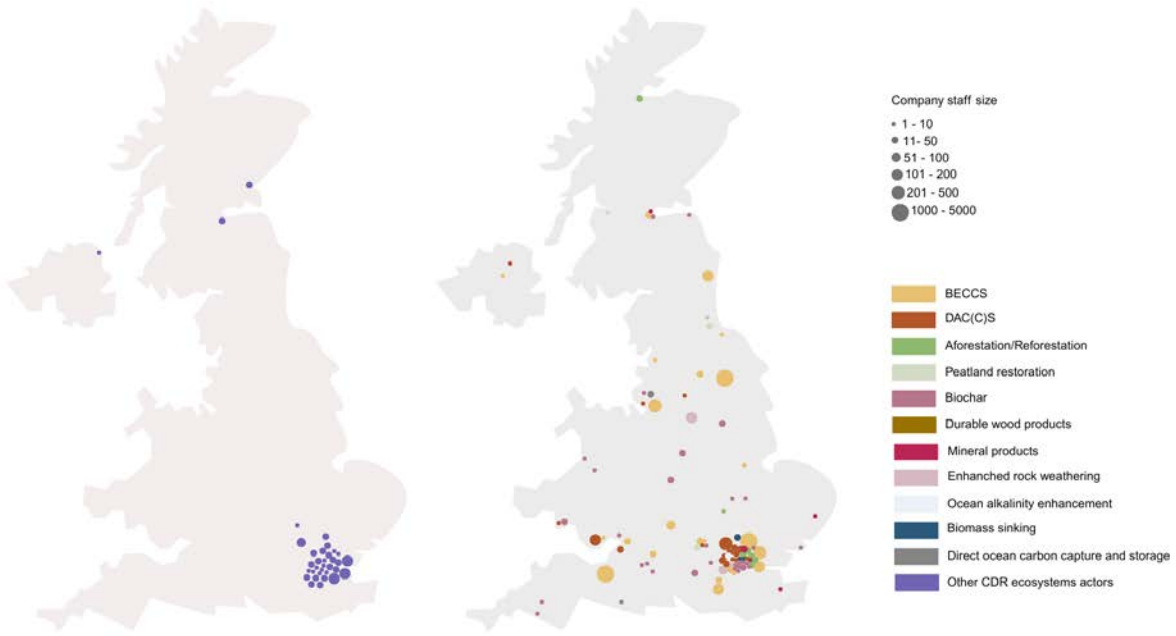



***Figure 3.2*** *Map of UK CDR companies, according to method and staff size (2000–24)*[k]
*Note: These maps are based on a compiled database drawing from public and proprietary sources.*
*Source: Database assembled internally by CO2RE. Sources include NetZero Insights, PitchBook, CDR.fyi, government documents, and internet*

## Organisational models

Various organisational models for carbon removal are emerging in the UK, each tailored to specific technologies and market opportunities. Some companies adopt a comprehensive approach, managing the entire CDR process – from $CO_2$ capture to storage – in a search for cost efficiencies. Others are focusing only on particular stages of the CDR value chain, with specialisation facilitating deep expertise and optimisation. Some ventures are shifting their business model towards licensing their technologies to other businesses.[l] This practice is already being seen in the biochar sector, and technologies in DACCS and BECCS are following suit.

## Co-benefits

Given the nascency stage of the sector, characterised by uncertainties in costs and policies, many companies are actively experimenting with strategies to enhance revenue generation. Beyond traditional carbon credit mechanisms and voluntary carbon markets, there is a growing emphasis on co-benefits and co-products, i.e., additional marketable goods derived from CDR activities. For example, BECCS projects may produce electricity, hydrogen, bio-oil or biofuel alongside carbon sequestration. Biochar projects can yield biofuel and bio-oil as co-products. Some DACCS models explore integration with renewable energy systems or the production of synthetic fuels, offering additional revenue streams beyond $CO_2$ removal alone. Conventional methods, such as afforestation and peatland restoration, can offer biodiversity enhancements that could be subsidised or included in nature markets. By integrating these co-benefits and focusing on a "carbon plus" business model, companies aim to diversify revenue streams and mitigate uncertainties inherent in the evolving demand for carbon removal.

*k Companies with missing staff size data have been excluded from the map. Additionally, firms founded before 2000 have been omitted to avoid distortion from large legacy engineering companies, some of which report workforces exceeding 5,000 employees. The map is therefore intended as an indicative overview only.*

*l Insights on CDR business models are based on interviews with entrepreneurs and investors conducted by the $CO_2$RE Business Models team. A detailed analysis of these findings is forthcoming.*

### Company locations

The UK's CDR sector shows signs of regional clustering, particularly around existing research networks, academic institutions, business ecosystems and renewable energy sources (see **Figure 3.2**). Proximity to industrial infrastructure and potential carbon storage sites, such as those being developed within the UK's carbon capture, usage and storage (CCUS) clusters, may also be shaping where projects are emerging (see **Chapter 5**).

London is the dominant hub for UK CDR companies: many early-stage CDR companies, including those working on DACCS, biochar and carbon marketplaces, are headquartered there. The city is home to a concentration of investors, policy institutions and research organisations, which may contribute to its prominence as a base for these firms. However, the data reflect company headquarters rather than necessarily the locations where operations or pilot projects are taking place, as deployment sites are often chosen based on infrastructure, land availability and storage potential. The North of England, which benefits from industrial hubs and proximity to geological carbon storage capacity, features a concentration of DACCS projects.

University cities such as Aberystwyth, Bangor, Cambridge, Edinburgh, Nottingham and Oxford are focal points for research-driven CDR innovation, particularly in DACCS, mineralisation and novel biological capture methods. These institutions contribute to technology spinouts and collaborations between academia and industry. Both Wales and the Midlands feature a noticeable presence of biochar projects. This may reflect the proximity of agricultural operations, access to biomass feedstocks and land availability for deployment. Compared to other novel removals, biochar projects are more dispersed across the UK rather than concentrated close to major urban hubs.

## 3.2 Key CDR methods and market trends in the UK

The UK CDR sector features a diverse mix of methods at different stages of innovation, demonstration and deployment (see **Table 3.1**). While some methods, such as biochar and afforestation, have more established supply chains, others, including DACCS, ocean alkalinity enhancement and enhanced weathering, remain in earlier phases of R&D. Out of the 15 CDR removal methods identified in the global state of CDR report, 11 are present in the UK.[43] There has been a noticeable rise in novel CDR removal methods in recent years, indicating a shift towards solutions based on engineering technology.

| UK companies by CDR method | Count |
|---|---|
| Biochar | 35 |
| BECCS | 27 |
| DACCS | 18 |
| Afforestation, reforestation, agroforestry, forest management | 7 |
| Mineral products | 6 |
| Enhanced rock weathering | 5 |
| Peatland and coastal wetland restoration | 3 |
| Biomass sinking | 2 |
| Direct ocean carbon capture and storage | 2 |
| Ocean alkalinity enhancement | 2 |
| Durable wood products | 1 |
| Other CDR ecosystem actors | 37 |
| **Total** | **145** |

***Table 3.1*** *Breakdown of UK CDR companies by removals methods* [m]

*Source: NetZero Insights, PitchBook, CDR.fyi, government documents, and internet search.*

*m The classifications of DACCS and BECCS include companies developing $CO_2$ capture technologies intended for carbon removal, regardless of whether they currently have access to durable storage infrastructure. The majority are not yet operating full end-to-end removal systems. Where applicable, alternative $CO_2$ use cases may also be explored by these firms.*

## Biochar

Biochar is the most prevalent CDR method by UK company count, driven by its relatively low technological barrier to entry, and the existing demand for its co-benefits in the agricultural sector.[44] Biochar companies are relatively decentralised, with only 20% of reported companies headquartered in London. Nearly three quarters (74%) of biochar companies were founded after 2012. These newer companies tend to be more focused on the durability of carbon removal and storage. However, biochar has sold the lowest amounts of carbon credits on the voluntary carbon market (see **Chapters 4** and **7**).

## DACCS and BECCS

Throughout this chapter, we use the terms 'DACCS' and 'BECCS' to include UK companies developing direct air capture (DAC) and bioenergy with carbon capture (BEC) technologies that are intended for use in durable carbon removal. Many of these companies do not currently operate full end-to-end removal systems with verified durable storage. Several DAC companies are in early stages of development and are focusing on $CO_2$ capture only, while others (e.g., Mission Zero Technologies) are partnering with downstream actors for mineralisation or concrete curing. Similarly, some BECCS-oriented firms include alternative $CO_2$ utilisation pathways in their business models. While all companies included here identify carbon removal as a potential or explicit goal, the actual deployment of complete DACCS or BECCS systems is limited.

After Biochar, BECCS is the second-most prevalent CDR method, measured by the number of UK companies. Individual BECCS projects tend to have the largest $CO_2$ removal capacity of all CDR methods, and are often integrated with existing biomass supply chains, bioenergy plants and waste-to-energy infrastructure. Most ventures in this category were either established or pivoted towards carbon capture after 2012.

A notable example is Drax Group, one of the UK's leading BECCS developers, which is retrofitting its biomass power station in North Yorkshire with carbon capture technology.[45] The project aims to capture and store up to 8 $MtCO_2$ per year, which would make it by far the largest CDR project in the UK and one of the largest in the world.[46]

DACCS is the third-most highly represented method among UK companies and the most sought-after CDR method among investors, recognising its presumed high-durability and potential for scalability. [n] While some DAC companies date back to 2009, most have emerged since 2018. Currently, most DACCS ventures operate in the pilot and demonstration phases, capturing only a few kilotonnes of $CO_2$ per year. Some UK-based DAC ventures are piloting or demonstrating their technologies abroad – where infrastructure, incentives or renewable energy are more favourable. DOCCS, a related approach that separates dissolved $CO_2$ from water rather than from air, has also gained traction, with two new ventures founded in 2023.

## Forestry, durable wood products, and peatland and coastal wetland restoration

Conventional removal solutions remain widely adopted due to their lower costs, accessibility and integration with existing land use practices (see **Chapter 7**). Companies engaged in this sector may not necessarily brand themselves as carbon removal enterprises, leading to likely under-reporting in our analysis.

Afforestation, reforestation, agroforestry and forest management can provide co-benefits beyond carbon removals, such as biodiversity enhancement, soil retention and habitat restoration. However, trade-offs may arise, especially where monocultures or non-native species are used. According to available data, 75% of ventures in this category were founded after 2020. Most focus on tree plantations, forestry management and carbon sequestration. All three recorded ventures focusing on peatland and coastal wetland restoration were established before 2020. Some

*n Insights on CDR business models are based on interviews with entrepreneurs and investors conducted by the $CO_2$RE Business Models team. A detailed analysis of these findings is forthcoming.*

companies operate across multiple conventional CDR categories, including afforestation and peatland restoration.

### Other CDR methods

Emerging methods such as enhanced weathering, marine biomass sinking, and ocean alkalinity enhancement have fewer UK-based developers. Most of these methods have emerged since 2019 and remain at lower TRLs.

### Platform-based marketplaces

While not directly removing carbon, there is a diverse range of other CDR ecosystem actors that support the development, deployment, and management of removal methods. These include marketplace platforms, insurance providers, technology developers across the value chain, MRV services, ratings and certification bodies, carbon marketplaces, and finance and trading platforms. Among these, there is a concentration of companies in the platform-based marketplaces for CDR. These platforms facilitate carbon credit transactions and enhance transparency in carbon accounting. Their rise reflects the growing demand for high-integrity carbon removals and structured, verifiable exchanges between buyers and CDR providers (see **Chapter 4**).

## 3.3 Funding patterns

Funding for CDR in the UK has been unevenly distributed across different approaches, reflecting both technological maturity and investor confidence. Funding data is available for more than half (80 out of 141) of CDR companies, but is reported as cumulative capital raised to date rather than detailed deal-by-deal information. BECCS (76%), DACCS (7.3%) and other ecosystem actors (10.5%) have raised the highest capital to date with mean funding of £42m and median funding of £3.7m. This figure is heavily skewed by three large BECCS companies founded before 2014. When these are excluded, the mean funding falls to £14.3m, and the median to £3.1m. Notably, other CDR ecosystem actors have secured substantial investment (£346m in total), highlighting the growing interests of investors in enabling services in the scaling of CDR.

To better understand recent funding dynamics, a subset of companies (n=53) founded in 2020 or later, with available funding data, were analysed. In this group, no new BECCS ventures have been established, while other CDR ecosystem actors (46%), DACCS (35%) and mineralization (7.6%) dominate the funding landscape. This suggests a growing shift toward CDR-enabling services and engineered removals in recent years. For these newer ventures, the mean total funding raised was £12.1m, while the median was £3m, indicating a potentially more balanced distribution of capital in the emerging CDR sector. The median is slightly lower than the typical size of government or seed-stage VC grants, which reflects both the early-stage nature of these startups, as well as the relatively modest level of capital invested in the sector. This highlights the continued need for public and blended finance mechanisms to de-risk early innovation and unlock scale of CDR technologies.

As this shows, although DACCS remains capital-intensive, it has attracted major funding in recent years. However, BECCS, despite its scalability potential, has seen relatively fewer independent startup-led projects. Emerging methods such as enhanced weathering, ocean CDR and enhanced ocean alkalinity remain at the lower end of the funding spectrum, primarily reliant on research grants and pilot-scale investments, likely due to higher uncertainty or limited commercial readiness.

| CDR method | Total raised to date (£m) | |
|---|---|---|
| | Companies founded 2020 or later (n=53) | Companies founded 2020 or later (n=53) |
| BECCS | 5.0 | 2523.5 |
| Other CDR ecosystem actors | 276.0 | 346.4 |
| DACCS | 205.6 | 236.7 |
| Mineral products | 46.5 | 53.7 |
| Peatland & coastal wetland restoration | 0.0 | 46.0 |
| Afforestation, reforestation, agroforestry, forest management | 21.5 | 36.2 |
| Biochar | 12.8 | 26.6 |
| Enhanced rock weathering | 18.0 | 18.0 |
| Biomass sinking | 3.5 | 3.5 |
| Direct ocean carbon capture and storage | 3.0 | 3.0 |
| Ocean alkalinity enhancement | 0.3 | 0.3 |
| **Grand total** | **592.2** | **3294.0** |

***Table 3.2*** *Total capital raised to date by UK CDR companies by removals method (for companies with funding data available)*

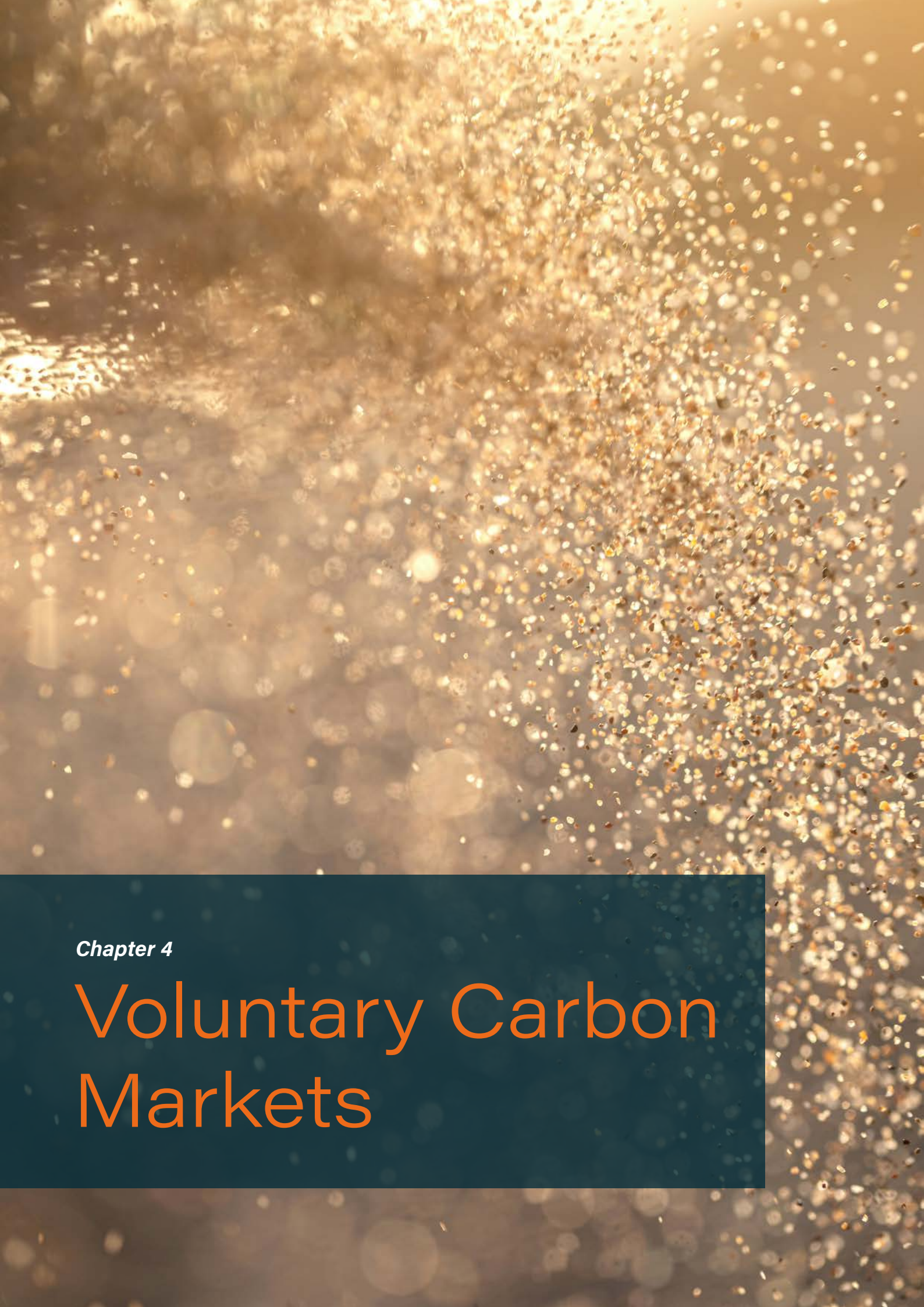
## 3.4 Conclusion

The UK's CDR sector has experienced rapid growth, particularly since the early 2020s, with over 100 companies actively engaged across a range of methods. This expansion has been driven by entrepreneurial activity, robust research capabilities and support from public funding programmes and private venture capital.

Most UK CDR companies remain small and at early stages of technology deployment, primarily operating pilot-scale or pre-commercial projects. This reflects both the sector's immaturity and innovation-focused approach that characterises the UK's broader climate tech landscape.

While some novel methods, such as biochar, have shown early commercial traction, others like DACCS and BECCS are attracting increasing attention and investment, highlighting the potential for scalable, durable removals in the future.

As detailed in **Chapter 2**, the UK's well-established R&D ecosystem continues to play a crucial role in underpinning innovation and technical advancement across various CDR approaches. Additionally, **Chapter 5** illustrates the strength of the UK's policy and regulatory environment, which can further enhance the growth and commercial viability of carbon removal solutions.



*Chapter 4*

# Voluntary Carbon Markets

# Chapter 4: Voluntary Carbon Markets

Unlike compliance markets such as the UK Emissions Trading Scheme (ETS), which oblige specific operators to participate under legally binding caps, participation in voluntary carbon markets (VCMs) is optional. Participation is motivated by corporate climate commitments, consumer pressure, and sustainability goals, as opposed to regulatory requirements. The UK's interaction with VCMs remains small in scale, but currently plays an important role in supporting CDR.

## 4.1 Defining VCMs

Broadly, VCMs are a set of platforms through which companies, governments and individuals voluntarily finance projects that avoid, reduce or remove emissions. VCMs are estimated to account for around 2% of total carbon trades; compliance markets (i.e. emissions allowance trading schemes) cover the rest.[47] VCMs nonetheless play a role in enabling companies to go beyond their regulatory obligations and finance additional climate action.[48]

The majority of carbon credits historically issued on VCMs come from avoidance and (particularly deforestation) reduction projects, renewable energy projects, and clean cookstove distribution.[49, 50, 51] While these dominate the market by volume, removal-based credits are gaining attention as companies seek to meet net zero targets.

Similar to its global counterpart, this report adopts a broad definition of VCMs, encompassing both transactions that occur via voluntary marketplaces and those where CDR is directly procured from suppliers and publicly reported. This includes traditional registry-based VCMs, as well as niche markets that facilitate the pre-purchase of novel CDR. Some CDR projects selling into VCMs now could in the future become eligible to sell credits into compliance schemes.

**Box 4.1 How do VCMs work?**

To understand CDR in the VCMs, it is important to first understand the role of VCMs in climate change mitigation more broadly. VCMs is generally understood as a platform through which actors voluntarily finance projects that reduce or remove CO2 emissions. VCMs are estimated to account for around 2% of total carbon trade, with compliance markets (emissions trading schemes) covering the remaining 98%.[52] The vast majority of carbon trading involves emissions allowances, while VCMs deal exclusively in carbon credits. Despite its relatively small share, VCMs play a role by enabling companies to go beyond their regulatory obligations and finance additional climate action.

While traditionally used by companies to demonstrate voluntary climate leadership, VCMs may increasingly intersect with government-led efforts. Under Article 6 of the Paris Agreement, governments may use credits, including those originating in voluntary schemes, as part of their international trading under their Nationally Determined Contributions (NDCs). This emerging interface between voluntary and compliance systems introduces further scrutiny over credit quality, accounting rules and governance frameworks.[53, 54]

Carbon credits are tradable certificates typically generated from projects developed and governed by private project developers and owners. One credit represents 1 tonne of avoided, reduced or removed $CO_2$ (or $CO_2$- equivalent emissions of other GHG). Such projects can occur in different sectors, such as forestry, agriculture or energy, and may come with co-benefits (e.g. improvements to biodiversity).

Carbon credits are usually issued by carbon crediting programmes, which certify projects according to recognised methodologies. Certification follows third-party verification, after which credits are issued on a registry. Each credit can only be retired once, to avoid double counting.

Carbon crediting programmes include the American Carbon Registry, Climate Action Reserve, Verra (Verified Carbon Standard), Gold Standard, Isometric, Plan Vivo and Puro.earth. In the absence of a single international regulator, this diversity has led to fragmentation and variation in credit quality and oversight.[55]

Credits can be sold directly to buyers (such as corporations), via intermediaries (such as brokers) or through pre-purchase agreements. Once a credit is retired or cancelled, it is considered used and cannot be traded again. However, some credits are not immediately retired, and are instead held for future use or resale.

## A brief history of VCMs

VCMs began several decades ago; however, the Clean Development Mechanism (CDM) under the Kyoto Protocol marked the launch of the first international carbon credit market under the United Nations Framework Convention on Climate Change (UNFCCC).[56] Although the CDM officially came into force in 2005, crediting had already begun earlier. Its purpose was twofold: to help higher-income countries meet their emissions targets, and to direct climate finance toward mitigation projects in lower-income countries.

However, the CDM faced persistent concerns about transparency, the actual climate impact of its projects, and additionality, i.e., whether or not an activity would happen without the incentive of carbon credits.[57] Despite these challenges, the underlying process and methodologies supporting the generation of carbon credits have continued to evolve and improve, and now underpin emerging approaches to the generation of carbon credits under Article 6.4 of the Paris Agreement.

This historical reliance on CDM methodologies remains relevant and, in some cases, problematic. Research has shown that a number of CDM projects produced low-quality credits with questionable additionality, meaning the credited emissions reductions may have occurred even without the carbon finance provided through the mechanism.[58,59,60] Nonetheless, Parties agreed at COP29 to allow afforestation/reforestation and other CDM projects to transition without requiring a new additionality assessment.[61] These decisions indicate that legacy methodological challenges may continue to shape the credibility of carbon markets under Article 6.

For the UK, understanding this history is important because the lessons from the CDM's shortcomings directly inform the current focus on ensuring high-integrity VCM credits through initiatives like the Integrity Council for the Voluntary Carbon Market (ICVCM) and the Voluntary Carbon Markets Integrity Initiative (VCMI). As the UK seeks to align its domestic standards with these evolving global benchmarks, ensuring the credibility of UK-based removals is key. However, challenges remain. For instance, the ICVCM currently requires a minimum of 40 years of monitoring and compensation for reversal risks for certain conventional removal categories - a threshold that may be viewed as insufficient to guarantee permanence over climate-relevant timescales. [o 62,63,64]

## The role of VCMs in supporting CDR development

VCMs have served an important but limited role in financing early-stage CDR development and deployment. Current VCM volumes for novel CDR methods remain low. According to CDR.fyi, global durable CDR purchases reached 8 million tonnes in 2024 (up 78% from 2023), but actual deliveries remain modest at just 319,000 tonnes, or 4.4% of booked volume. Purchases remain heavily concentrated, with over 75% coming from Microsoft, Google, and Frontier coalition buyers, underscoring the sector's reliance on a small number of highly committed actors.[65]

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*o Note: REDD+ projects, previously excluded from the CDM due to concerns about permanence and leakage, are now eligible under Article 6 and recognised within ICVCM and the Core Carbon Principles (CCP) framework. The latter are ten fundamental, science-based principles for identifying high-quality carbon credits that create real, verifiable climate impact. This shift reflects broader debates over evolving definitions of quality and integrity in carbon crediting.*

VCMs support a broader portfolio of removal methods than existing UK or international policy frameworks. In 2024, purchased volumes spanned BECCS, DACCS, biochar, enhanced weathering, mineralisation, ocean-based methods, and more. Biochar accounted for the largest share of deliveries globally (86% in 2024), while DACCS and BECCS dominated total tonnes purchased.

Price signals in VCMs remain method-sensitive: globally, DACCS credits averaged $316/t in 2024 (down from $692/t in 2023), while BECCS credits averaged $227/t and biochar rose to $165/t. This pricing reflects the niche, high-quality segment of VCMs, where early adopters help de-risk investment and support the emergence of robust MRV frameworks. However, these prices are unlikely to support mass deployment without broader policy support or procurement incentives.

The data also reinforce that the strength of VCMs lie in their role as first-mover market, not primary finance mechanism for scale-up. Only 36% of CDR suppliers listed on CDR.fyi have recorded a sale, and new buyer growth remains slow. The CDR market thus continues to depend on a small set of corporate leaders and needs stronger policy tailwinds to expand (see **Section 4.2** for more on government procurement and support schemes).

## 4.2 The role of VCMs in expanding CDR in the UK

### The UK's early attempts to shape VCMs (2007–09)

Between 2007 and 2009, the UK Government took early steps to strengthen the integrity of the emerging VCM. Defra launched a public consultation and developed a Draft Code of Best Practice for Carbon Offset Providers in 2008, proposing a voluntary accreditation scheme and quality mark for offsets.[66] It used accurate accounting, Kyoto-compliant credits, and focused on transparent communications. In parallel, the Environmental Audit Committee conducted an inquiry and released a report in July 2007, urging the UK Government to lead on defining offset quality standards to prevent consumer mistrust.[67] While the quality mark saw limited uptake and no mandatory standard followed, these early initiatives reflect the UK's long-standing interest in high-integrity carbon markets. Many of the same concerns from that period, such as additionality, permanence and consumer confidence, remain central to current debates around carbon removals in VCMs.

### The UK's experience with carbon credit programmes and standards

Following its early engagement with voluntary offset accreditation, the UK Government launched the Quality Assurance Scheme to certify high-quality carbon credits. However, uptake was low. Key standards like the Gold Standard and Verified Carbon Standard opted out, and the scheme was discontinued in 2011.[68] The same year, the UK established the Woodland Carbon Code as its official standard for UK-based forestry-based removals, followed by the Peatland Code in 2018. Both provide government-backed MRV frameworks and credit issuance systems.

Agriculture soil carbon crediting is being developed, with several private initiatives underway, though no formal UK standard yet exists.

### Re-engagement post-COP26

Following COP26 in Glasgow in 2021, the UK re-engaged in VCM governance, recognising its role in mobilising private finance for carbon removals. The UK played a key role in shaping Article 6 of the Paris Agreement, laying the groundwork for future alignment between voluntary and compliance markets.[69] As part of this effort, the Government's 2024 principles for Voluntary Carbon and Nature Market consultation proposes endorsing the outputs from two key initiatives funded by the UK COP26 Presidency: the Integrity Council for the Voluntary Carbon Market (ICVCM) and the Voluntary Carbon Markets Integrity Initiative.[70] These global frameworks aim to set clear quality benchmarks for projects and clear rules for how companies can credibly use voluntary credits in their climate strategies.

### UK Government's 2024 Principles for Voluntary Carbon and Nature Market Integrity

In 2024, the UK Government published six principles for high-integrity voluntary and nature markets:

1. Credits must complement emissions reductions within company value chains.
2. Credits must meet high-integrity standards, including additionality, verification and safeguards.
3. Planned credit use should be disclosed in sustainability reporting.
4. Credit use should align with credible transition plans and science-based targets.
5. Green claims must be clear and accurate.
6. Market participants should collaborate to strengthen governance and access. [71, 72]

These principles reinforce that VCMs are a complement to decarbonisation and not a substitute. They intend to support credible climate action and unlock finance for high-quality removals. In April 2025, the UK Government launched a consultation on how best to implement these principles in practice, including improving transparency, building market confidence, and clarifying the role of corporate credit use in credible climate strategies.[73]

### How VCMs fit into the UK's Net Zero Strategy

The Net Zero Strategy (2021) and Net Zero Growth Plan (2023) recognise that carbon removals are essential to reaching net zero by 2050 (See **Chapter 5**). While public funding supports early-stage innovation, the government acknowledges that private finance is needed to scale removals. As the UK aims to increase the role of novel removal methods, the government has committed to using an approved registry for credits issued under its business models, which will record and track each credit from issuance to retirement. This reflects alignment with emerging international standards such as the ICVCM's Core Carbon Principles, which include requirements for robust tracking and transparency.

By aligning with international standards, promoting high-integrity credit use, and developing its Contract for Difference support mechanism around the voluntary credit purchases (see **Chapter 5**), the UK aims to position VCMs as a trusted financing tool within its broader climate strategy, particularly for novel methods.

## 4.3 Snapshot of UK VCM activity

### Overview and data gaps

Data on the participation of UK-based projects and buyers in voluntary carbon markets is patchy. A mix of registries provide some information on credit issuances, retirements, and prices. However, many transactions still occur through bilateral contracts that are not publicly disclosed or tracked on registries, limiting visibility into total market dynamics. Data from CarbonPlan's OffsetsDB also shows that only around 13% of issued UK credits have been retired so far. This illustrates a gap in understanding how credits are ultimately used, whether for voluntary corporate climate strategies, future compliance obligations, or other purposes.

Additionally, data on buyer identity and location is limited. This means we cannot analyse UK-based buying behaviour, nor show whether UK-issued credits are purchased primarily by UK-based companies or by international buyers.

As a result, the data presented below offers only a partial view of the UK's overall VCM activity. Data availability is expected to improve over time: the UK government has committed to using an approved registry for removal credits issued under its business models, to record and track each credit from issuance to retirement; also, the EU's Corporate Sustainability Reporting Directive will apply to many large companies operating in the UK, requiring them

to report not just how much they offset, but the origin of those credits.

## UK credit issuances on international registries

Data from the Berkeley Voluntary Registry Offsets Database (2024) and CarbonPlan's OffsetsDB (2025) (see **Table 4.1**) indicates that the majority of UK-listed projects in global registries fall outside the Woodland Carbon Code and the Peatland Code. Instead, UK projects listed with Verra, Gold Standard and other international registries focus more heavily on methane capture and agricultural interventions, with removals playing a much smaller role in voluntary credit issuance.

The data in Table 4.1 shows that 98% of UK-issued credits tracked in these global registries come from methane reduction or avoidance projects in either the industrial or agricultural sector (including reduction from enteric fermentation by cattle). $CO_2$ reductions from energy efficiency projects (particularly housing retrofits) contribute a further 1–2%.

| Category | Scope and type | Credits issued | Credits retired | % of total UK issuance |
|---|---|---|---|---|
| Emission Reduction | GHG management (methane capture) | 104,000 | 11,400 | 95% |
| | Agriculture (enteric fermentation) | 3,300 | 1,100 | 3% |
| | Energy efficiency (housing decarbonisation) | 1,480 | 1,480 | 1.3% |
| CDR | Novel | Not recorded | Not recorded | N/A |
| | Conventional | Not recorded | Not recorded | N/A |
| Total | | 108,606 | 14,000 | 100% |

***Table 4.1*** *UK credits issues and retired, as of April 2025*

*Source: Haya, B. K. et al. Voluntary Registry Offsets Database v2025-04.Berkely Carbon Trading Project, University of California, Berkely. https://gspp.berkeley.edu/faculty-and-impact/centers/cepp/projects/berkeley-carbon-trading-project/offsets-database (2025); CarbonPlan. OffsetsDB. https://carbonplan.org/research/offsets-db (2025)*

The lack of conventional CDR methods likely reflects the preference of UK land-based projects to find domestic buyers through the domestic Woodland Carbon Code and Peatland Code frameworks, whereas projects targeting international buyers tend to register under other frameworks such as Verra or Gold Standard.

The absence of novel removal methods such as DACCS and BECCS in both databases is notable. No novel removal credits have yet been formally issued or retired from UK projects within these registries. This is in part due to the early-stage nature of most novel removal transactions, which are typically structured as forward purchase agreements that deliver credits only after verification has occurred.[74] Registries have only recently begun to define conditions under which such future removals can be transacted as "credits", which cannot be retired until the removal is verified and issued. This underscores the early stage of market development for novel CDR methods in the UK.

## UK credits from conventional CDR projects

Voluntary credits available for purchase are generated in the UK from some conventional removal projects, particularly afforestation and peatland restoration. These projects are certified and placed on domestic registries under the Woodland Carbon Code and Peatland Code, which are government-backed standards for quantifying and verifying removals.

The Woodland Carbon Code, established in 2011, certifies projects that sequester carbon through afforestation.

These projects issue Pending Issuance Units (PIU) before full verification, which are converted to Woodland Carbon Units after monitoring and verification, typically after five years and then every ten years thereafter.[75] The Peatland Code, launched in 2018, covers restoration projects aimed at reversing emissions from degraded peatlands.[76] This also issues PIUs that convert to Peatland Carbon Units after verification events.

Woodland Carbon Code prices have shown a steady upward trend, reflecting growing demand for high-integrity UK-based conventional removal methods. In 2023, the average price per PIU reached £25.36, up from £14.93 in 2021. Verified Woodland Carbon Units, which represent fully delivered and verified removals, command even higher prices.[77]

| | 2021 | 2022 | 2023* part year |
|---|---|---|---|
| Volume | 233,022 | 212,275 | 60,355 |
| Spread price (i.e., difference between highest and lowed reported price) | £27.76 | £33.20 | £37.50 |
| Volume weighted average price per PIU – nominal terms | £14.93 | £19.13 | £25.36 |
| Volume weighted average price per PIU – real terms (adjusted to 2022 prices) | £15.74 | £19.13 | £24.15 |

***Table 4.2*** *Woodland Carbon Code Units: volume and value (2021–23)*
*Note: * Over 99% of units transacted were PIUs. Volume weighted average is the ratio of the value of credits traded to the total volume traded during a given timeframe ([price x volume summed over all transactions] / total volume). Assumed 5% inflation from 2022 to 2023 based on Bank of England Base Rate in June 2023.*
*Source: IUCN National Committee UK Peatland Programme. UK carbon price index. https://www.iucn-uk-peatlandprogramme.org/peatland-code/uk-carbon-price-index (2023)*

For the Peatland Code, pricing data is more limited due to the smaller project base and lower transaction volumes. However, recent data shows PIUs transacting at around £23.95 in 2022, with verified Peatland Carbon Units likely to attract higher prices when they become more common.[78] Despite rising prices, volumes for both codes declined in 2022, potentially signalling supply chain, permitting, and land use barriers.

| | 2021 | 2022 | 2023* part year |
|---|---|---|---|
| Volume | -- | 11,416 | -- |
| Spread price (i.e., difference between highest and lowest reported price) | -- | £25.00 | -- |
| Volume weighted average price per PIU – nominal terms | -- | £23.95 | -- |

*Table 4.3 Peatland Code Units: volume and value (2022)*
*Note: * 100% of units transacted were PIUs. Volume weighted average is the ratio of the value of credits traded to the total volume traded during a given timeframe [(price x volume summed over all transactions] / total volume). Insufficient data reported in 2021 and 2023 at time of publication.*
*Source: IUCN National Committee UK Peatland Programme. UK carbon price index. https://www.iucn-uk-peatlandprogramme.org/peatland-code/uk-carbon-price-index (2023)*

## UK credits from novel CDR projects

Sales, deliveries and average prices by method for novel CDR credits are aggregated by the CDR.fyi database.[79] The data for UK-based projects indicates that a total of just over 130,000 tonnes have been sold, spanning six different methods - enhanced rock weathering (around 40,000 tonnes), mineral products (around 40,000 tonnes), BECCS (30,000 tonnes), DACCS (around 20,000 tonnes), as well as biochar and biomass burial (1,000 tonnes each).[80] Unlike

the more developed voluntary markets for emission reductions and conventional removals, only a small number of those (7,900, equating to 5%) have been delivered to date (see **Table 4.3**).

All deliveries of novel CDR credits in the UK come from just four companies. They have all occurred since 2022, indicating comparatively rapid growth from a small start. Prices are not publicly available for individual projects, but globally-aggregated and weighted data for each method indicates that they are substantially more expensive than other carbon credits.

| CDR method | Credits sold | Credits delivered | Global weighted average price ($) |
|---|---|---|---|
| Enhanced rock weathering | 40,445 | 3,814 | 360 |
| Mineral products | 38,724 | 3,296 | 340 |
| BECCS | 30,498 | 0 | 180 |
| DACCS | 19,670 | 0 | 490 |
| Biomass burial | 1,706 | 0 | 61 |
| Biochar | 1,050 | 792 | 150 |

*Table 4.4 UK novel CDR credits issues and retired, as of April 2025*
*Source: CDR.fyi. Leaderboards. https://www.cdr.fyi/leaderboards*

### Contextualising UK VCMs within a global context

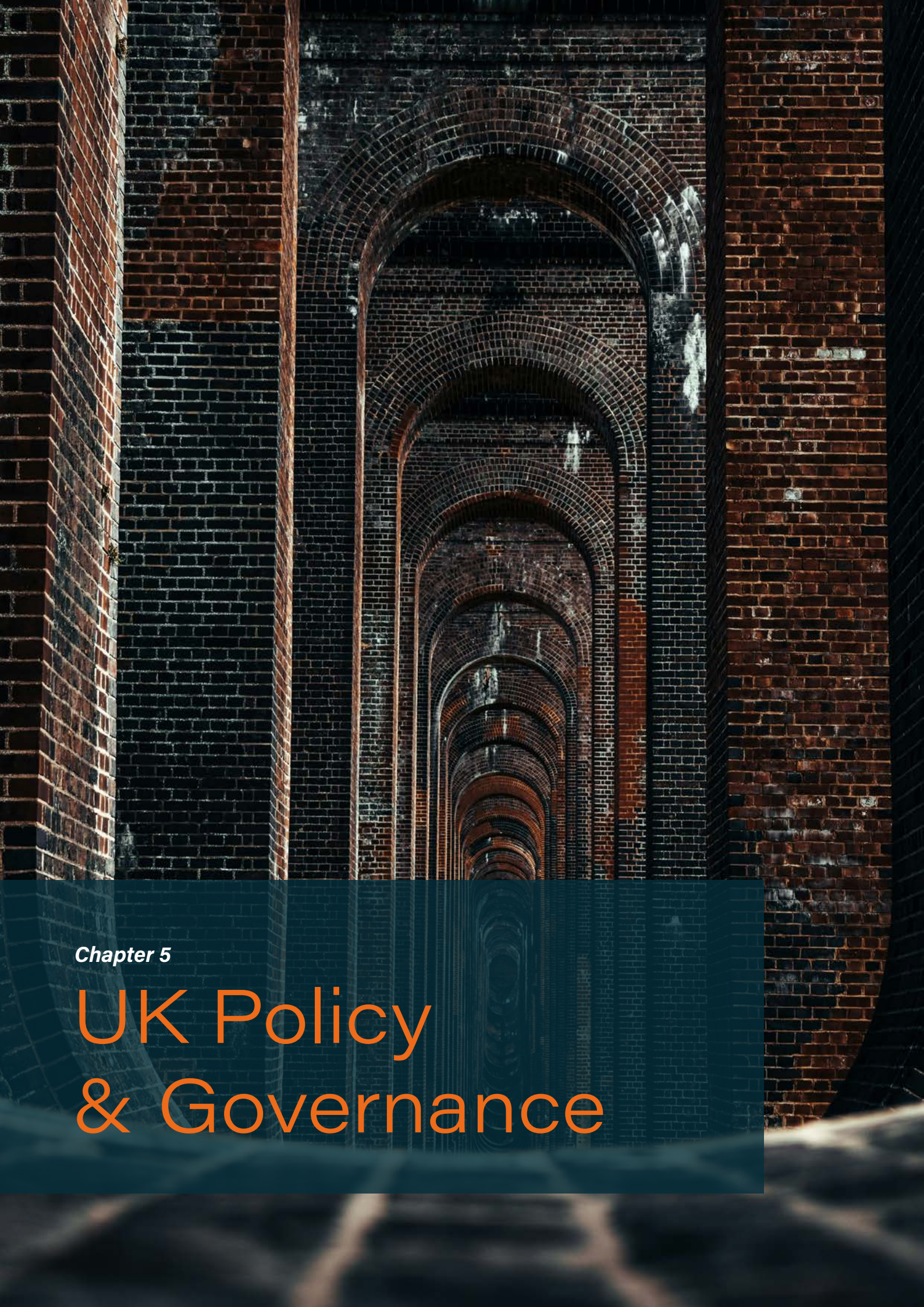
Globally, CDR credits account for less than 10% of all credits traded on VCMs in 2023.[81] Within this small global share, conventional CDR, primarily afforestation and reforestation, dominates in terms of volume, while novel CDR methods such as DACCS and biochar remain a niche within the niche, representing just a fraction of a percent of global voluntary market transactions.[82] For novel CDR, voluntary demand has grown significantly, with cumulative purchases increasing from 600kt in 2022, to 4.6Mt in 2023 and, as of mid-2025, cumulative purchases of CDR stand at 28Mt. This surge highlights early corporate willingness to invest in emerging removals, though the volumes remain far below what is required for net zero pathways globally.[83]

## 4.4 Conclusion

The UK's interaction with VCMs remains small in scale, but currently plays an important role in supporting CDR. While conventional removals such as afforestation and peatland restoration dominate issuance, novel CDR methods like biochar, DACCS, and BECCS are emerging primarily through pre-purchase agreements rather than verified credits. According to CDR.fyi, UK-based projects have sold around 130,000 tonnes of novel CDR to date, however, actual deliveries remain low. VCMs in the UK also support a wider range of removal methods than public policy frameworks (see **Chapter 5**), highlighting their role as a testbed for innovation.

However, persistent data gaps - especially on buyer identity, pre-purchase agreements, and retirement - limit market visibility. Only 13% of UK-issued credits tracked in global registries have been retired, and there is currently no formal integration between voluntary and compliance carbon markets in the UK.

Looking ahead, the effectiveness of VCMs in the UK in contributing to net zero will depend on improving transparency, tracking novel removals more comprehensively, and aligning voluntary efforts with long-term climate goals. High-integrity standards like the Woodland Carbon Code and Peatland Code provide a strong foundation, but expanded coverage into newer CDR methods, clearer data, and alignment between voluntary markets and the UK's long-term net zero policy goals will be critical to scaling CDR in line with the UK's net zero strategy.



*Chapter 5*

# UK Policy & Governance

# Chapter 5: UK Policy & Governance

The governance of CDR in the UK is evolving within a policy landscape shaped by funding mechanisms, market incentives and legally binding commitments to reduce emissions. The UK was one of the first major economies to legislate a long-term climate target through the 2008 Climate Change Act, which originally mandated an 80% reduction in emissions from 1990 levels by 2050. This was strengthened in 2019, when the target was amended to net zero by 2050, creating a legally binding framework that continues to shape UK climate policy and governance.

This chapter explores the current state of UK CDR policy and governance, identifying key policies, market mechanisms and future directions.

## 5.1 The overarching UK climate policy framework

The previous government outlined specific plans for CDR, including a target of 5 $MtCO_2$/year of novel removals by 2030, MRV standards, incentives for scaling novel removals, and integration into carbon markets. In parallel, land-based removals such as afforestation and peatland restoration continue to be embedded in broader land use strategies. These conventional approaches are supported through devolved government schemes and national initiatives such as the Nature for Climate Fund.

### The Climate Change Act and the Climate Change Committee

The Climate Change Act (2008) provides the legislative framework for national climate action. Initially, the Act set a target of an 80% reduction in UK emissions from 1990 levels by 2050; however, this was strengthened in 2019 to a net zero target (i.e., 100% net GHG reductions below the 1990 baseline) by 2050.[84]

The Climate Change Act mandates that the UK government:

- Achieve net zero UK GHG emissions by 2050.
- Set legally binding carbon budgets to provide a structured emissions reduction pathway to 2050.
- Publish plans and policies demonstrating how these targets will be met.
- Receive advice from the independent Climate Change Committee (CCC) on the level of carbon budgets and progress made.

The CCC, established under the Climate Change Act, plays a central role in the UK's climate governance. As an independent statutory body, it provides scientific advice on setting carbon budgets, monitors government progress, and evaluates the effectiveness of policy measures. The CCC's carbon budget reports identify how much CDR will be needed to achieve decarbonisation; its annual progress reports highlight policy gaps regarding the deployment of CDR. The government is legally required to respond to CCC recommendations, reinforcing evidence-based policymaking in the UK's decarbonisation strategy.

This legal framework has been instrumental in driving long-term climate planning, and has led to CDR being progressively integrated into national decarbonisation pathways. CDR is particularly relevant in balancing residual emissions to achieve net zero.

## UK carbon budgets

A central mechanism of the Climate Change Act is its carbon budgeting system, which imposes five-yearly limits on the total volume of UK GHG emissions. These legally binding carbon budgets provide regulatory certainty, ensuring emissions are progressively reduced towards the 2050 net zero target. The UK has successfully met its first three carbon budgets, with total emissions falling by over 50% from 1990 levels by 2022.[85] Specifically, the first carbon budget (2008-2012) was outperformed by one per cent and official statistics indicated that the second budget (2013-2017) was outperformed by around 14%. For the third carbon budget (2018-2022), the UK exceeded its target, achieving a 50% reduction in emissions by the end of 2022, compared to the 38% target. [86,87] The fourth, fifth, and sixth budgets remain targets for the future, with the fourth budget currently in progress. The UK's ability to meet these upcoming budgets will depend heavily on the scale-up of CDR methods through policy enablers and investment in research, development and deployment. The legally mandated carbon budgets are shown in **Figure 5.1** (also see **Chapter 8**). [88]

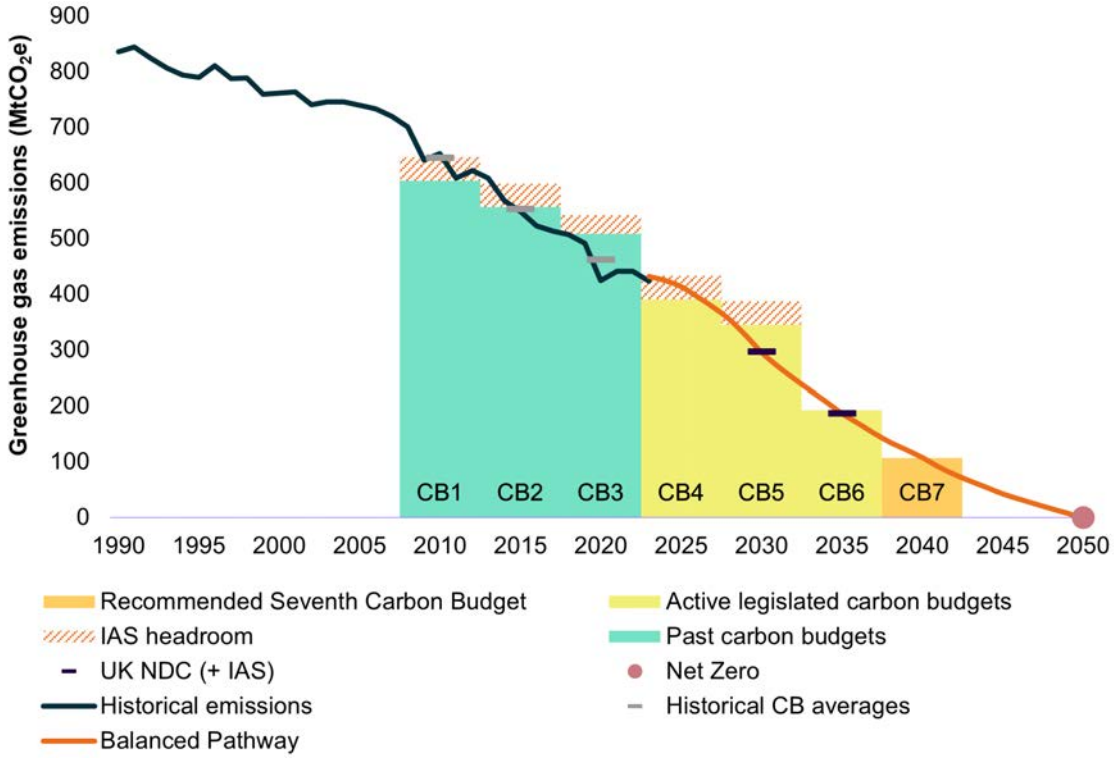



***Figure 5.1*** *UK emissions and Carbon Budgets (2008–37), including the recommended level for the Seventh Carbon Budget (2038–42)*
*Source: Climate Change Committee. The Seventh Carbon Budget. https://www.theccc.org.uk/publication/the-seventh-carbon-budget/ (2025)*

## UK net zero policies

The UK Net Zero Strategy (2021) was the first comprehensive plan to 2050 published by a UK government following the adoption of the net zero emissions target in 2019. It aligns with the UK's international obligations under the Paris Agreement, including the 2030 NDC to reduce emissions by 68% from 1990 levels.[89] In January 2025, the government submitted its updated 2035 NDC, committing to an economy-wide emissions reduction of at least 81% by 2035,[90] which is consistent with advice from the Climate Change Committee and supports the UK's pathway to net zero by 2050.[91]

The Net Zero Strategy is structured around ten core sectors, covering power, transport, buildings, industry, fuel supply, land use, waste and GGRs. The Net Zero Growth Plan (2023) updated the strategy in response to a High Court requirement to provide more detail on how the government intended to reach net zero.[92] Following the 2024

UK general election, the Labour government published a Plan for Change, including a commitment to "accelerate to net zero".[93]

## 5.2 CDR ambition

The UK's approach to CDR is underpinned by specific deployment targets and policy mechanisms, reflecting a recognition of carbon removals being a key part of its net zero strategy. The government has set ambitions for scaling CDR through market incentives, regulatory frameworks, business model development, and direct investment, ensuring both novel and conventional solutions contribute to long-term emissions reductions.

The Net Zero Strategy (2021) explicitly recognised CDR as a pillar of the UK's decarbonisation pathway. Key policies supporting CDR include:

- Targets for deployment of at least 5 $MtCO_2$/year of novel removals by 2030 (scaling to 23 $MtCO_2$/year by 2035), alongside scaling conventional removals such as afforestation and soil carbon sequestration.
- Funding of around £100m in 2021–25 for innovation, including the Direct Air Capture and Greenhouse Gas Removals Innovation Programme for CDR technologies, supporting the demonstration and commercialisation of BECCS, DACCS, biochar, direct ocean CCS and methane removal techniques (see **Chapter 2**).[94]
- Exploration of market mechanisms, including integrating novel removals into the UK ETS.
- Development of robust MRV standards, ensuring the integrity and durability of carbon removals.
- Expansion of land-based removals, with commitments to plant 30,000ha of trees per year from 2025 in order to increase UK forestry cover from 13% to 17% by 2050,[95] and to restore 280,000ha of peatland by 2050.

The 2023 Net Zero Growth Plan explicitly recognises and reaffirms the role of CDR in achieving long-term emissions reductions and meeting the Sixth Carbon Budget (2033–2037). The government committed to developing markets and incentives for CDR investment, with a specific focus on integrating removals into the UK ETS as a long-term compliance mechanism. It also announced a £124 million boost for the Nature for Climate Fund (NCF), ensuring a total spend of approximately £678 million on woodland creation and woodland management by 2025.

### Sectoral breakdown of CDR integration

CDR deployment in the UK is closely linked to sector-specific decarbonisation strategies, particularly in energy, industry and land use. Responsibility for CDR development is also split institutionally: novel removals such as DACCS and BECCS are led by DESNZ, while conventional removals fall primarily under the remit of Defra. Furthermore, land management is a devolved responsibility in the UK, meaning the administrations of Scotland, Wales and Northern Ireland have power to set their own policies. This distinction affects how targets, regulations and incentives are developed and implemented across the different CDR methods.

The power sector is expected to drive novel removals through BECCS, which will play a key role in negative emissions electricity generation while supporting the decarbonisation of the UK grid. The UK Biomass Strategy (2023) affirms BECCS as a priority technology for achieving net zero.[96] Power BECCS (in the form of energy from waste) is also included among Track-1 CCUS cluster projects, reinforcing its role in the UK's industrial carbon management strategy.

While there are no active DACCS projects, the UK Government has indicated that they would be eligible to take part in the expansion of the Track-1 HyNet cluster in Merseyside by 2030.[97] In 2023, the previous government committed up to £20bn to support the initial rollout of CCUS infrastructure. Their plan aimed to establish four CCUS clusters by 2030, with a target of storing 20–30 $MtCO_2$ annually.[98,99] However, in its 2024 submission to the Public Accounts Committee, the government acknowledged that this ambition is now unlikely to be met.[100]

The agriculture and land use sectors are central to conventional carbon removals, including the aforementioned tree-planting and peatland restoration targets.[101] These targets are closely linked to planning and prioritisation of land use more widely, on which the current government has launched a "national conversation" in advance of completing a Land Use Framework.[102]

### Devolved government policies

Devolved governments have begun to develop their own approaches to CDR. For instance, the Welsh Government's proposed Sustainable Farming Scheme published in November 2024 does not include enhanced rock weathering as a viable carbon removal practice, citing limited field-scale trials, uncertainties around MRV and logistical barriers such as transport costs and material availability in rural regions.[103] However, it does recognise its sequestration potential and suggests it may be suitable in some future scenarios, pending further evidence. Biochar was also excluded due to limited UK data, high application costs, regulatory complexity and concerns over feedstock availability, despite strong interest from farmers and the recognized co-benefits for soil health.

## 5.3 Market and commercialisation mechanisms

The UK is still developing its approach to CDR commercialisation, including market mechanisms and funding models. While the government has committed to developing revenue support schemes, the inclusion of novel removals in compliance-based markets remains under consultation.

### Contract for Difference for BECCS and DACCS

The Contract for Difference (CfD) scheme provides a fixed price for low-carbon electricity, regardless of wholesale prices.[104] This model has been successful for offshore wind, and its application to removal technologies is under development.[105] As part of this, the UK has proposed CfDs for BECCS and DACCS as a mechanism to de-risk novel removals, offering long-term revenue stability by guaranteeing a fixed price per unit of $CO_2$ removed.

The government recently closed its "GGRs and Power BECCS business models" consultation, which is exploring how CfDs could be adapted for novel removals, ensuring investor confidence while maintaining market efficiency.[106] At the time of writing, the intention is for eligible projects to sell carbon removal credits on voluntary markets, with the CfD mechanism then topping up any shortfall in price to an agreed strike price. The effectiveness of CfDs in scaling CDR will depend on the final funding structure and integration with the wider carbon market.

### Inclusion of CDR in the UK ETS

The UK ETS remains a central policy instrument for driving emissions reductions. The UK Net Zero Strategy and subsequent policy documents have indicated that the UK ETS Authority considers the UK ETS to be an appropriate long-term market for CDR.[107] However, these technologies have not yet been integrated, and discussions on their inclusion are ongoing. The UK ETS Authority consulted publicly on this matter in 2024, outlining key considerations including whether to include both "engineered" methods (e.g., BECCS and DACCS) and "nature-based" methods (e.g., afforestation, soil carbon sequestration and coastal wetland restoration), the necessity of a robust MRV framework, and how to prevent double-counting between voluntary and compliance markets.[108]

The UK ETS Authority's consultation on market design has confirmed that the scheme will continue until at least 2050, which could provide greater market certainty for future CDR integration.[109] However, no final decision has been made on how novel removals will be treated within the compliance market.

### Commercialisation mechanisms for conventional land-based CDR

Several grant-based mechanisms have been employed by governments in recent years to stimulate conventional removal methods, focused mainly on forestry. As land management is a devolved responsibility, Scotland, Wales and Northern Ireland have their own mechanisms.

In England, the £640m Nature for Climate Fund was launched in 2021 to support tree planting and peatland restoration until 2025.[110] It primarily supported the England Woodland Creation Offer, providing capital funding and maintenance payments.[111] This largely replaced the previous Countryside Stewardship Woodland Creation Grant. In addition to grants, the government also previously supported woodland revenues through the Woodland Carbon Guarantee. Now closed, the scheme offered long-term contracts to purchase verified carbon credits for a guaranteed price, similar to a CfD mechanism.[112] This helped provide more certain revenues from woodland creation, improving the prospects of a viable commercial model.

In Scotland, the Forestry Grant Scheme offers financial support for woodland creation and management. It supports the aim of planting 18,000ha of new woodland per year, with a budget of £53m in 2025/6.[113] Wales introduced the Glastir Woodland Creation scheme,[114] which has since closed to new applications and is transitioning to the Sustainable Farming Scheme, with interim funding available under the Woodland Creation Planning Scheme.[115] Northern Ireland aims to plant 9,000ha of new woodland by 2030 under a Forest Expansion Scheme that covers planting costs and provides 10-year financial support, as well as a Small Woodland Grant Scheme.[116]

Peatland removals also received grants for restoration and paludiculture (farming on wetland) via England's Nature for Climate Fund. Scotland has committed £250m through the Peatland ACTION Programme to restore 250,000ha by 2030. Wales aims to restore 45,000ha by 2050, and in December 2024 launched a grant scheme for landowners. Northern Ireland's Peatland Challenge Fund offers grants to councils and not-for-profit organisations during 2024–7.

## 5.4 MRV, regulation, and standards for CDR

Effective MRV is the process by which the performance of CDR activities is quantified and assured. MRV frameworks are used for national GHG inventories (reported to the UN, and the basis by which national targets are set), corporate reporting, and for project- or product-level reporting. National-level MRV follows internationally agreed guidelines set by the IPCC. These are often adapted for project-level MRV frameworks. However, uncertainties and gaps exist, in particular for several novel methods that present several scientific and practical MRV challenges.

### National-level MRV

As with all parties to the UNFCCC, the UK reports national GHG emissions and removals according to IPCC guidelines.[117] This MRV framework is the basis by which the UK's targets are set and measured – both NDCs under the Paris Agreement, and carbon budgets under the domestic Climate Change Act.

IPCC guidance exists for conventional CDR methods, which include forestry, peatland and coastal wetland restoration, soil carbon sequestration, and durable wood products. Guidance for novel CDR methods is less complete: it exists for BECCS and geological storage more generally, and a simple approach for biochar is provided as a "basis for future methodology". There are no further IPCC guidelines, meaning gaps for other methods, such as enhanced rock weathering, ocean alkalinity enhancement and the capture elements of DACCS and Direct Ocean Carbon Capture and Storage (DOCCS).

The IPCC is scoping a methodology report to provide MRV guidelines for CDR methods not currently covered in the guidance for national inventories.[118] In the meantime, parties to the UNFCCC are free in principle to implement their own MRV approaches if they wish and those approaches stand up to international scrutiny. However, MRV development for novel CDR methods is happening primarily at the project level for use in VCMs.

### MRV for novel removal projects

The British Standards Institution (BSI) has been commissioned by the UK Government to develop technical methodologies for CDR, beginning with BECCS and DACCS. In 2025, BSI will first publish Minimum Quality Thresholds (also known as BSI Flex), which will establish baseline criteria for integrity and performance. These are planned to mature into full methodologies in the form of Publicly Available Specifications in 2027.[119] These will provide detailed standards for how CDR projects should quantify removals, monitor and report impacts, assess sustainability, demonstrate additionality, and account for permanence, referencing best practice and existing government standards where appropriate.

Rather than serving as a certification or tracking system, the BSI's work will establish the underlying impact assessment protocols that project developers must meet. These will help ensure that carbon removal activities are scientifically robust and consistent across compliance and voluntary market settings. The methodologies are also intended to align with broader regulatory frameworks, including the UK and EU ETS, to promote interoperability and reduce administrative burdens.[120, 121]

The BSI process aims to reflect the UNFCCC's five "pillars" of MRV: transparency, accuracy, comparability, completeness and consistency.[122] However, many novel methods still face high uncertainty over permanence, particularly in the absence of long-term data for techniques like biochar and enhanced weathering. As a precaution, initiatives such as the BSI Nature Markets Standard propose a 20% buffer for land-based credits to account for reversal risk.

Barriers to MRV development include limited access to high-quality, shareable datasets; proprietary methods; and the lack of standardised approaches to full life-cycle assessment. These issues are especially pressing for novel removals, where ensuring "net negativity" requires accounting for emissions across the entire project chain, from energy inputs and materials to transport and storage.[123]

MRV costs also remain poorly understood. Recent research suggests that establishing and maintaining MRV systems, especially for novel methods, could significantly affect project economics. This creates a trade-off between methodological rigour and feasibility.[124]

The BSI contract includes an optional extension to cover up to six additional CDR methods in future phases, depending on policy priorities and market development.[125] Overall, this initiative reflects the UK's broader ambition to embed high-integrity CDR within formal carbon accounting systems that support its net zero targets.

## MRV for conventional removal projects

### The Woodland Carbon Code

The Woodland Carbon Code is the UK's voluntary standard for afforestation and woodland carbon projects (see **Section 4.3**). It provides a robust MRV framework to ensure that woodland-based $CO_2$ removals are credible, additional and permanent. Landowners can then generate verified Woodland Carbon Units, which can be sold on voluntary carbon markets.

To participate in the Woodland Carbon Code, woodland projects must undergo independent validation and verification, ensuring that carbon sequestration estimates are scientifically robust and accurately monitored. The Woodland Carbon Guarantee scheme provides an option for landowners to sell their verified credits to the UK government at a guaranteed price, offering financial certainty and encouraging long-term investment in afforestation.

### The Peatland Code

The Peatland Code serves as the UK's certification standard for peatland restoration projects (see **Section 4.3**). Peatlands are one of the UK's largest carbon sinks, but when degraded, they become significant emission sources. The Peatland Code provides a structured MRV system to quantify avoided emissions and removal benefits, generating independently verified Peatland Carbon Units.

Projects under the Peatland Code follow strict MRV protocols, including baseline assessments, long-term monitoring and third-party verification. By aligning with international best practices, the Peatland Code helps attract private sector investment, supporting large-scale peatland recovery efforts.

### Other UK carbon codes

There are carbon codes for several other land and coastal ecosystems at varying stages of development, including:

- The UK Farm Soil Carbon Code, led by the Sustainable Soils Alliance in partnership with academic institutions and industry stakeholders.[126, 127]
- A proposed UK Saltmarsh Code, being developed by a consortium led by the UK Centre for Ecology and Hydrology. [128]
- Earlier-stage proposals for a UK Seagrass Carbon Code.[129]

## 5.5 Summary of UK policy status

Despite policy developments for both reducing emissions and scaling removals, the CCC's 2024 Progress Report to Parliament shows that the UK is off track to meet its 2030 target of a 68% emissions reduction compared to 1990 (see **Section 5.1** for more on carbon budgets).[130] The Committee found that only around one third of the reductions required to meet the target are currently covered by credible plans. They identified ten priority actions that the UK Government needed take in 2024 to get back on track. Two of these focused on CDR: finalising the business model for engineered (novel) removals, and ramping up tree planting and peatland restoration.

In February 2025, the CCC released its advice for the seventh carbon budget (covering the years 2038–42, see **Chapter 8**). Within the CCC's Balanced Net Zero Pathway is a requirement to ramp up conventional CDR beyond the government's existing targets, to 37,000ha per year for tree planting and 49,000ha per year for peatland restoration.

The overall status of UK CDR policies is summarised in **Table 5.1**. The CDR methods for which there are stated deployment targets are currently off track. While MRV frameworks exist – so conventional CDR methods can contribute towards national targets and project-level carbon reductions – the same is not yet true for any novel CDR methods. MRV and commercialisation mechanisms are in development for BECCS and DACCS, but significant gaps remain for biochar, enhanced rock weathering and DOCCS. Further policy clarity is needed to de-risk investment, strengthen regulatory frameworks and establish long-term financial stability for CDR deployments at scale.

| CDR method | Regulated MRV | | Commercial mechanisms | Target | Target on track? |
|---|---|---|---|---|---|
| | National level | Project level | | | |
| Forestry | Yes | Yes | Grant schemes in England, Scotland, Wales & N Ireland; limited in scale and long-term certainty | Create 30,000 ha per year | No |
| Peatland | Yes | Yes | | Restore 32,000 ha per year | No |
| Soil carbon sequestration | Yes | No | No | No | |
| Durable wood products | Yes | Yes | No | No | |
| Coastal wetland | Yes | No | No | No | |
| Biochar | Basis for development | No | No | Ambition of at least 5 $MtCO_2$ per year by 2030 | No |
| Enhanced rock weathering | No | No | No | | |
| BECCS | Yes | In progress (BSI standard) | In development (CfD + ETS) | | |
| DACCS | No | In progress (BSI standard) | In development (CfD + ETS) | | |
| Other (DOCCS, mineral products, etc.) | No | No | No | | |

***Table 5.1*** *Summary of UK policy elements and gaps*

In March 2025, the UK Government commissioned an "Independent Review of Greenhouse Gas Removals", which will assess current policy progress and make recommendations for governance, incentives and market frameworks.[131] Its report is expected to be submitted to the Secretary of State for DESNZ in October 2025. This signals increasing attention to the long-term role of removals in national climate planning.

## 5.6 Comparison with other jurisdictions

The UK was one of the first countries to establish an explicit ambition for CDR deployment, but other major economies are also setting targets. For example, the European Commission's "2040 climate target" suggests a possible role for up to 400 $MtCO_2$ of removals from both industrial and land-based sources to help meet a proposed 90% net emissions reduction target by 2040.[132] However, the final composition and role of removals within the target are pending clarification. The Commission is exploring the inclusion of novel removals in the EU ETS, alongside the development of the Carbon Removals and Carbon Farming Regulation to establish standards for monitoring and verifying removals.[133] These initiatives aim to integrate carbon removals into the EU's climate architecture and ensure environmental integrity as the region moves toward climate neutrality.[134]

In contrast to the UK, the United States has adopted a direct funding approach to support CDR, especially novel methods. The Inflation Reduction Act of 2022 extended the 45Q tax credit, offering up to $180 per tonne for DACCS projects that securely store $CO_2$ underground.[135] These credits can be combined with other revenue streams, such as those from the California Low Carbon Fuel Standard, through which DAC projects anywhere in the world can earn credits, with prices reaching up to $190 per tonne in recent years.[136] Federal funding programmes have further accelerated DAC deployment. The Department of Energy's DAC Hubs programme, launched with $3.5bn, supports four large-scale hubs that will each demonstrate capture of at least 1Mt of $CO_2$ per year, paired with geologic storage or utilisation.[137] Additionally, in 2024, the Department of Energy introduced a $35m CDR Purchase Pilot Prize to procure verified tonnes of durable carbon removal, offering near-term demand incentives for emerging technologies.[138] The US has also committed to a $100/$tCO_2$ cost target under the Carbon Negative Shot, a government initiative to make durable carbon removal cost-competitive by 2032.[139] This combination of fiscal incentives, infrastructure development and price signals made the US a leading destination for large-scale investment in DACCS. For example, Occidental and BlackRock are jointly developing STRATOS, the world's largest DACCS facility, aiming to capture up to 500kt of $CO_2$ annually by the end of 2025.[140] It should be noted however that all of these policies were put in place by the

previous federal administration, and the current administration, as of January 2025, is in the process of reversing many aspects of past US climate policy.

Several other jurisdictions are putting in place support mechanisms for different types of novel CDR. Examples include:

- **Denmark**: The Danish Government has committed to a 20-year subsidy scheme for two BECCS plants, aiming to capture 430,000 tonnes of $CO_2$ annually from 2026.[141] In parallel, through the Green Tripartite Agreement, Denmark plans to fund novel CDR methods, notably including estimated support of DKK 10 billion (EUR 1.3 billion) until 2045 for biochar production. The Green Area Fund (DKK 40 billion / EUR 5.4 billion), also established under this agreement, includes incentives for less durable removals such as land-use change and afforestation, supporting the first phase of the Danish Climate Adaptation Plan.[142]
- **Germany**: The Federal Climate Protection Act sets GHG removal targets for the LULUCF sector, requiring at least 25 $MtCO_2e$ removals annually by 2030, 35 $MtCO_2e$ by 2040, and 40 $MtCO_2e$ by 2045.[143] In August 2024, the German government allocated €3 billion through 2030 for industrial decarbonisation, with funding split between two main tracks - one focused on industrial decarbonisation and the other on carbon capture, utilisation, and storage (CCUS).[144] While the primary focus is on emission reductions, the programme may support engineered CDR projects where relevant to industrial processes.
- **Sweden**: The Swedish Government has allocated SEK 36 billion (approx. EUR 3.3 billion) from 2026 to 2046 to support BECCS (referred to as "Bio-CCS"). Stockholm Exergi has been awarded SEK 20 million over 15 years through a reverse auction to construct a BECCS plant, with the aim of capturing 800,000 tonnes of $CO_2$ per year.[145] A public inquiry proposed that Bio-CCS should deliver 1.8 $MtCO_2$/year by 2030 and scale to 3–10 $MtCO_2$/year by 2045. In addition, state-funded R&D is supported through the Industrial Leap (Industriklivet) initiative, which has been granted an additional SEK 600 million (EUR 55 million) annually from 2023 to 2025 and a total mandate of SEK 5.2 billion (EUR 545 million) from 2024 to 2030, including funding for CDR.[146]
- **Japan**: Launched in 2023, Japan's Emissions Trading Scheme (GX-ETS) is a voluntary system for Japanese companies, transitioning to mandatory compliance in 2026. It is expected to be the second-largest carbon market in Asia. GX-ETS accepts credits from four CDR methods: biochar, BECCS, DACCS, and coastal wetland restoration. Other methods are being considered for future inclusion, such as enhanced rock weathering and ocean alkalinity enhancement.[147]

## 5.7 Conclusion

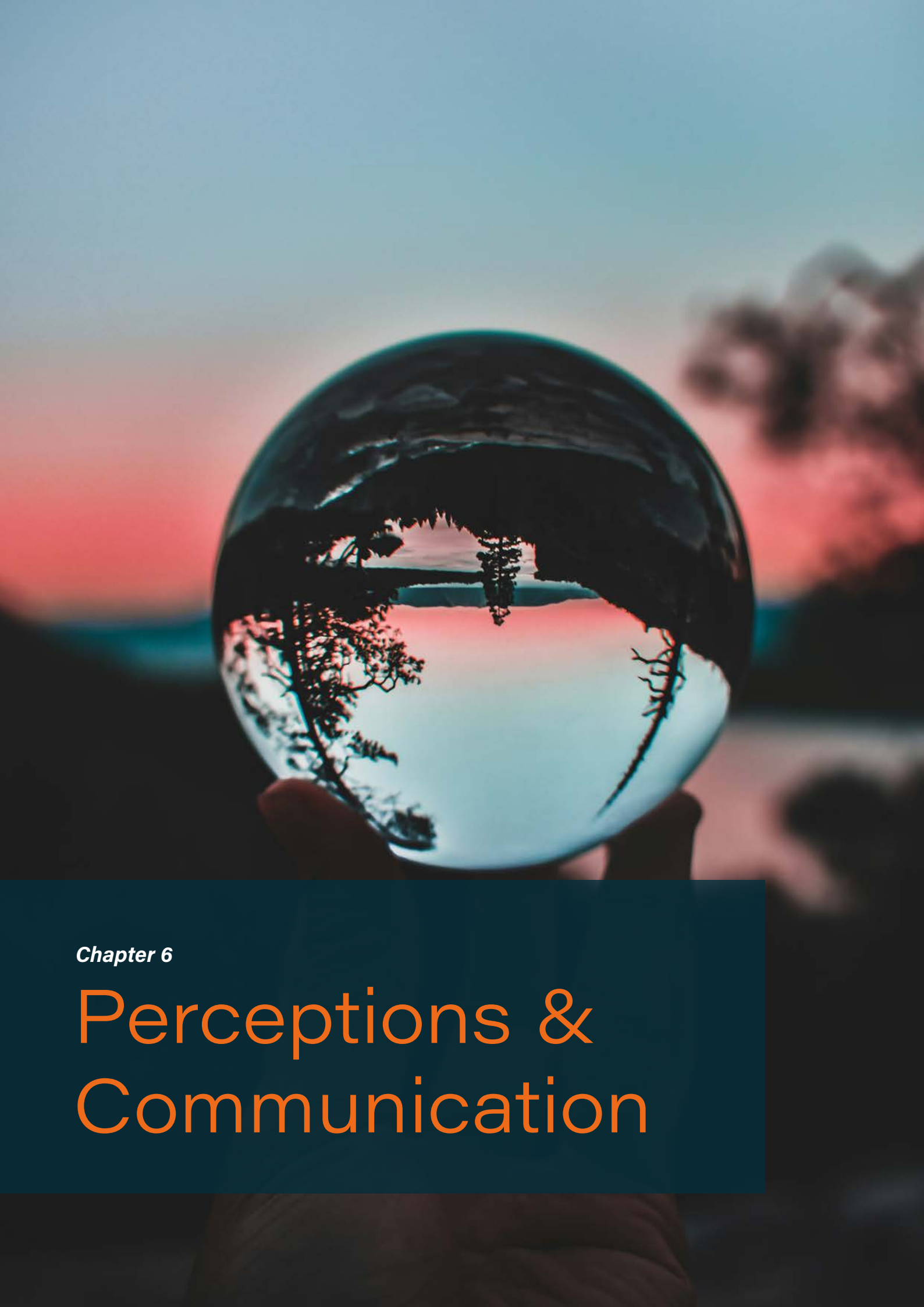
The future of UK CDR will be shaped by critical decisions on the overall level of ambition for CDR within the UK's climate strategies, technology development, creation of business models, MRV frameworks and wider international progress.

While the UK is taking steps, such as setting a quantified target for novel removals by 2030, developing MRV standards for BECCS and DACCS, and consulting on inclusion in the UK ETS, several policy gaps remain. For example, the grant-based schemes for forestry and peatland restoration have little in place to maintain the commercial viability of these projects after establishment. There are not yet MRV standards and mechanisms to make BECCS and DACCS projects, as well as other emerging CDR methods, commercial at scale. The success of these methods will depend on effective delivery of these elements.

Although the reductions in the first three Carbon Budgets were met or surpassed, it will be more difficult to continue this into the subsequent Budgets. The CCC has indicated that the UK as a whole is significantly off-track from delivering on the government's own targets and the levels necessary to reach net zero by 2050. Further policy clarity is needed to de-risk investment, strengthen compliance frameworks, and establish long-term market stability for

CDR deployment at scale.

Research suggests that UK governments can learn lessons from past efforts to regulate emerging sectors, in which top-down governance based on assumptions of national need were stymied by a lack of meaningful public engagement.[148] Drawing on these lessons may help shape more responsive and enabling institutional arrangements for removals.



*Chapter 6*

# Perceptions & Communication

# Chapter 6: Perceptions & Communication

Public perceptions play a crucial role in the acceptability – and ultimately, the adoption or rejection of – new technologies. This chapter considers the importance of public perceptions, what the public thinks about various CDR methods and why, and how the way information about CDR is communicated shapes opportunities and risks for its future acceptability.

## 6.1 The relevance of public perceptions in the UK

The acceptability of new technologies have been derailed by public controversies in the past, e.g., nuclear energy and genetically modified crops.[149] In the same way, public perceptions will play a crucial role in the adoption or rejection of CDR methods. However, this is not their only feature.

Eliciting public perceptions of CDR through societal engagement provides opportunities to strengthen:[150]

- Accountability and transparency by involving citizens in considerations that concern their interests.
- CDR methods themselves by learning from citizens and building social intelligence.
- Trust and legitimacy around decision on CDR by building relationships between citizens, state and non-state actors.

More broadly, understanding perceptions is important for building public engagement with climate change, developing effective communication and educational approaches, as well as constructing and implementing effective and acceptable policies together with socially robust technologies.[151]

## 6.2 Public opinion on CDR in the UK

The literature review around public perceptions for this report follows the same method set out in the second edition of the global State of Carbon Dioxide Removal report, but limited to empirical UK studies on public perceptions of CDR up to May 2023.[152] The systematic search of the literature identified 17 such scientific papers. The geographical distribution of these studies is shown in Figure 6.2. All regions of the UK have been studied to some extent, but studies are concentrated in the East of England and Wales, with relatively fewer in the West Midlands, Scotland, Yorkshire and the Humber, the South East, and the South West. They have employed a range of methods including interviews, surveys, survey experiments, deliberative workshops, experimental workshops and deliberative mapping. The North East, North West, East Midlands, London and Northern Ireland have so far only been studied as part of wider nationally representative surveys.

A literature review of studies of public perceptions about CDR in the UK finds evidence relating to a variety of different methods. Relative attention to different CDR methods in the 17 studies over time is shown in **Figure 6.2**. It can be seen that earlier studies of UK public perception examined broader categories – including "geoengineering" and "carbon dioxide removal" – before focusing on more specific CDR methods. This attention began with DACCS, which has maintained a significant level of attention since. More recently, attention to BECCS and enhanced rock weathering has become more significant. DACCS, BECCS and enhanced rock weathering together dominate attention in studies of UK public perception. Other methods, including biochar, afforestation, ocean fertilisation, wood in construction and peatland restoration have been examined in just two studies.[153, 154]

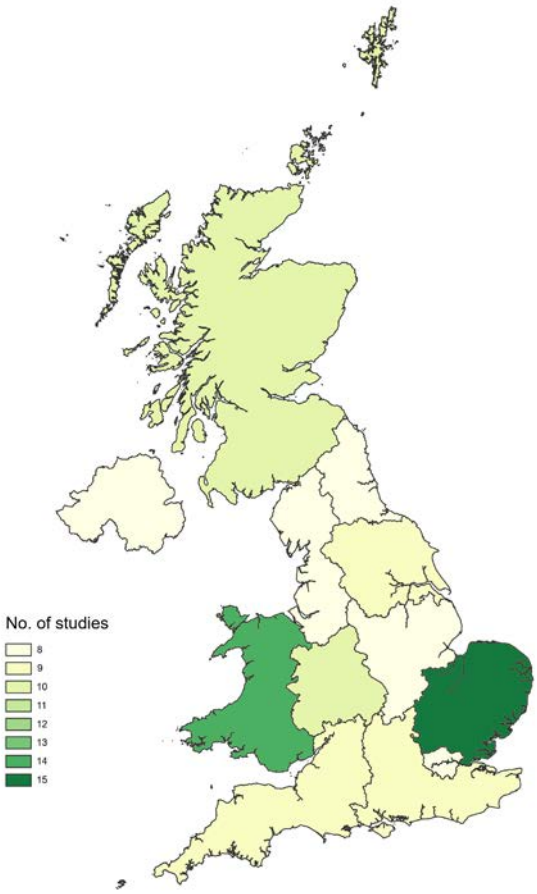



***Figure 6.1*** *Studies of public perceptions of CDR in the UK by region (2012–22)*

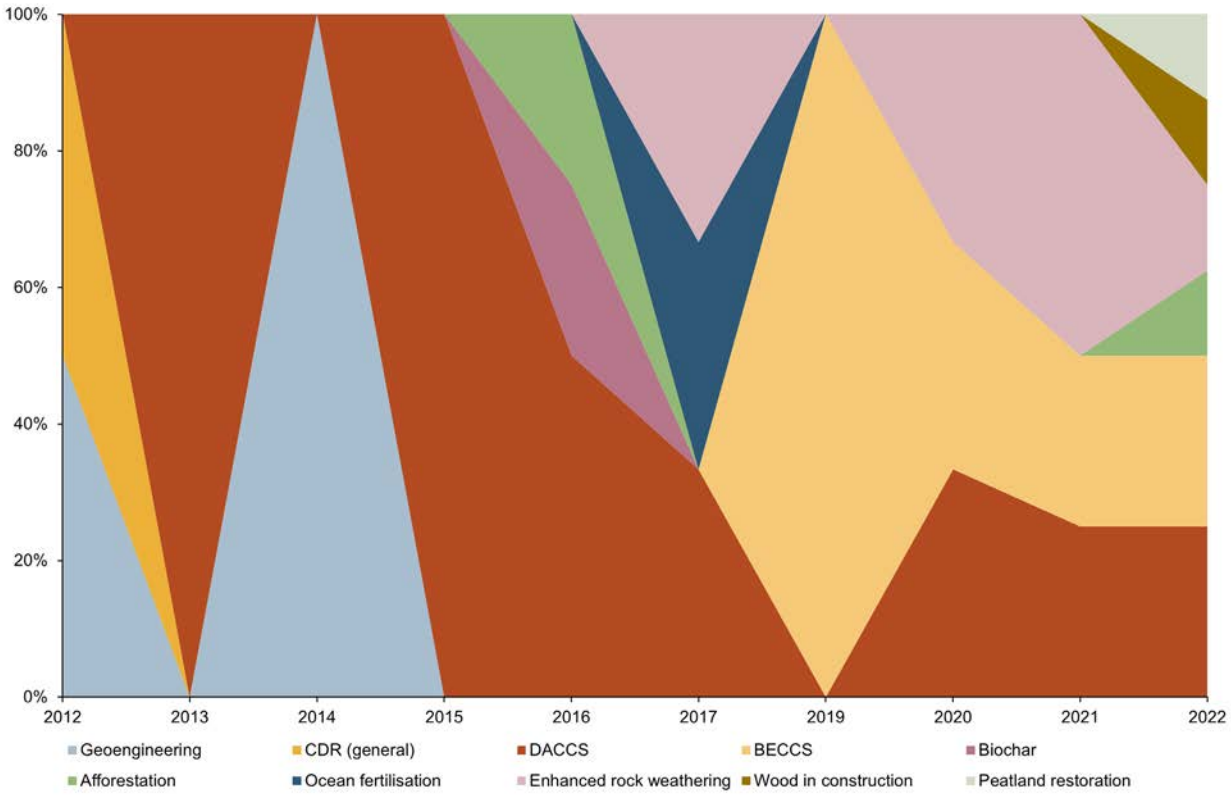



***Figure 6.2*** *Attention to CDR methods in studies of public perceptions of CDR in the UK over time (2012–22)*

Nationally representative studies on public perceptions in the UK report low levels of prior awareness and knowledge of CDR. Awareness of enhanced rock weathering stands at 30%[155, 156], with no data yet available for other CDR methods. Knowledge of a "a great deal" or "a fair amount" about CDR in general stands at 5.7%,[157] while 18-19% report knowledge of CDR as part of approaches to "climate engineering." [158, 159] Data on prior knowledge about specific CDR methods is not yet available.

Recent national public appraisals show a decisive rejection of the notion that there should be no CDR in UK climate policy,[160] with earlier support for CDR in general reported at 48.2% in a national survey.[161] Quantitative studies on public perceptions in the UK indicate different levels of support for different CDR methods:

- **DACCS** has received relatively less support than other CDR methods in national public appraisals[162], echoing an ambiguous performance in earlier deliberative mapping appraisals.[163] Feelings about DACCS have been reported as slightly negative in deliberative workshops (4.79/10),[164] with negative memory associations across a national survey (-13).[165] Nevertheless, most people support small-scale field trials (45%, with 21% opposing).[166]
- **BECCS** has also received less support relative to other CDR methods, except for DACCS, in national public appraisals.[167] Nevertheless, experimental workshops have shown 72.8% of people indicating that they were somewhat or strongly in support of the technology.[168] Feelings about BECCS have been reported as slightly positive in deliberative workshops (5.47/10),[169] with slightly negative memory associations across a national survey (-3).[170] Most people support small-scale field trials (45%, with 21% opposing).[171]
- **Enhanced rock weathering** has received 37.2% support in a national survey,[172] though most people neither support or oppose the technology (46%) and in a more recent national survey most people said that they were unsure about supporting it (49.7%).[173] Feelings about enhanced rock weathering have been reported as slightly negative in deliberative workshops (4.04/10),[174] with negative memory associations across a national survey (-19).[175] Most people nevertheless support small-scale field trials (41%, with 25% opposing).[176]
- Other CDR methods for which there is quantifiable support, including biochar, afforestation, wood in construction, and peatland restoration have been examined in just two studies.[177, 178] In these, **biochar** was a middle-performing option in deliberative mapping appraisals, scoring higher than DACCS. **Afforestation** was a high performing option in national public appraisals and in deliberative mapping appraisals, scoring higher than biochar and DACCS. **Wood in construction** was a middle-performing option in national public appraisals. And **peatland restoration** was the highest performing overall option in national public appraisals.

In the one study that maps public appraisals of different CDR methods by UK region, regional differences were not statistically significant, but nevertheless show that certain regions could be more or less likely to support or oppose certain CDR deployments (see **Figure 6.3**).[179] In turn, it would be important to match up any physical requirements for siting CDR methods with appropriate social contexts. For example, those in the North West appraise DACCS and BECCS relatively higher than other regions, and happen to be adjacent to areas of significant carbon storage potential in offshore saline aquifers.[180] Similarly, those in Northern Ireland, the North East and South West appraise peatland restoration relatively higher than other regions – and those regions contain significant areas of peatland.[181]

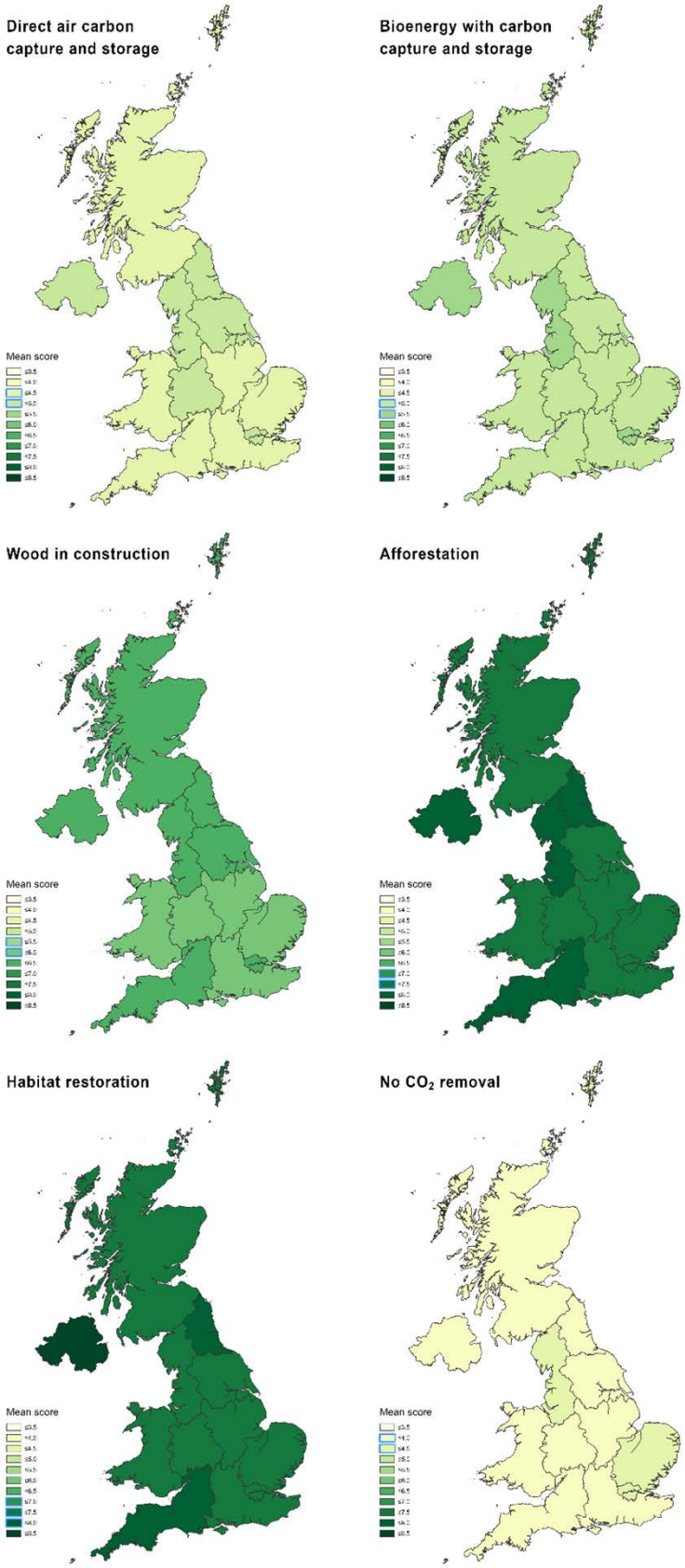



***Figure 6.3*** *Public appraisal of CDR methods by UK geographical region*
*Source: Bellamy, R. Mapping public appraisals of carbon dioxide removal. Global Environmental Change 76, 102593. https://doi.org/10.1016/j.gloenvcha.2022.102593 (2022).*

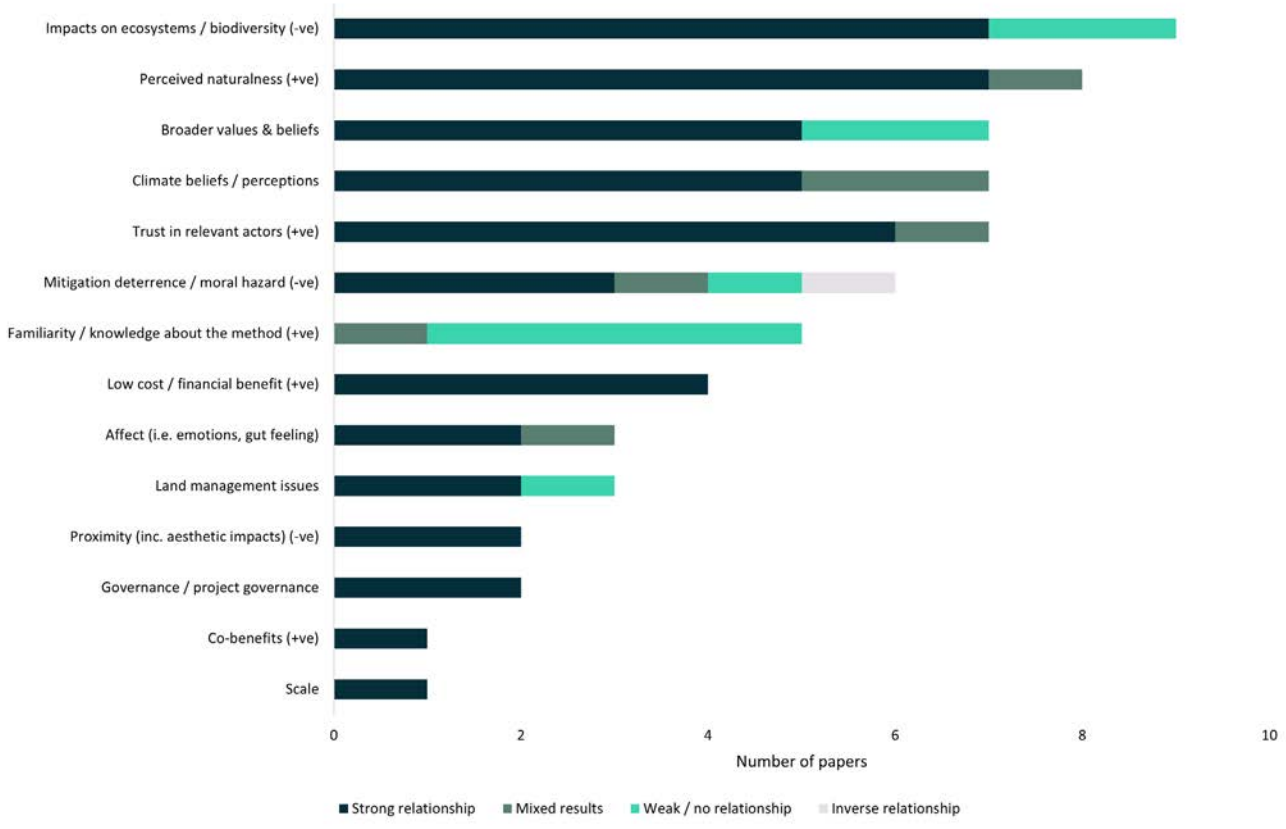
## 6.3 Factors driving attitudes and conditions for deployment in the UK

Studies on public perceptions also reveal the qualitative reasonings behind why people perceive CDR methods in the UK the way that they do. Echoing the findings of the second edition global State of CDR report, this review finds 14 distinct factors driving public attitudes towards CDR in the UK, and 12 distinct conditions for deployment of CDR (some indicators are both factors and conditions) (see **Figure 6.4**).

As in the global report, the most evidenced factors driving public attitudes are concerns about impacts on ecosystems and biodiversity; whether or not a method is seen to be "natural" or "messing with nature"; the influence of broader values and beliefs; perceptions of climate change itself; and trust in relevant actors. Evidence on mitigation deterrence or moral hazard – the idea that CDR may delay or deter efforts to reduce emissions – is mixed. Evidence on familiarity or knowledge about CDR as a factor driving public attitudes is weak. Relatively more limited, but strong, evidence exists for other factors driving public attitudes, including low costs and financial benefits; affect (i.e., emotions or gut feelings); land management issues; proximity and aesthetic impacts; governance and project governance; the existence of co-benefits; and scale.

Similar to the global report, safety, controllability and low scientific uncertainty are among the largest bodies of strong evidence on conditions for deployment of CDR in the UK. There is relatively more evidence on feasibility and practicality, and low costs and financial benefits as conditions in the UK compared to at the global level – and relatively less evidence for CDR being needed to address the root cause (i.e., not being used as a "band aid") and its relationship to mitigation goals. As in the global report, there is also evidence for conditions regarding connecting CDR to broader social and environmental goals, having good project governance, creating co-benefits, being reversible, and of a smaller scale.

**a)**



b)

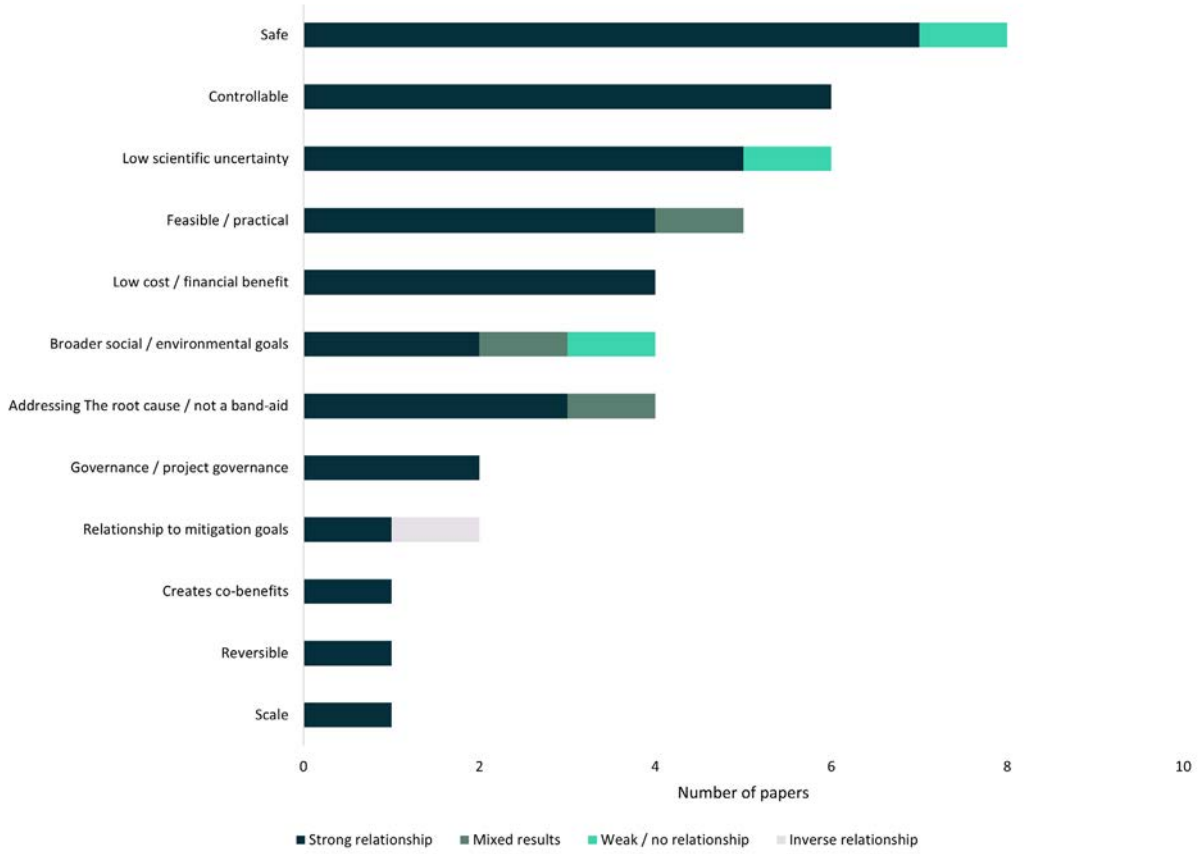



***Figure 6.4*** *Factors affecting a) public attitudes to CDR in the UK and b) conditions for deployment*
*For the methodology, see: Smith, S. M. et al. (eds.) The State of Carbon Dioxide Removal 2024 – 2nd Edition. https://doi.org/10.17605/OSF.IO/F85QJ (2024) pp. 107–9*

## 6.4 Conclusion

Public engagement is both an opportunity and a challenge for CDR. It is an opportunity to ask people about things that will affect their interests, learn how CDR methods and policies can be made more effective, and make more legitimate decisions. It is a challenge because general awareness about CDR is low. The literature on public perceptions is beginning to yield lessons for responsible communication of CDR.[182]

The following three lessons for responsible communication are derived from explicit recommendations in the UK literature on public perceptions:

- **Give information specifically about CDR**: Giving information about CDR will increase awareness,[183] but pre-existing technical terms that are distinct from CDR (e.g., "carbon capture") can confuse.[184] Communications need to be tailored to specific CDR methods and locations.[185]
- **Talk about benefits and risks**: Perceptions of benefits are a strong driver of acceptance.[186] By identifying and deliberating negative attributes, innovation trajectories could be altered to avoid or minimise them. Salient aspects include displeasing aesthetics, "quick fixes", artificiality and unknown effects,[187] as well as threats to emotionally and ethically significant ecological and geological systems.[188]
- **Avoid framing CDR as natural (or otherwise)**: Perceived "naturalness" is known to increase acceptance of CDR.[189] However, where the lines are drawn on what constitutes a "natural" or "unnatural" method is arbitrary and diverts attention away from the actual qualities of CDR methods.[190]

These UK-specific recommendations can be complemented by broader recommendations made in the literature:[191]

- Inform the public about carbon removal using clear language and analogies but make clear how it differs from these existing processes.
- Stress that carbon removal is not a substitute for necessary and urgent emissions reductions: reductions first, removals second.
- Communicate the social arrangements of carbon removal as well as the technical objects, and articulate the alternative trajectories that carbon removal implementation could take.

*Chapter 7*

# Current UK Levels of CDR

# Chapter 7: Current UK Levels of CDR

This chapter presents the estimates of UK CDR deployment, summarising current removal levels based on official GHG inventory reporting, academic literature and industry data. Throughout, we aim to provide an accurate assessment of the UK's current CDR deployment while acknowledging the limitations and uncertainties in available data.

## 7.1. Overview

The UK currently delivers carbon removal through conventional biological processes, primarily in forests and grasslands, which are reported annually in the national GHG inventory using globally standardised reporting categories.[192] Alongside these established removals, novel CDR technologies are starting to be deployed, though they are currently at small scales and are not yet comprehensively tracked under any national or internationally-standardised framework.

This assessment broadly follows the reporting approach to CDR established in the global State of CDR report. Estimates focus on the gross amount of $CO_2$ moved from the atmosphere into durable storage in a given year as a result of human activity.[193] This framing excludes emissions over time from carrying out the activity (for instance heat or electricity use, transport of materials, or subsequent re-release of $CO_2$). Such emissions are included in a lifecycle approach, which typically used in issuing carbon credits. Our framing aligns more closely to that of national GHG inventories, in which emissions are reported by year and by sector (for instance, heat or electricity emissions are reported in the energy sector).

## 7.2. Levels of conventional CDR reported in the UK Inventory

The national GHG inventory, published annually, provides the most consistent and comprehensive accounting of the UK's GHG balance, including land-based carbon removals.[194] Following IPCC guidelines, these removals are reported within the Land Use, Land Use Change and Forestry (LULUCF) sector, covering forest land, cropland, grassland, wetlands (including peatlands), settlements, and other land categories.[195] These fluxes represent a key component of conventional CDR, which occurs primarily through biological processes such as tree growth, soil carbon accumulation and wetland restoration.

Since the UK's Climate Change Act was passed in 2008, the amount of GHG removals provided by forestry, grassland and bioenergy crops has declined slightly from approximately -29 $MtCO_2e$ in 2008 to -26 $MtCO_2e$ in 2023. In comparison, the LULUCF sector as a whole has remained a steady net emitter at around +0.5 $MtCO_2e$ per year on average between 2008 and 2023. Total reported UK net emissions have declined over the period from 658 $MtCO_2e$ to 385 $MtCO_2e$.

Compared to many other countries, the UK's net land sink is relatively modest. This is largely due to its limited land area and low forest cover (~13%), although the latter is gradually increasing. At the same time, extensive areas of historically drained peatland continue to act as a major source of emissions, offsetting a significant share of the removals from forest and grassland soils.[196] As a result, total net land-based removals have plateaued in recent years. Across the main land use categories, based on inventory data from 2008–23:[197]

- **Forestry** has provided the largest carbon sink, averaging -21.0 to -17.6 $MtCO_2e$ per year between 2008 and 2023. While still substantial, there was a gradual declining trend in net removals over this period.
- **Grassland** is also a carbon sink, contributing between -7.5 and -8.5 $MtCO_2e$ per year.
- **Bioenergy crops** provided a small sink, no greater than –0.2 $MtCO_2e$ per year. This measures the increase

in below-ground carbon generated by growing these perennial crops, rather than the carbon reductions resulting from using the harvested biomass (which are measured in the energy sector).

- **Peatland** emissions remained persistent, averaging around +16.5 to +15.0 $MtCO_2e$ per year, reflecting the continued drainage and degradation of peat soils, particularly for cropland and grassland use.
- **Cropland** is a consistent net source, having emitted approximately +9.6 to +9.0 $MtCO_2e$ per year, with little variation over time – largely due to cultivation on carbon-poor soils and historical land use practices.
- **Settlement land** emissions have declined modestly, from +3.7 $MtCO_2e$ in 2008 to +3.2 $MtCO_2e$ in 2023.

**Figure 7.1** shows the trends in these land-based removals and emissions, covering the main subcategories: forest land, peatland, grassland and cropland mineral soils.

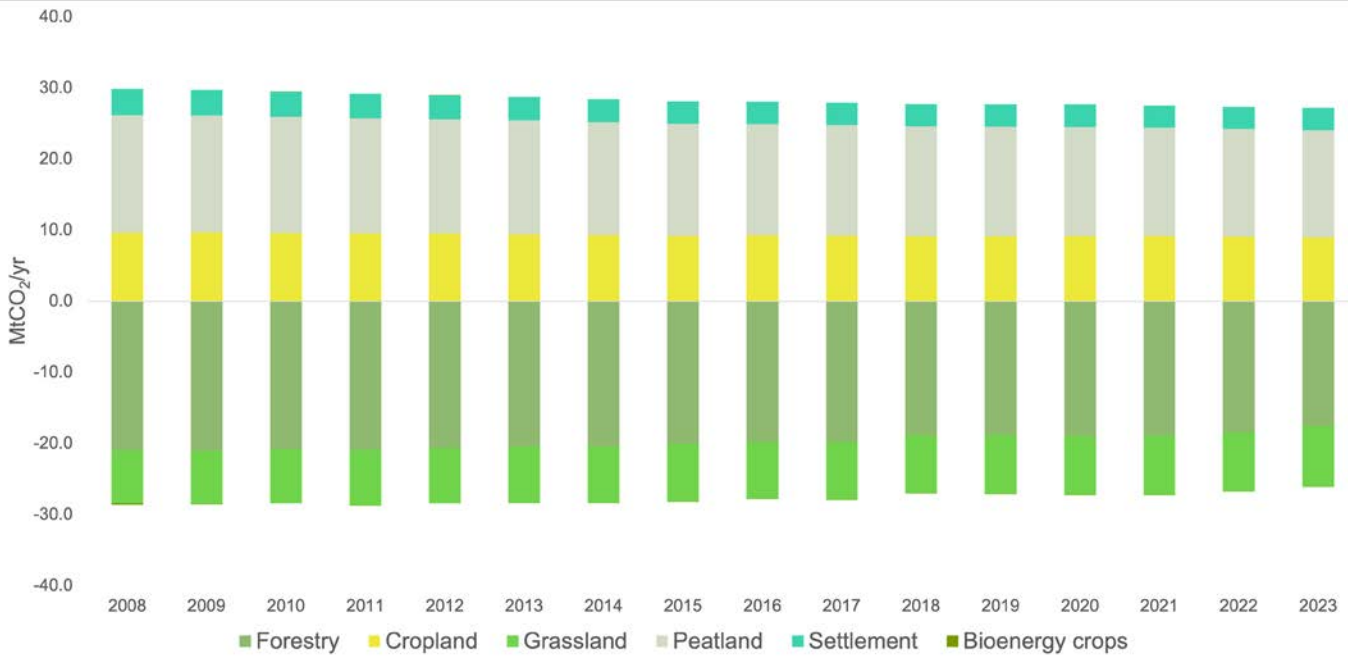



***Figure 7.1*** *Annual UK land-based removals and emissions, by land use category (2008–23)*
*Source: DESNZ. Final UK greenhouse gas emissions statistics: 1990 to 2023. https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-statistics-1990-to-2023 Table 1.2*

## 7.3 UK conventional CDR as measured in the Global Carbon Budget

In accordance with IPCC guidelines, the UK national GHG inventory reports emissions and removals using the concept of "managed land". The areas of land used by humans (for production of food and fibre, and for other ecological or social functions) are defined as "managed", and all emissions and removals in those areas are counted in the inventory as arising from human activity.

The advantage of this approach is that it can be derived pragmatically from direct observations of GHG fluxes. The drawback is that these fluxes are a complex combination of the natural carbon cycle, direct human-caused factors (such as tree planting) and indirect factors (such as increased carbon uptake by land as a result of higher $CO^2$ concentrations in the air and warmer temperatures). As such, it does not align precisely with the definition of CDR given by the IPCC 6th Assessment Report, which *"...excludes natural uptake not caused directly by human activities".*[198]

This difference in definition matters for climate stabilisation and net zero targets. The scientific finding that net zero emissions of $CO_2$ will halt the rise in global temperature rests on counting only direct human-caused emissions and removals. As national inventories, designed to track those emissions and removals, include some natural carbon uptake on managed land, they over-estimate the contribution of conventional CDR on land. [199]

In closer alignment with the IPCC definition of CDR, direct human-caused emissions and removals on land are estimated by the Global Carbon Budget and in the mitigation pathways assessed by the IPCC. [200, 201] These estimates are based on land use activities, rather than areas designated as managed land, although they rely on modelling and cannot be inferred directly by observations.

Global Carbon Budget estimates for CDR from UK forestry (excluding harvested wood products) are lower than estimates from the national GHG inventory (see **Figure 7.2**). The difference between the estimates has grown from 2.4 $MtCO_2e$ in 2008 to 3.3 $MtCO_2e$ in 2022. While this is roughly 20% of the inventory estimate for forest removals, it is much smaller than the nearly 70% difference observed for forests in total at the global level.[202]

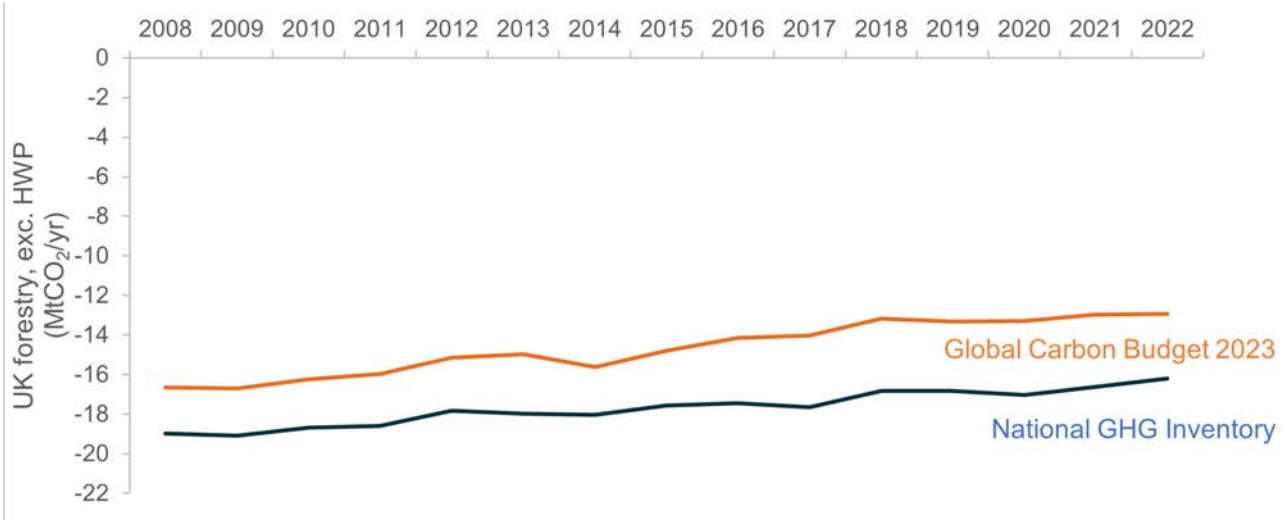



***Figure 7.2*** *Estimates of removals from UK forestry, excluding harvested wood products, as reported by the national GHG inventory and Global Carbon Budget (2023)*
*Source: European Commission. EU observatory on deforestation and forest degradation. https://forest-observatory.ec.europa.eu/carbon/fluxes*

Looking ahead, the difference between IPCC definitions of removals and IPCC-guided inventory reporting has implications for policy projections. Net zero pathways by the UK Government and the CCC follow inventory methods. Calculating the precise impact of following the more restrictive IPCC definition of CDR would require further detailed modelling and assumptions. As an illustration, however, if the roughly 20% difference were to continue, then the CCC Balanced Net Zero Pathway (see **Chapter 8**) would fall short of net zero by around 6 MtCO2e per year by 2050. The IPCC's Seventh Assessment Report (AR7) scoping process and its Expert Meeting on Reconciling Land Use Emissions Estimates highlight international efforts to improve alignment between these different reporting approaches. [203]

## 7.4. Estimated levels of novel CDR in the UK

Novel CDR approaches are not yet reported in the UK's national GHG inventory, as they fall outside the scope of current inventory methodologies provided by the IPCC. However, a small number of UK-based projects have begun reporting removal volumes through public disclosures and third-party registries.

According to publicly available information gathered from UK-based CDR companies, only limited volumes of novel removals have been achieved to date. Carbon removals sold and delivered to date remain low, primarily from pilot-scale biochar, enhanced weathering and mineralisation projects. Companies such as Carbon Hill, O.C.O. Technology,

Premier Forest and UNDO have announced operational projects (not necessarily all delivered in the UK). **Table 7.1** shows the tonnes of credits delivered by these companies. Moreover, as discussed in **Chapter 4**, no novel removal projects based in the UK have yet issued or retired carbon credits through international registries such as Verra, Gold Standard or Puro.earth, according to the 2024 CarbonPlan OffsetsDB and Berkeley VCM registry aggregator.

| Company | CDR Method | Tonnes Delivered |
|---|---|---|
| Carbon Hill | Biochar | 467 |
| O.C.O. Technology | Mineral Products | 3,296 |
| Premier Forest | Biochar | 325 |
| UNDO | Enhanced Weathering | 3,814 |

***Table 7.1*** *Novel CDR delivered by UK companies, tonnes (as of July 2025)*
*Source: CDR.fyi. Leaderboards. https://www.cdr.fyi/leaderboards*

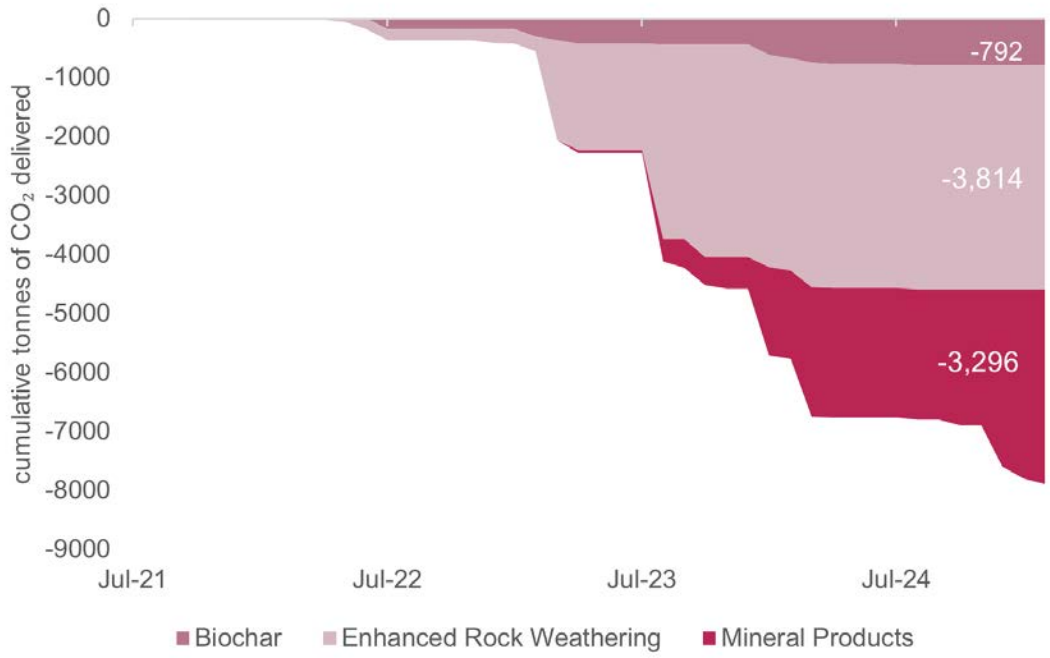



***Figure 7.3*** *Timeseries of novel CDR delivered by UK companies, cumulative tonnes (as of July 2025)*
*Source: CDR.fyi. Leaderboards. https://www.cdr.fyi/leaderboards*

UK CDR companies have achieved sales for future credits with voluntary buyers at a larger scale: current deployment is estimated at just under 8,000 tonnes, but total sales are over 130,000 tonnes (see **Figure 7.4**). Only around a quarter of these sales come from BECCS and DACCS projects, which are the CDR methods being prioritised by the government under its GGR Business Model development (see **Chapter 5**).

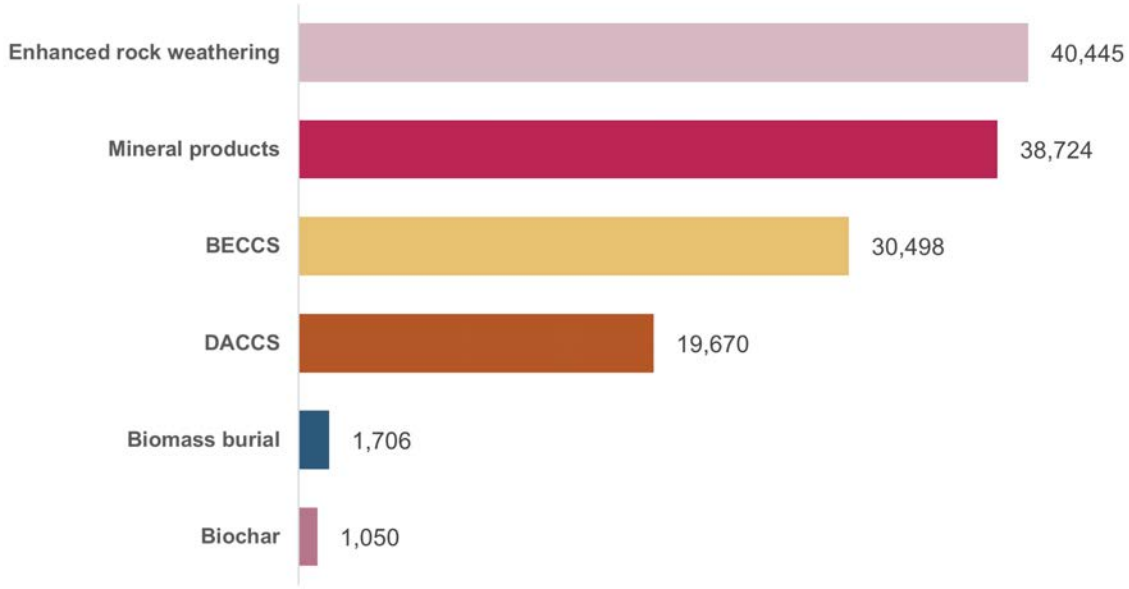



***Figure 7.4*** *Novel CDR sold by UK companies, tonnes (as of July 2025)*
*Note: Values represent cumulative sales as reported to CDR.fyi, as of early 2025. These sales represent forward contracts, not necessarily delivered removals.*
*Source: CDR.fyi. Leaderboards. https://www.cdr.fyi/leaderboards*

In addition to voluntary credit sales, data from the Carbon Capture and Storage Association (CCSA) provides a broader view of BECCS and DACCS projects under development in the UK, as well as CCS-based emission reduction projects.[204] This dataset, illustrated in **Figures 7.5** and **7.6**, includes projects in government negotiation, shortlisted for funding, or otherwise eligible under the Track 1 cluster sequencing process, as well as others at earlier stages of planning. While there is some small overlap between these projects and the BECCS and DACCS sales in the voluntary carbon market data (see **Figure 7.6**), the CCSA pipeline represents a more expansive snapshot of the UK's emerging CCS-based CDR landscape. Up to 19.2 $MtCO_2$/year of potential CCS-based removals has been proposed in some shape or form, although none is operational yet and the vast majority is still at early stages of development. Just 0.6 $MtCO_2$/year of removals is at the most developed negotiation stage with government, while a further 0.2 $MtCO_2$/year has been shortlisted and 1.8 $MtCO_2$/year is eligible for Track 1. Further proposed projects would be part of other clusters beyond Track 1, unlikely to be in place this decade.

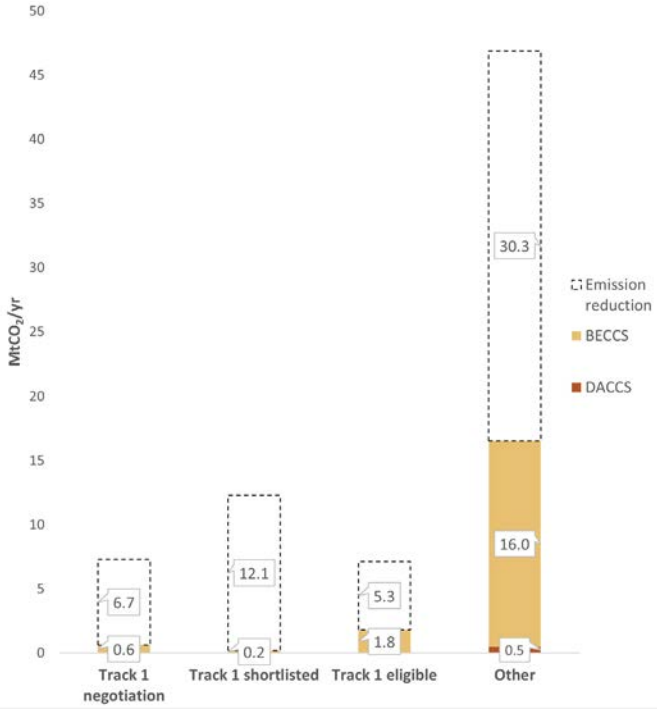



***Figure 7.5**: Estimated $CO_2$ Removal Capacity of UK BECCS and DACCS Projects by Development Stage ($MtCO_2$/year) Note: This figure shows estimated carbon removal capacity for BECCS and DACCS projects in the UK based on their status within the government's Track 1 cluster sequencing process or other stages of development, as recorded in the CCSA project pipeline (2024). These figures reflect potential future capacity and do not represent verified or delivered removals. The total from projects in negotiation, shortlisted, and eligible under Track 1 is 2.7 $MtCO_2$/year, with an additional 16.5 $MtCO_2$/year from other announced projects, yielding a combined potential of 19.2 $MtCO_2$/year.*

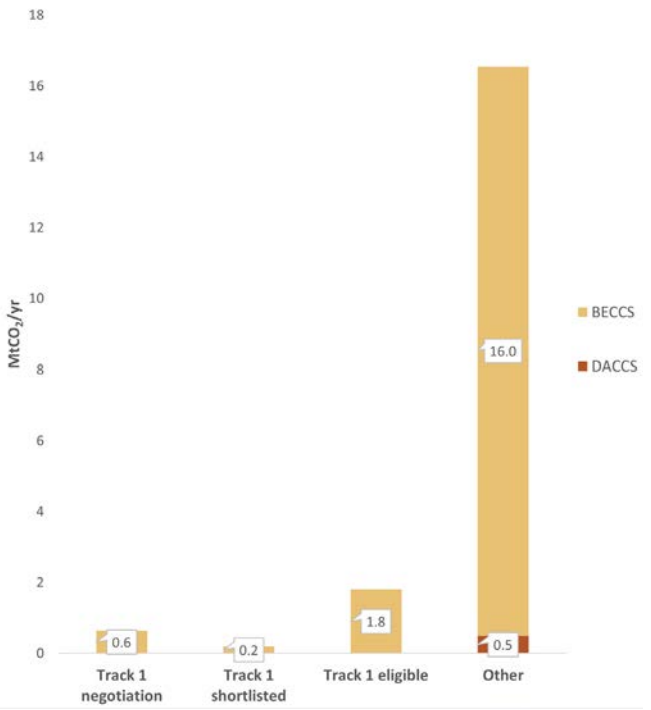



***Figure 7.6:** Total $CO_2$ Capture Capacity of UK BECCS and DACCS Projects, Including Emission Reductions ($MtCO_2$/year) Note: This figure includes both estimated CDR (carbon dioxide removal) and emission reduction capacities for BECCS and DACCS projects in development, as recorded by the CCSA. The stacked dashed bars represent total $CO_2$ capture potential, including emissions avoided, while the solid segments indicate removals only. These values provide insight into the broader CCS pipeline but should not be conflated with carbon removal volumes eligible for crediting under CDR-specific MRV systems.*

Both planned deployments and carbon credit sales for novel removals currently fall short of the 5 $MtCO_2$/yr government ambition by 2030, as well as the 3 $MtCO_2$/yr of removals by 2030 and 36 $MtCO_2$/year by 2050 needed under the CCC's Balanced Pathway

## Data limitations and outlook

As mentioned, data on novel CDR deployment in the UK and by UK companies operating abroad are limited and fragmented. There is no nationally standardised disclosure protocol, and figures are often announced via corporate press releases or buyer communications. MRV protocols and third-party verification for novel removals remain project-specific. Moreover, many early projects have not yet been listed on formal registries, and most rely on bilateral arrangements between buyers and suppliers. The IPCC Task Force on National Greenhouse Gas Inventories is planning to explore how to provide guidance to countries on how emerging CDR methods, such as biochar, enhanced weathering and DACCS, might be included in inventory reporting.[205]

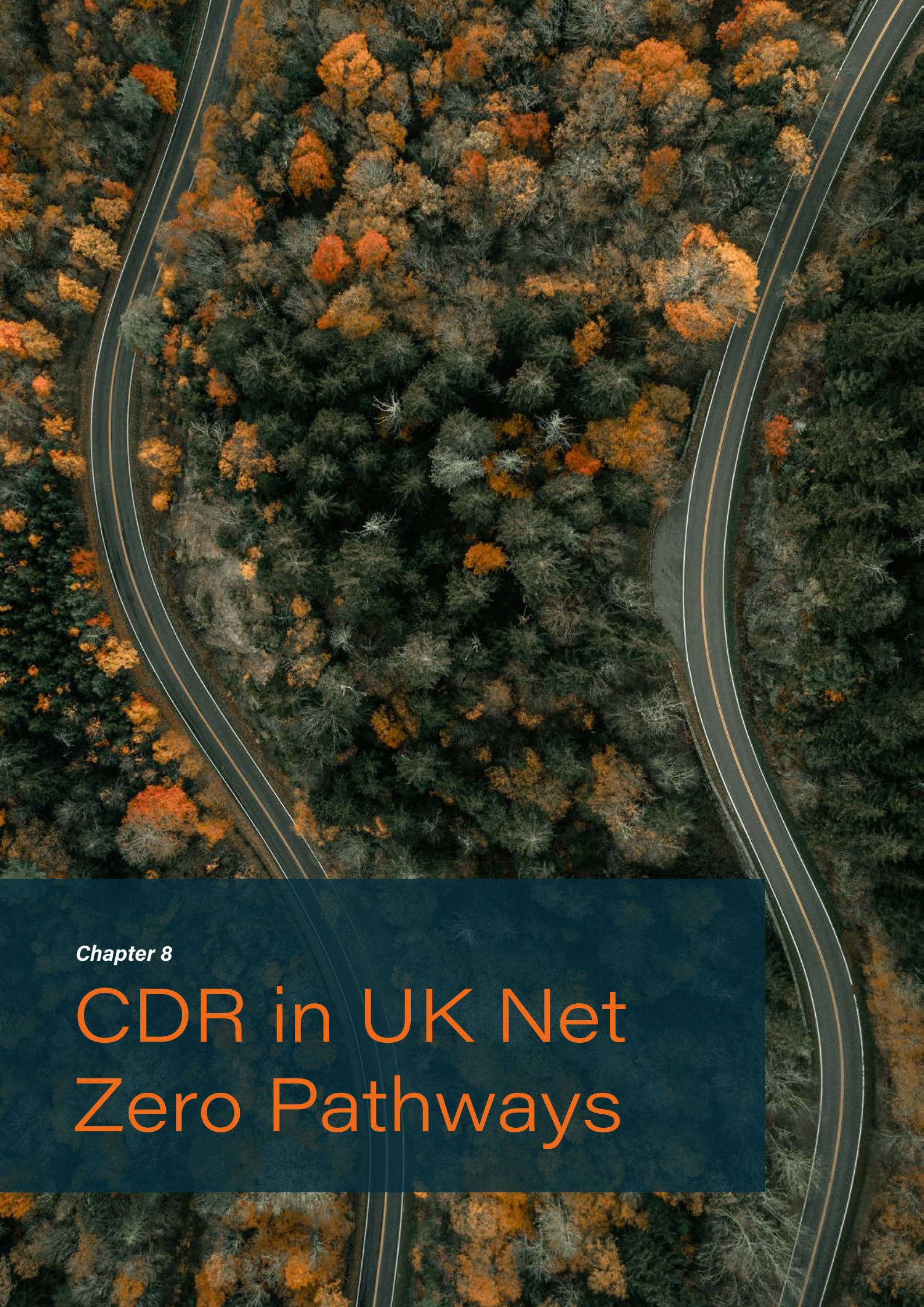
Given these caveats, estimates of current novel removal levels in the UK should be treated as informative of scale and trends rather than precise. Continued tracking of deployment will require consistent MRV frameworks, public disclosure mechanisms, and integration with national accounting systems.

## 7.5. Conclusion

Conventional land-based removals continue to deliver measurable, though modest, climate benefits, while novel CDR methods are both nascent and largely outside official accounting frameworks. Recent data shows the overall land sink has weakened: while forest land (-21.0–17.6 $MtCO_2e$/year) and grassland mineral soils (-7.5–8.5 $MtCO_2e$/year) provide significant removals, the LULUCF sector as a whole has shifted to becoming a small net source (+1.1 $MtCO_2e$ in 2023) due to persistent emissions from degraded peatlands and land conversion.

Novel removals are beginning to emerge through pilot projects and voluntary market activity, yet total volumes remain low and reporting is fragmented. Although the CCC projects novel removals to reach 36 $MtCO_2e$ by 2050 under the Balanced Pathway, this will require coordinated action across inventory methodologies, policy incentives and monitoring systems. As the UK moves toward its 2050 net zero target, integrating both conventional and novel CDR into national accounting, market tracking, and policy frameworks will become increasingly important.

Coherence across reporting systems, inventory data, carbon budgets, and project-level disclosures, will be essential for transparent progress tracking and sound decision-making. Current data offer a foundational snapshot, but improved MRV will be necessary to capture the full picture of the UK's carbon removal efforts in the years ahead.



*Chapter 8*

# CDR in UK Net Zero Pathways

# Chapter 8: CDR in UK Net Zero Pathways

As UK climate action has progressed, multiple "pathways" have been published to show how emission targets can be achieved. Principally these have been generated by the CCC in providing advice on carbon budgets, and then by successive governments in laying out their plans and policies to achieve those budgets. At least some CDR features in all these net zero pathways, balanced with various levels of emissions to achieve net zero by 2050. This chapter examines the evolving role of CDR in UK net zero pathways, comparing different approaches across successive carbon budgets and alternative scenarios.

## 8.1 Historical context of CDR in UK climate planning

The treatment of CDR in CCC pathways has developed in detail, scope and magnitude over time, in response to new information on emissions, the status of different mitigation options, and the change in the 2050 target from an 80% reduction to net zero.

For instance, the CCC's Sixth Carbon Budget, published in 2020, provided the first detailed modelling of CDR required to meet the UK's strengthened 2050 net zero target. In its Balanced Pathway, the CCC projected the need for around 58 $MtCO_2$ per year of novel removals by mid-century, primarily through BECCS. These removals were intended to offset residual emissions from sectors such as aviation and agriculture. At the time, the modelling also assumed higher levels of residual emissions than are currently expected, which contributed to the higher removal requirements.

Building on this, the UK Government's Net Zero Strategy (2021) adopted a novel CDR ambition of 5 $MtCO_2$/year by 2030, increasing to 75–81 $MtCO_2$/year by 2050. The strategy explicitly stated that these removals were not intended to replace emissions reductions, but to balance residual emissions in order to meet the UK's statutory climate goals. The methods identified included BECCS, DACCS, biochar and enhanced rock weathering, reflecting a broadening of the novel CDR portfolio beyond BECCS alone.

## 8.2 The Seventh Carbon Budget CDR pathway

The Seventh Carbon Budget was published by the CCC in February 2025 and sets a recommended emissions cap of 535 $MtCO_2e$ for the period 2038–42. This represents an 87% reduction relative to 1990 levels. If legislated, it will form part of the UK's legally binding path to net zero by 2050.[206]

### A single 'Balanced Pathway'

The Seventh Carbon Budget proposes a single Balanced Pathway, representing what the CCC sees as the most feasible and economically efficient route to net zero (see **Figure 8.1**).

In this Balanced Pathway, the projected requirement for novel removals by 2050 stands at approximately 36 $MtCO_2$/year, which is less than the 58 $MtCO_2$/year estimate in the Sixth Carbon Budget and the 75–81 $MtCO_2$/year target in the Net Zero Strategy.

While the Seventh Carbon Budget reduces the projected dependence on removals, it maintains their role for sectors in which deep decarbonisation presents significant technical challenges.

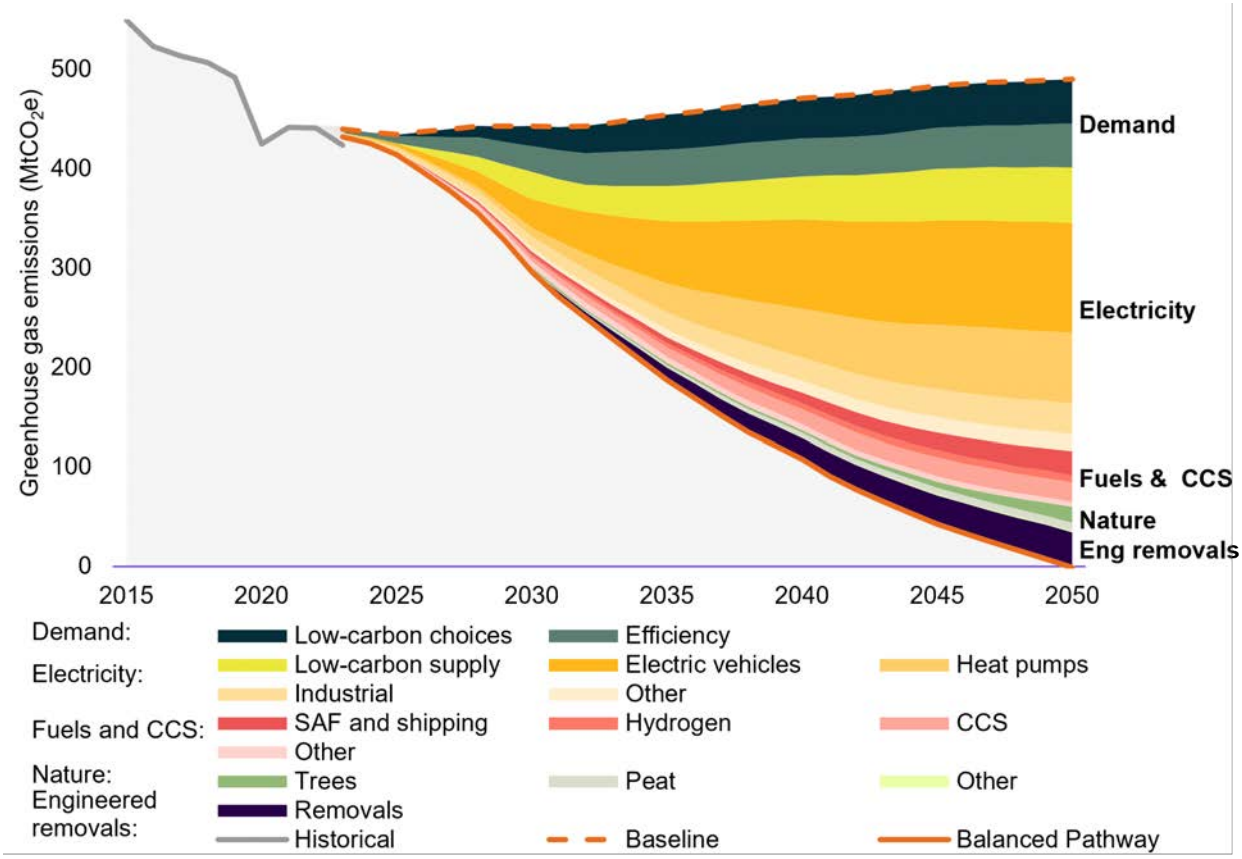



***Figure 8.1*** *The CCC's Seventh Carbon Budget "Balanced Pathway"*
*Source: Climate Change Committee. The Seventh Carbon Budget. https://www.theccc.org.uk/publication/the-seventh-carbon-budget/ (2025)*

## Different routes for emissions reductions

The Seventh Carbon Budget identifies five routes for achieving emissions reductions:

1. **Electricity**: Large-scale electrification of energy use, supported by renewables.
2. **Low-carbon fuels and CCS**: Hydrogen, biofuels and CCS for industrial and transport applications.
3. **Nature-based (conventional) removals**: Woodland expansion, peatland restoration and bioenergy crops.
4. **Engineered (novel) removals**: BECCS, DAC and other negative emissions technologies.
5. **Demand reduction**: Efficiency improvements and behavioural shifts.[207]

CDR is integrated primarily through nature-based solutions and engineered removals, with supporting infrastructure under low-carbon fuels. These pathways aim to offset residual emissions from hard-to-abate sectors to achieve net zero by 2050.

## Nature-based removals

In the Balanced Pathway, "nature-based sequestration" fully offsets the remaining emissions from agriculture and land use by 2050, with most of the required scale-up occurring before 2030. Specifically:

- **Woodland expansion**. UK woodland cover is projected to increase from 13% today to over 16% by 2040, requiring tree planting rates to rise to 37,000ha per year by 2030. This expansion is expected to deliver long-term carbon sequestration through both biomass and soil carbon storage.

- **Peatland restoration**. The proportion of UK peatlands in natural or rewetted condition is set to increase from 26% in 2023 to 55% by 2040, delivering over half of all land use emissions reductions by 2040. The CCC emphasises that most of this scale-up must occur before 2030.
- **Perennial energy crops**. In addition to BECCS feedstock supply, perennial energy crops such as miscanthus and willow contribute to land-based removals, as they enhance soil carbon storage during cultivation.

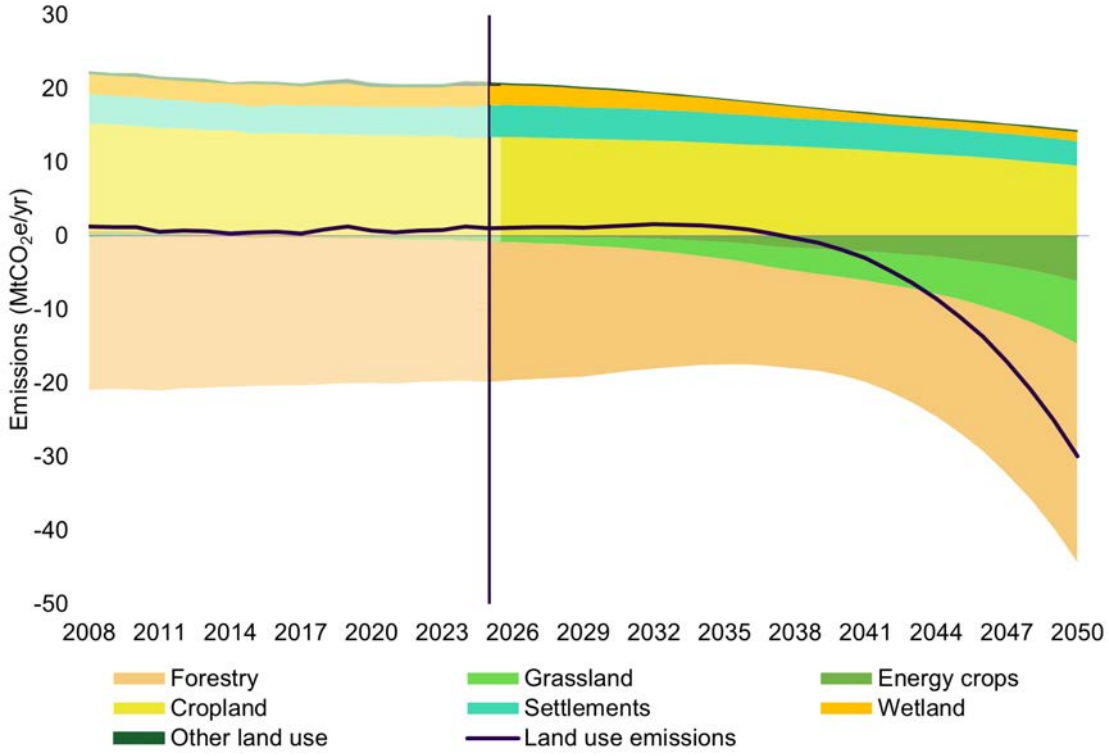



***Figure 8.2*** *CCC's land use emissions by subsector, historical (2008–22) and Balanced Pathway (2025–50)*
*Note: Land categories in the CCC's pathways differ slightly from those used in the national GHG inventory.*
*Source: Climate Change Committee. The Seventh Carbon Budget. https://www.theccc.org.uk/publication/the-seventh-carbon-budget/ (2025)*

## Engineered removals

Engineered removals are identified as critical in balancing residual emissions, particularly from aviation and other hard-to-abate sectors. By 2040, both BECCS and DACCS are projected to be operational at scale. Additionally, biochar and enhanced rock weathering were incorporated for the first time, allocating them a combined level of 3 $MtCO_2$ per year by 2050. While these methods constitute a small share of overall removals, their inclusion reflects growing evidence to suggest they could play a scalable, cost-effective role.

## Low-carbon fuels and CCS

By 2040, CCS is projected to be deployed in industrial subsectors with unavoidable process emissions, such as chemicals, cement and lime. CCS is included in power generation, facilitating dispatchable low-carbon electricity by pairing with hydrogen and bioenergy. Importantly, both BECCS and DACCS depend on the same functional $CO_2$ transport and storage network that is used for CCS on conventional point-sources of emissions. Achieving both CCS and novel removals in this trajectory requires the development of $CO_2$ storage sites and pipelines.

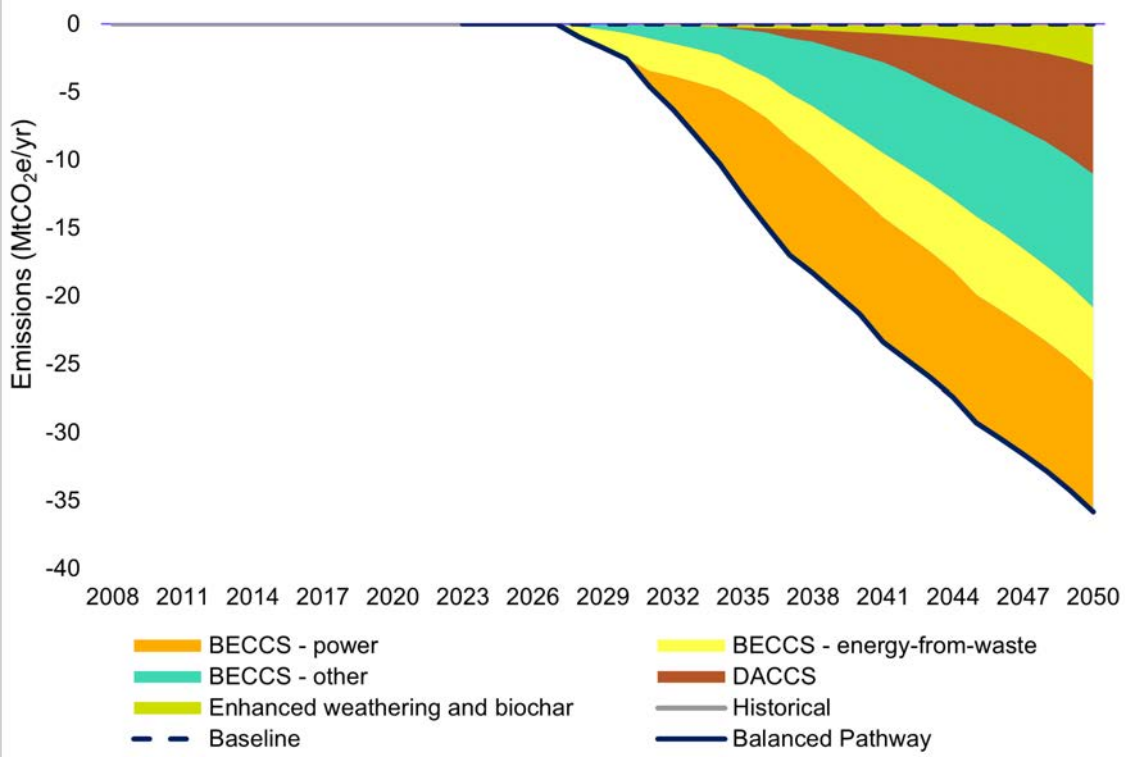



*Figure 8.3 CCC's sources of abatement for novel removals in the Balanced Pathway (2025–50)*
*Source: Climate Change Committee. The Seventh Carbon Budget. https://www.theccc.org.uk/publication/the-seventh-carbon-budget/ (2025)*

## 8.3 Comparison of CDR pathways

### Evolution of CDR targets in UK climate policy

As mentioned, the UK's approach to CDR has evolved over successive policy frameworks, reflecting changing expectations about the feasibility and necessity of removals. Specifically looking at novel removals, the Net Zero Strategy (2021) set an initial goal of 5 $MtCO_2$/year by 2030, scaling up to 75–81 $MtCO_2$/year by 2050.[208]

The CCC, in its Net Zero: The UK's contribution to stopping global warming report projected novel removals deployment reaching up to 53 $MtCO_2$/year by 2050.[209] The Sixth Carbon Budget (2020) explored a broader range of scenarios depending on the level of residual emissions, and societal and technological ambition, with engineered removals of 45–112 $MtCO_2$ in 2050. The Seventh Carbon Budget revised these expectations downward in a single Balanced Pathway, now projecting 36 $MtCO_2$/year of novel removals by 2050, reflecting lower residual emissions and an associated reduced reliance on large-scale CDR deployment.

### Range of CDR projections in UK pathways

Beyond government and CCC pathways, a range of scenarios published by other research groups illustrate different possible contributions to net zero for CDR in the UK. They range from pathways requiring significant novel removals, to strategies that eliminate the need for novel CDR entirely:

- The Zero Carbon Britain scenario, developed by the Centre for Alternative Technology, outlines a pathway that requires no CDR. Instead, it proposes to achieve net zero by transforming energy, transport, land use and diets, eliminating residual emissions rather than offsetting them. The scenario achieves 47.8 $MtCO_2e$/year of removals by 2050, sourced from afforestation (25.3 Mt), biomass in construction (14.7 Mt), biochar

(1.6 Mt), peatland restoration (1.9 Mt) and silo storage (4.3 Mt). The pathway also involves a 60% reduction in energy demand and major dietary shifts, repurposing 75% of grazing land, while improving self-sufficiency and reducing agricultural emissions by 57% compared to 2017 levels.[210]

- A study published by Barrett et al. (2022) in Nature Energy, explores the potential for energy demand reduction to contribute to achieving UK net zero. It sets out three demand-focussed scenarios, with removals in 2050 ranging from 34 to 118 $MtCO_2$. The study finds that a 52% reduction in energy demand by 2050 (compared with 2022 levels) could remove the need for novel CDR such as BECCS and DACCS, although it still involves at total of approximately 58 $MtCO_2$/year removals from a combination of afforestation, energy forestry and soil sequestration.[211]
- Ward et al. (2019) present an "Absolute Zero" scenario, which models a future in which all emissions are fully eliminated by 2050, requiring no carbon removals. To achieve this, the scenario goes even further in reducing demand for energy and materials than the above by, for example, the complete cessation of flying and shipping, and an end to the production of virgin cement and steel.[212]
- The National Energy System Operator's Future Energy Scenarios (2024) model three net zero-compliant pathways, all of which include around 70 $MtCO_2$/year of CDR by 2050, split across BECCS to power, BECCS to hydrogen/fuels, DACCS, and conventional land-based methods. The report highlights that CDR is considered essential across all net zero pathways.[213]
- The UCL Institute for Sustainable Resources (2021) analysed five scenarios for BECCS deployment. They found novel CDR could range from 38 to 80 $MtCO_2$/year by 2050, with biomass use and sectoral application (e.g., power vs hydrogen) varying significantly across scenarios. In contrast to CCC assumptions, some scenarios leaned more heavily on DACCS or natural removals due to sustainability constraints. [211]

The broad trade-offs between societal transformation and reliance on carbon removals and CCS across these studies have been summarised.[212] Scenarios involving minimal behavioural change, such as continued demand for aviation, meat, and fossil fuels, require substantially higher CDR (up to 109 $MtCO_2$/year), particularly from BECCS and DACCS. Scenarios that seek to avoid novel removals entirely achieve net zero through energy demand reduction, dietary shifts, and land-use change. Electricity demand in 2050 varies widely from 51% to 160% above 2020 levels depending on electrification and hydrogen uptake.

## Looking ahead for CDR deployment

There is substantial uncertainty regarding both the balance between different removal technologies and the trade-offs between removals, carbon-free supplies of energy and materials, and demand-side measures. Moreover, the modelling tools used to generate these future pathways have known limitations. They often do not capture second-order societal, ecological, and economic impacts, and the deep uncertainties involved are rarely made fully explicit.[213] Acknowledging these constraints is important to avoid over-reliance on specific CDR projections and to support more adaptive and robust climate planning.

Despite these limitations, all analyses point to the importance of rapid action across multiple sectors to give confidence in reaching net zero. This action includes enabling a CDR portfolio to grow quickly and sustainably, while also ensuring that removals complement, rather than substitute, deep emissions cuts. The role of specific CDR and emission reduction methods in UK net zero pathways will continues to develop in light of technological advancements, economic and social considerations, and specific policy choices.

## 8.4 Conclusion

CDR plays an increasingly well-defined role in UK net zero pathways. While early strategies relied heavily on BECCS and afforestation, newer scenarios, including the Seventh Carbon Budget, incorporate a more diverse mix of methods, and anticipate lower overall volumes. The reduced reliance reflects updated data on emissions trends, and a greater emphasis on demand-side mitigation and direct decarbonisation.

In any scenario, the successful delivery of CDR across these pathways faces several challenges. Tree planting rates remain below required levels, peatland restoration efforts must scale rapidly before 2030, and progress on $CO_2$ transport and storage infrastructure is still at an early stage. For novel removals, policy and investment mechanisms remain under development. Removal methods, such as biochar and enhanced rock weathering, are now included in official pathways, but lack dedicated MRV standards and commercialisation frameworks, limiting their ability to attract investment or scale with confidence. Addressing these gaps will be important to support a balanced and resilient portfolio of CDR options.

The evidence from UK pathways confirms that CDR is not a substitute for rapid emissions reductions, but a necessary complement to address residuals from hard-to-abate sectors. The scale and role of CDR will continue to evolve alongside technological innovation, policy priorities and societal choices.

# Abbreviations

| | |
|---|---|
| AR6 | Sixth Assessment Report of the Intergovernmental Panel on Climate Change |
| BAU | Business-as-usual |
| BECCS | Bioenergy with carbon capture and storage |
| BSI | British Standards Institution |
| CCC | Climate Change Committee |
| CCPs | Core Carbon Principles |
| CCS | Carbon capture and storage |
| CCSA | Carbon Capture and Storage Association |
| CCU | Carbon capture and utilisation |
| CCUS | Carbon capture, utilisation and storage |
| CDM | Clean Development Mechanism |
| CDR | Carbon dioxide removal |
| CDTs | Centres for Doctoral Training |
| CfDs | Contracts for Difference |
| CGE | Computable General Equilibrium |
| $CH_4$ | Methane |
| $CO_2$ | Carbon dioxide |
| CRCF | Carbon Removals and Carbon Farming |
| DAC | Direct air capture |
| DACCS | Direct air carbon capture and storage |
| DESNZ | Department for Energy Security and Net Zero, UK Government |
| DOCCS | Direct ocean carbon capture and storage |
| DTPs | Doctoral Training Partnerships |
| EIRO | Energy Innovation & Research Office |
| EPSRC | Engineering and Physical Sciences Research Council |
| ERW | Enhanced rock weathering |
| ETS | Emissions Trading Scheme |
| EU | European Union |
| FGS | Forestry Grant Scheme |
| FLF | Future Leaders Fellowships |
| GGR | Greenhouse Gas Removal |
| GGR-D | Greenhouse Gas Removal Demonstrators Programme |
| GHG | Greenhouse gas |
| Gt | Gigaton |
| Ha | Gectares |
| ICVCM | Integrity Council for the Voluntary Carbon Market |
| IPCC | Intergovernmental Panel on Climate Change |
| Kt | Kiloton |
| LCA | Life-cycle assessment |
| LULUCF | Land use, land-use change and forestry |
| MRV | Monitoring, reporting and verification; or measurement, reporting and verification |
| $MtCO_2$ | Metric tonnes of $CO_2$ |
| $N_2O$ | Nitrous oxide |
| NDCs | Nationally Determined Contributions |
| PASs | Publicly Available Specifications |
| R&D | Research and development |
| UKCCSRC | UK Carbon Capture and Storage Research Centre |

| | |
|---|---|
| UNFCCC | United Nations Framework Convention on Climate Change |
| UKRI | UK Research and Innovation |
| US | United States |
| VCM | Voluntary Carbon Markets Integrity |
| VCMI | Voluntary Carbon Markets Integrity Initiative |

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CO$_2$RE THE GREENHOUSE GAS REMOVAL HUB

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Funded through the UKRI SPF Greenhouse Gas Removal Demonstrators (GGR-D) Programme, CO$_2$RE co-ordinates the Programme and conducts solutions-led research to evaluate a balanced portfolio of economically, socially and environmentally scalable Greenhouse Gas Removal options, with associated policy design, engagement and outreach.

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