Slow but Sure: Expert Perspectives on Carbon Dioxide Removal Policy in the United Kingdom

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Competing interests
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Abstract

Carbon dioxide removal (CDR) methods are essential to meeting national net zero targets, yet governments have only recently engaged with the need for CDR policymaking. The United Kingdom's government is amongst the most active, introducing explicit targets and dedicated policies for CDR deployment. To assess how both commercial and policy actors view these policy developments, we conduct semi-structured interviews with 25 experts active in UK CDR policymaking, with expertise spanning all relevant CDR methods. Through inductive coding, we identify and detail several key themes and policy recommendations. Firstly, a scepticism towards the voluntary carbon market, reflecting a need for the government to stimulate near-term demand for CDR. Secondly, a need to implement credible monitoring, reporting, and verification through a government standard, standardising how differences in the permanence of CDR methods are managed. Thirdly, a need to improve state capacity, to be met by a new cross-government body tasked with overseeing CDR. Fourth, a need for 'net-negative ready' policy, ensuring that the proposed integration of CDR within the UK emissions trading scheme continues to provide long-term demand, given the likelihood of temporary temperature overshoot and net-negative emission targets, as the next necessary extension of climate policy.

Key policy insights

- Through interviews with 25 participants active in UK CDR policymaking, we reveal a scepticism towards the UK government policy approach to use the voluntary carbon market to provide near-term demand for CDR.
- We identify a need to improve state capacity to deliver on the government's plans for CDR, which should be addressed by a new cross-government body and a government standard for monitoring, reporting and verification.
- The UK government should also ensure its policy plans are 'net-negative ready', by, for example, providing a pathway to a net-negative emission trading scheme.

Introduction

With net zero targets as the guiding principle of national climate governance, governments now face the challenge of turning pledges into plans and policies, transforming multiple sectors of their economies within a matter of decades (Green, Hale and Arceo, 2024). Reaching a national net zero target requires a means of balancing positive residual emissions with negative emissions, either directly within policy design or within national accounts (Fankhauser *et al.*, 2022; Pahle *et al.*, 2025). An essential component of reaching national net zero targets is therefore carbon dioxide removal (CDR); a term used to describe methods of removing carbon dioxide (CO_2) from the atmosphere and durably storing the carbon in terrestrial, ocean, or geological sinks, thereby producing (net) negative emissions (Babiker *et al.*, 2022). CDR is both an established area of climate policy and a nascent early-stage industry, depending on the method (Powis *et al.*, 2023). Nature-based methods of CDR[1], that enhance the uptake of CO_2 in land, are a long-standing element of global climate policy since the 1997 Kyoto Protocol, the predecessor to the 2015 Paris Agreement (Dooley and Gupta, 2017; Carton *et al.*, 2020). Since the emergence of net zero as a guiding concept in climate science and climate policy, the land's ability to store carbon has taken on a new importance as a means to compensate for residual hard-to-abate emissions elsewhere in an economy (Rogelj *et al.*, 2015; Dooley, 2024; Green, Hale and Arceo, 2024).

Engineered methods of CDR, such as bioenergy with carbon capture and storage (BECCS) and Direct Air Carbon Capture and Storage (DACCS), are a recent addition to climate policy, gaining traction from their prominent role in Integrated Assessment Models (IAMs) – energy-economy-climate models influential in IPCC Assessment Reports (Fuss *et al.*, 2014; van Beek *et al.*, 2020; Gusheva, Pfenninger and Lilliestam, 2024). Engineered CDR methods are at an early stage of policy support, with many governments supporting companies undertaking pilot plants, field trials, or exploring the feasibility of retrofits to existing sites (Ricardo, 2023; Nemet *et al.*, 2024). Engineered methods of CDR, following the trajectory common to many low-carbon technologies, are said to be in the '*formative phase*', between the first commercial projects and widespread commercial adoption (Nemet *et al.*, 2023).

The United Kingdom (UK) has been an early advocate of CDR, the UK Government has funded research programmes into CDR since at least 2017, and has consulted academics on the concept as early as 2009 (Lezaun *et al.*, 2021). CDR features prominently in scenarios published by the UK Government and the

[1] In this article we refer to two categories of CDR: nature-based and engineered. This mirrors the distinction made by the UK government. 'Nature-based approaches', in UK government communications, refer to CDR methods such as afforestation, forest management, and soil carbon sequestration, whereas 'engineering-based approaches' refer to methods such as Direct Air Carbon Capture and Storage (DACCS), Bioenergy with Carbon Capture and Storage (BECCS), wood in construction, biochar, and enhanced weathering (HM Government, 2021). Notably, many engineered methods rely on land to provide the means of capture and/or storage of carbon, for example, BECCS, enhanced weathering and biochar (Bellamy and Osaka, 2019). Further sub-categories are also used, for example, more recent policy announcements distinguish between 'CCUS-enabled' and 'non-CCUS' approaches, with the former describing BECCS and DACCS, and the latter, biochar and enhanced weathering (DESNZ, 2023c). These sub-categories delineate between methods that rely principally on geological storage, given the policies developed to support offshore geological storage by pipeline transport (DESNZ, 2023c). Whilst in this article we use CDR as the umbrella terms to describe all methods, irrespective of categories or sub-categories, UK climate policy commonly uses 'greenhouse gas removal', or 'GGR', to allow for methods that remove other greenhouse gases, such as methane (The Royal Society, 2018; HM Government, 2021). We use CDR as the most widely accepted term in academia and international climate policy (Renforth *et al.*, 2023).

Climate Change Committee (CCC), the independent statutory climate advisory body (CCC, 2020b; HM Government, 2022). For the CCC, the Balanced Net Zero Pathway, used by the committee to benchmark the progress and policies of the UK government, features 58 $MtCO_2$ of engineered removals in 2050 (CCC, 2020a). Whilst the removals from land-use, land-use change and forestry (LULUCF) amount to 39 $MtCO_2$ in 2050 (CCC, 2020a).

The UK Government's Net Zero Strategy, published in 2021, features 75-81 $MtCO_2$ of engineered removals in 2050, 17 $MtCO_2$ more than the CCC's Balanced Pathway, though well within the range explored in the four exploratory scenarios used to construct the CCC's pathway, ranging from 44-111 $MtCO_2$ of engineered removals in 2050 (HM Government, 2022; Joffe, 2023). Based on these scenarios, and the latest estimates of the UK's greenhouse gas emission inventory, LULUCF and engineered removals combined may amount to 20% (IQR, 16-23%) of the required mitigation between 2022 and 2050, the vast majority delivered by engineered removals (DESNZ, 2024a). Based on the trajectory set out in the strategy, the government has set ambitions for engineered removals, deploying 5 $MtCO_2$ by 2030, and 23 $MtCO_2$ by 2035, alongside targets for woodland creation and peatland restoration (HM Government, 2022; DESNZ, 2023a).

The UK government have been lauded as '*policy entrepreneurs*', developing dedicated policies for CDR (Schenuit *et al.*, 2021; Schenuit, Geden and Peters, 2024). Criticisms, however, have been levelled by industry and the CCC that the necessary policy commitments have not kept pace, and these efforts are now overshadowed by policy developments in the United States (US) and the European Union (EU) (Schenuit *et al.*, 2021; CCSA, 2023; CCC, 2024). As with engineered removals, CDR policymaking itself may be described as in a similar '*formative phase*', as interest groups seek to shape policy formation and the surrounding policy discourse (Boettcher, Schenuit and Geden, 2023).

The UK government has been amongst the most active in designing CDR policy, financing supply, through grants or contract for differences (CfDs), and ensuring longer-term demand, by proposing to integrate removals into the UK emission trading scheme (the UK ETS) (DESNZ, 2023c; UK Government *et al.*, 2024). This reflects a policy sequence common to climate policy, transitioning from research and development, to incentives for deployment, to integration into carbon pricing (Linsenmeier, Mohommad and Schwerhoff, 2022). Further transitions are envisaged within this sequence, such as a transition from voluntary to compliance markets, and a transition from public to private finance (DESNZ, 2023c). This sequence is similar to the sequence common to technology development, moving from ‘supply-push’ to ‘demand-pull’ policies, inducing innovation through deployment, lowering costs by ‘learning-by-doing’ and economies of scale (Nemet, 2009; Malhotra and Schmidt, 2020).

Whilst this sequence has accelerated the deployment of many low-carbon technologies, most prominently wind power, solar, and electric vehicles (Malhotra and Schmidt, 2020), CDR methods differ in their readiness, cost, potential, and permanence (Fuss *et al.*, 2018; Borchers *et al.*, 2024). Given these differences, advocates of CDR commonly recommend governments adopt a portfolio of methods, whilst simultaneously maintaining emission reductions and balancing multiple further policy objectives, such as restoring biodiversity (Honegger *et al.*, 2022; Dooley, Pelz and Norton, 2024). CDR policy, though informed by these sequences, is likely markedly more complex in practice. Given the number of policy developments, and the prominent role of CDR in national scenarios, the UK serves as a valuable example for governments similarly exploring the integration of CDR within their own plans and policies.

Addressing the need for detailed national case-studies to compliment comparative assessments across countries (Schenuit *et al.*, 2021), and building on prior practice in stakeholder-led studies (Forster *et al.*, 2020; Yang *et al.*, 2024), we carry out semi-structured interviews with 25 participants, spanning commercial actors and policy advocacy organisations, active in UK CDR policymaking. We consider engineered and nature-based removals, covering the majority of methods, including those with limited policy support in the UK, such as enhanced weathering and biochar (DESNZ, 2023c). We provide a summary of the main CDR policy developments in the UK, detail our methodology, and then explore themes emerging from the qualitative coding of our interviews.

A summary of CDR policy developments in the UK

Through multiple consultations, the UK government has refined it’s approach, setting out a broad policy sequence familiar to climate policy, beginning with government support for research and development, prior to dedicated incentives, followed by wider integration into existing carbon pricing schemes, such as the UK ETS (Schenuit *et al.*, 2024). We address each part of this sequence, in turn, delineating between supply and demand. For engineered CDR methods, government support for research and development, though preceded by smaller academic programmes (UKRI, 2010, 2023), began in 2020, with the Direct Air Capture and other Greenhouse Gas Removal technologies Competition, a two-phase competition for project developers totalling £70 million in announced government grants (BEIS, 2020, 2021). Phase two of the competition saw £54.4 million allocated across 15 pilot projects, including for methods; BECCS, DACCS and biochar (BEIS, 2022b).

To bridge the investment risks of early engineered projects, the UK government plans to introduce a CfD scheme for project developers, also known as the 'GGR Business Model', building on the success of the CfD introduced for offshore wind (BEIS, 2022a; Watson and Bolton, 2024). In the scheme, a fixed 'strike price' per tonne removed (£/tCO_2) is negotiated between the government and the project developer, based on costs and investment returns (DESNZ, 2023c). The project developer then sells the project's removal credits into either the voluntary carbon market (VCM) or a compliance market, with the difference between the 'market price' and the strike price paid by the government to the developer if negative, or by the project developer to the government if positive, guaranteeing a set revenue for the project developer (DESNZ, 2023c). CfDs will also be supported by a government monitoring, reporting and verification (MRV) standard, setting out the requirements projects must meet to receive government support (DESNZ, 2023d, 2024b). Demand for removal credits is anticipated to initially come from the VCM, given the rise in corporate climate action and removal credit purchases from technology companies, such as Microsoft, Meta, and Google (DESNZ, 2023d).

In the longer-term, from 2028 or later, demand may come from substituting removals for allowances in the UK ETS, a cap-and-trade scheme established in 2021 after the UK's exit from the EU's emission trading scheme (UK Government *et al.*, 2024). These policies are complimented by policies that may induce spillover effects that benefit removal projects, such as the UK's Sustainable Aviation Fuel Mandate, which supports the utilisation of CO_2 from direct air capture to produce fuels, or policies that incidentally produce negative emissions, such as the Industrial Carbon Capture (ICC) Business Model and Waste ICC Business Model, which supports negative emissions from BECCS by combusting biomass for energy and heat, capturing and storing the resulting CO_2 (DESNZ, 2023b, 2024c; DfT, 2024).

Geological storage for BECCS and DACCS projects is supported by shared CO_2 storage and transport networks in the UK's industrial clusters, areas of concentrated industrial emissions that receive dedicated government support to decarbonise (Sovacool, Geels and Iskandarova, 2022; DESNZ, 2023d). Engineered removals, notably BECCS and DACCS, are therefore tied to the wider decarbonisation of both industry and aviation, the success of the industrial clusters, and the use of carbon markets to drive demand. Biochar and enhanced weathering, beyond their inclusion in academic trials, have comparatively limited government support (UKRI, 2022; DESNZ, 2023d; Welsh Government, 2024a).

Policies to incentivise the supply and demand of nature-based removals are most established for woodlands and peatlands. Since 2011, the government has supported the Woodland Carbon Code (WCC), a standard for woodland carbon projects, allowing private landowners to generate removal credits or, under the standard, 'woodland carbon units' (WCUs), sold to private buyers through a dedicated registry (West, 2019). WCC operates alongside the Woodland Carbon Guarantee, a £50 million scheme that allows landowners generating WCUs to sell these periodically to the UK government for a guaranteed price (Forestry Commission, 2019). Longer-term, WCUs may be integrated in the UK ETS (UK Government *et al.*, 2024). Supply is supported by a series of grants across the UK's devolved governments, paying for the capital costs of tree-planting and annual payments for their maintenance (Scottish Forestry, 2019; Forestry Commission, 2021).

This policy approach has been mirrored for peatland projects, establishing in 2015 the Peatland Code, a standard supporting private investment into peatland restoration, with grants available across the devolved governments (Natural England and Defra, 2021; IUCN, 2024; NatureScot, 2024). Similar codes are under development for saltmarshes and soil carbon (Environment Agency, Defra, and Natural England, 2021). Despite these efforts, targets for woodland creation and peatland restoration set before COP26 are likely to be missed (CCC, 2024).

Grants are to be expanded in England through the Environmental Land Management (ELM) schemes, which will pay landowners for actions that increase carbon sequestration in soils, peatlands and woodlands, replacing the payments paid to landowners under the EU's Common Agricultural Policy (HM Government, 2018). Similar 'agri-climate' schemes have been launched by the devolved governments (Scottish Government, 2024; Welsh Government, 2024b). To support greater private funding, the UK government plans to establish new nature markets, building on the example of biodiversity net-gain in England, whereby housing developers are obliged to purchase biodiversity units to compensate for the biodiversity lost through development (Defra, 2023). In these markets, the co-benefits of a carbon project can be 'stacked' or 'bundled' together, explicitly trading, for example, the biodiversity and carbon benefits as separate credits or as a singular 'bundle' (Defra, 2023). Nature-based removals, therefore, whilst a more established policy area, are similarly reliant on markets to drive demand.

Method

CDR, as an active and growing area of climate policy (Lück, Mohn and Lamb, 2024), is rarely static, and our interview period encompasses several policy developments that may have informed how our participants respond in interview. Notably, the government's consultation into integrating removals into the UK ETS, running from May to August of 2024, overlapping with our interview period of April to October (UK Government *et al.*, 2024).

Participants were selected by consulting publicly available lists (for example, the MRV Task & Finish Group, Phase 1 reports of the Direct Air Capture and other Greenhouse Gas Removal technologies competition), the registry of the WCC and Peatland Code, and organisations who have released publicly available documents in response to public consultations. In cases where an organisation, not an individual, was invited to interview, we requested the organisation nominate an individual with knowledge of the relevant policy context or direct involvement in acquiring relevant policy incentives, such as grants. In total, semi-structured interviews were held with 25 participants. All participants signed consent forms detailing how their interview will be used.

Participants were asked to self-select prior to interview the role of their organisation from a pre-defined list, later recategorized to produce a split between commercial actors and policy organisations. Commercial actors include not only project developers but also market platforms, registries, certifiers, and standard organisations, actors essential to a functioning commercial market (IEAGHG, 2024). Policy organisations include think tanks, the civil service, and specialist consultancies. We therefore consult participants involved directly in shaping UK CDR policy or those with experience of the relevant policy incentives. In doing so, we inevitably overlook other actors, such as investors (Yang *et al.*, 2024). In the following results section, we label participants according to their organisation's recategorized self-selected role, with 'C' for commercial actors and 'P', for policy organisations. Each participant is assigned a number and label, for example, P1. Interviews were held online from April to October 2024, lasting between 30 to 90 minutes. Interviews were transcribed and the transcripts checked against recordings.

We asked participants to describe those CDR methods they have expertise or familiarity with, using a figure providing an overview of CDR methods, sourced from the IPCC AR6 Report (Babiker *et al.*, 2022). Based on participants' responses, we allocate two levels of expertise, 'familiar', suggesting a degree of knowledge of, or familiarity with, a method, and 'expert', suggesting practical involvement in projects or a specialism within a specific method. Based on these allocations we further allocate each participant to an 'engineered' or 'nature-based' category, aiming to ensure a near-even balance between categories and across relevant methods. The results of these allocations are shown in Figure 1.

Interviews followed a semi-structured script with seven questions, three of which covered; the role of CDR in meeting UK climate commitments, what is working well, and what barriers remain. The remaining four questions followed either a 'nature-based' or 'engineered' removals script, depending on the participants' familiarity or expertise with certain CDR methods, in response to the opening question. These scripts contain similar questions but differ according to phrasing and prompts. Each script ended by asking participants to detail what they would like to see introduced or changed regarding new or existing policy. A copy of the semi-structured interview script can be found in Supplementary Information.

Transcripts were inductively coded in NVivo 14, a software tool commonly used for qualitative data analysis. Codes were created relating to themes within the textual data, iteratively clustered and aggregated across multiple rounds of review, until 'code saturation' is reached, whereby a full range of codes, describing all themes found in the textual data, are developed (Hennink, Kaiser and Marconi, 2017). These themes were then organised into the main themes and sub-themes used to structure our results. To focus our results, we prioritise only those sub-themes and themes mentioned by at least 6 of our participants.

Participant summary

Figure 1A**Error! Reference source not found.** shows participants' responses when asked to describe their expertise and familiarity with CDR methods. Participants have a range of knowledge and expertise, covering those methods directly subject to policy support in the UK, or demand within the VCM. More of our participants are primarily experts in engineered methods (14), with 11 classed as experts in nature-based methods.

Woodlands are the most common method amongst our participants, both in terms of the depth of expertise (11 participants consider themselves experts) and overall familiarity (16 considered themselves expert or familiar with the method). BECCS and DACCS similarly score highly, with a high level of expertise (9 for both methods) and familiarity. Despite limited government support for biochar, our participants were largely familiar with the method. No participants regarded themselves as experts in ocean alkalinity enhancement (OAE), however, OAE is of limited relevance to UK climate policy. The UK Government considers OAE in a third 'ocean-based' category, subject to early-stage development and legal risks (HM Government, 2021; DESNZ, 2023c). Figure 1b shows participants by type of organisation. Our participants predominantly hold commercial roles (15), with 10 participants coming from policy organisations.

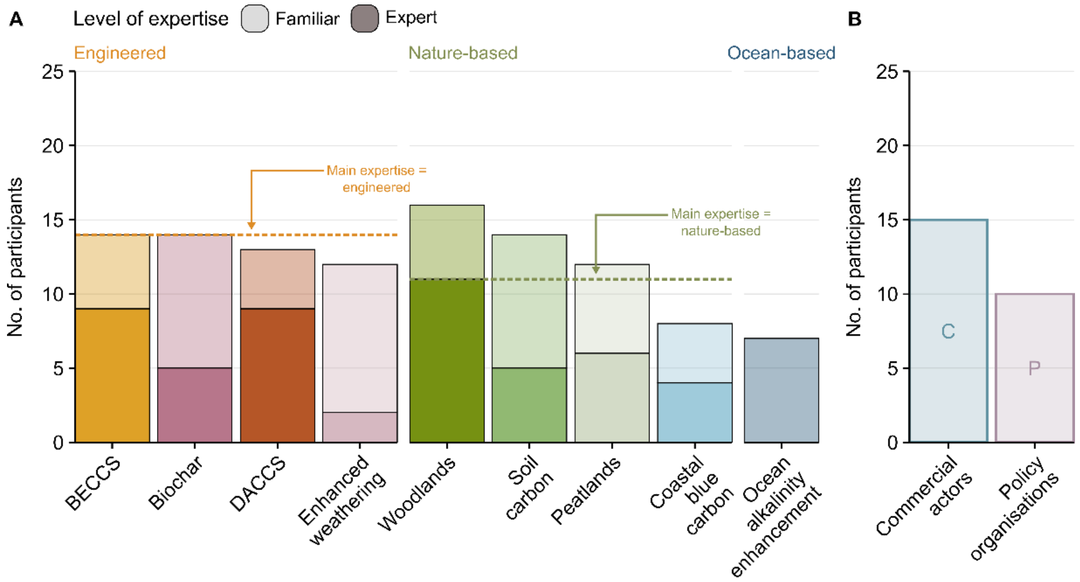

Figure 1 – Participants classed by expertise in CDR methods and organisation. Panel A details participants classed by expertise in CDR methods. 'Familiar' describes statements made that suggest a degree of knowledge, whereas 'expert' describes statements made that detail practical involvement in projects of that method, or specialism within that method. 'Coastal blue carbon' includes coastal wetlands. BECCS stands for bioenergy with carbon capture and storage. DACCS stands for direct air carbon capture and storage. Most participants have expertise across more than one method. Panel B details participants by organisation, classified into 'commercial actors' and 'policy organisations'.

Results

Figure 2 summarises the main themes and sub-themes identified through inductive coding, classed by type of organisation. As seen in Figure 2, the themes of commercial actors and policy organisations largely overlap. Selected quotes from these themes are detailed in Table 1, and the main themes further elaborated in dedicated sub-sections. We address the main themes 'Near-term demand, the VCM & corporate climate action', 'Monitoring, Reporting and Verification (MRV)', and 'Long-term demand' as dedicated sub-sections prior to combining many of the main themes with fewer sub-themes into a single section, entitled 'policy approach'. Though essential to the successful deployment of CDR, we omit 'feasibility constraints' from our results, given that feasibility may be better addressed through dedicated feasibility assessments (for example, see Förster *et al.*, 2022 and Borchers *et al.*, 2024). We note, however, that many of the most prominent sub-themes for feasibility constraints mirror the main constraints detailed in previous government commissioned assessments of CDR methods (Element Energy and CEH, 2021).

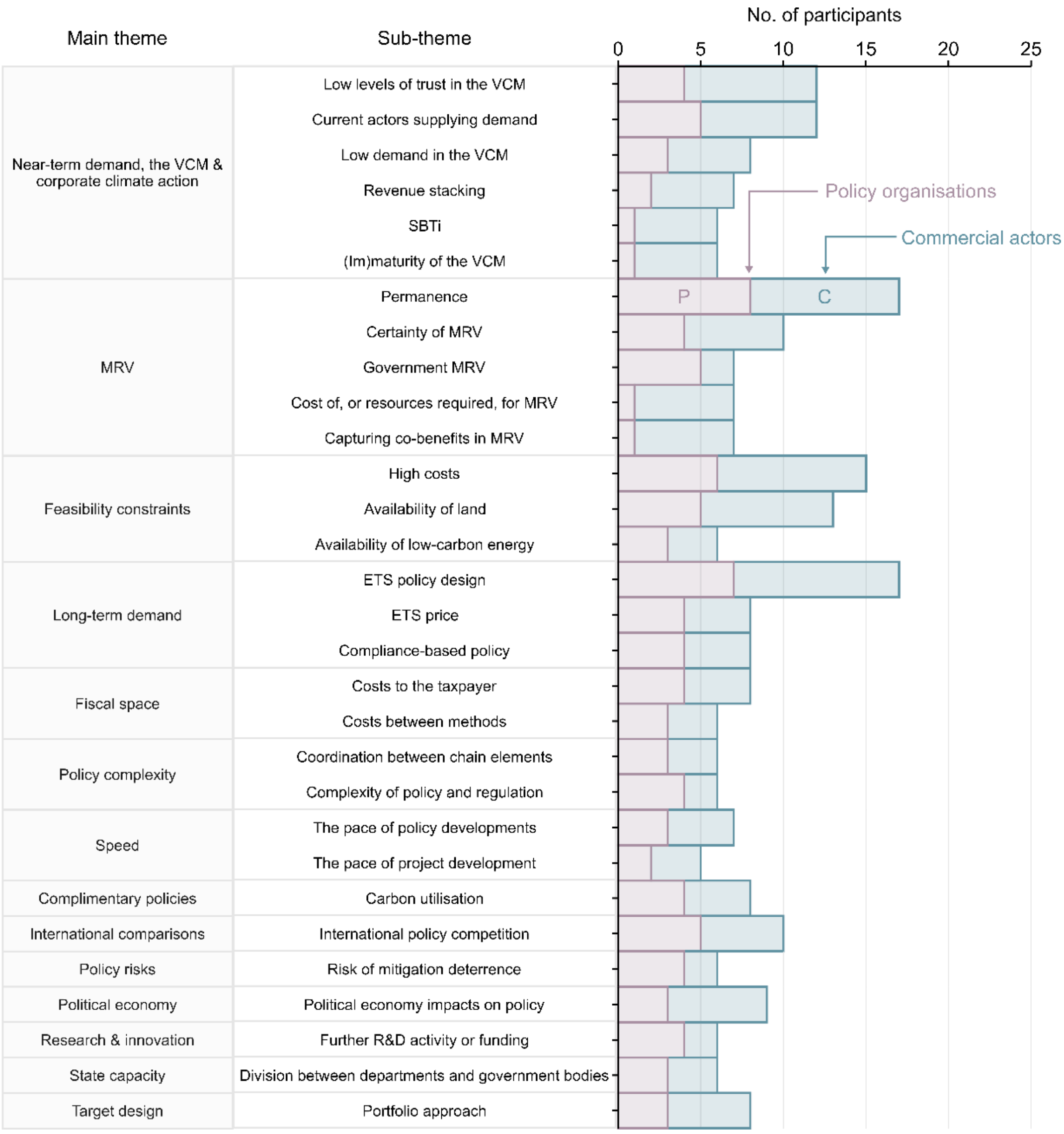

Figure 2 – Count of main themes and sub-themes discussed by participants. Participants classed by type of organisation. Only those sub-themes and main themes discussed at least 6 participants are presented. VCM stands for voluntary carbon market. MRV stands for monitoring, reporting and verification. ETS stands for the UK emission trading scheme.

Table 1 - Main themes and sub-themes identified through the inductive coding of interviews. For each main theme, we present select sub-themes. 'Participant count' is the number of participants that made statements pertaining to a sub-theme, not the total instances statements pertaining to that sub-theme were mentioned.

Main theme	Sub-theme (participant count)	Selected quotes
Near-term demand, the VCM & corporate climate action	Low levels of trust in the VCM (12)	'*The VCM, I have no trust in the VCM right now*.' [P4]
	Current actors supplying demand (12)	'*Tech companies and banks are providing the stimulus for CDR at the moment, and that's maybe ok, if they reduce costs in the short term for everybody else*' [P5]
	Low demand in the VCM (8)	'*Yeah, I think, as important as the VCM is I think there is a risk of hedging all your bets that it will continue growing, like, we saw in the last two years It shrunk*.' [P1]
	Revenue stacking (7)	'*One of the positives we see from our technology in the sense that you're not pinning your hopes on a single revenue stream*.' [C7]
	Science Based Targets Initiative (SBTi) (6)	'*Demand is not really growing at the moment because of what's gone on with the likes of SBTi's recent announcements and the kind of hesitancy around, well, are credits going to be used* [to offset emissions]?' [C15]
	(Im)maturity of the VCM (6)	'*The voluntary carbon market, I think that that is kind of the natural growth area for carbon removal for the moment, which is unfortunate because it's not the most mature market which makes it very hard to get any projects into bankability*' [C4]
MRV	Permanence (17)	'*So, the benefits are that you'll be able to more easily track and confidently state against carbon budgets a true removal as an engineered because of their enhanced durability. So that gives governments, scientific advisors, and even the academic world a bit more confidence when we say what our removals are*' [P2]
	Certainty of MRV (10)	'*The second point is we're mostly scientists and engineers and we like very clear permanent solutions, and don't necessarily like dealing with the complexity of nature-based removals, which have a lot of co-benefits that we don't know how to quantify, but also the removal elements seem to be a bit more vague*.' [P10]
	Government MRV (7)	'*I think it needs to start with, at least in the short term, the government needs to set all the guardrails. So, I would have a regulator, the government set the guardrails, which is what they're doing, eventually, they are in the process of setting minimum standards which companies can adhere, as long as they adhere to those minimum standards, that's fine*.' [P5]
	Cost of, or resources required for MRV (7)	'*So again, the number one philosophy on our MRV, which is really important, is that MRV is critical, but it has to be cost effective, not to kill the thing it's trying to MRV*' [C1]

Main theme	Sub-theme (participant count)	Selected quotes
	Capturing co-benefits in MRV (7)	‘*So, if we’re going to optimise for the time value of storage, we lose a lot of the co-benefits that a lot of these methods might have, whether that's ecosystem restoration, air quality benefits, water quality benefits, whatever it might be, there is a danger that we lose a lot of that*.’ [P5]
Feasibility constraints	High costs (15)	‘*So…there's the fundamental problem, which is the cost of achieving removals is very high, the world is used to a place where they think they can buy, that £20 buys them a negative tonne of emissions, whereas the engineered world is looking at £1000, £500 a tonne*.’ [C2]
	Availability of land (13)	‘*Afforestation is limited by the land that's available in the UK, there's just not that much in the UK and there's large demand for it*.’ [C14]
	Availability of low-carbon energy (6)	‘*If we can resolve for green electrons, make them accessible and at a decent price, I mean, the prices we see in the UK at the moment are ludicrous*.’ [C4]
Long-term demand	ETS policy design (17)	‘*Obviously there is a clear preference in government to go down a market route, so for example, bringing it into the ETS, for example. Again, I think that's fine, as long as there are safeguards against it effectively being a lifting of the CAP in the ETS system, because if you don't have a cap in a cap-and-trade system, then the whole system kind of falls apart*.’ [P6]
	ETS price (8)	‘*Market prices in the ETS are too low for many methods, so we need a prior phase of subsidies to bring those costs down, so that, when integrated into the ETS, those prices do really incentivize technologies*.’ [P5]
	Compliance-based policy (8)	‘*I do think that there should be a compliance-based kind of requirement for, for purchasing GGR or for financing it. I’m agnostic as to whether that should be a compliance market like the ETS or whether it should be…a removal obligation on certain sectors, …setting a trajectory for how much removal should be financed by them*.’ [P3]
Fiscal space	Costs to the taxpayer (8)	‘*We often overcomplicate our policy design. Trying to ring out the most cost and benefit for the taxpayer and that we have a preoccupation with that, and it often can slow down efforts*.’ [P5]
	Costs between methods (6)	‘*The challenges of that is obviously scalability and expense that nature based at the moment are vastly more scalable and vastly cheaper, than engineered*.’ [P2]
Policy complexity	Coordination between chain elements (6)	‘*So, I think, when you, when you look at DACCS and BECCS, I can't help but sense that we need to look at the full chain of activities and think of them as a package, not just as GGR versus fossil carbon, because I think there's generic challenges to building transport systems and there's certain generic challenges to developing storage sites*.’ [P8]
	Complexity of policy and regulation (6)	‘*It's* [The GGR business model] *certainly proving complicated and to the point where there’s only really a handful of people who seem to understand what's going on there*?’ [P8]
Speed	The pace of policy developments (7)	‘*So, these business models are usually seen as a success. But one of their weaknesses seem to be the slow rollout, because they're being perfected. The specific design is being perfected before anything launches*.’ [P10]

Main theme	Sub-theme (participant count)	Selected quotes
	The pace of project development (6)	'*The challenge is that we are relying quite a bit on engineered ones and those take time and money to be able to implement a true sector*.' [P2]
Complimentary policies	Carbon utilisation (8)	'*We're focusing more on utilization for the short to medium term and waiting for that mass market to come before then really getting stuck into removals themselves*.' [C4]
International comparisons	International policy competition (10)	'*Why would you move to the UK? if you, if you're carbon engineering and you've got cheap hydro in BC and a big tax credit, you know that that's more compelling than coming to the UK and having to bid into an auction*.' [P5]
Policy risks	Risk of mitigation deterrence (6)	'*Limiting GGR financing to residual emissions and not, kind of, overall increasing the window of emissions that are allowed, because more are being reduced, because we know that we've got finite capacity for GGRs, or that's our present understanding*.' [P3]
Political economy	Political economy impacts on policy (9)	'*I think we need to make sure that we have our vested interests clearly in check when it comes to BECCS*' [C11]
Research & innovation	Further R&D activity or funding (6)	'*I'm sure the ambition of innovation funding could be scaled up*' [P9]
State capacity	Division between departments and government bodies (6)	'*I think the departmental division between Defra and DESNZ is particularly unhelpful*' [P3]
Target design	Portfolio approach (8)	'*An understanding about the need to develop a diverse portfolio of solutions and providing funding and same levels of support to explore that. I think direct air capture and bioenergy carbon capture and storage are two very well understood…relatively simple to understand technologies. But there are other methods that have a lot of scalability potential and will be required, to be able to meet our targets, such as enhanced weathering or biochar, and I think these need to be, the support for these needs to be expanded and included as well*.' [C5]

Near-term demand, the VCM & corporate climate action

The VCM was raised by 16 of our participants, and was central to discussions of how near-term demand for CDR can be met, and by extension, the role of corporates in providing demand. To government, the VCM provides the near-term demand for both nature-based and engineered removals, prior to their integration into compliance markets, such as the UK ETS (DESNZ, 2023d). Yet participants cite dampened demand (n=8) owing to low levels of trust in the market (n=12), creating a need for greater government engagement or a need for policy alternatives.

Low levels of trust are seen by participants as stemming from negative publicity, following a series of public scandals concerning offset projects, as explained by one policy professional '*nobody wants another article written about them about junk credits they've purchased*' [P2]. Yet for credit buyers, the reputational risk of junk credits has pushed buyers to seek out quality projects, benefitting project developers who claim to adhere to stricter standards on additionality and permanence, as common with engineered removals. As one participant explained '*so, what it's done with carbon credit buyers is that they're much more sceptical of all carbon credits, but it also means they also want the best.*' [C1]. This creates, in the view of select participants, a welcome differentiation between the '*carbon removal space*' [C1] and the wider VCM.

Yet the VCM is not a single global market, but a patchwork of smaller marketplaces and standards, and negative publicity may have dampened the enthusiasm of landowners towards the WCC, the UK's own domestic voluntary market for woodland projects. A commercial actor explained that '*anecdotally it appears to be farmers and landowners thinking the carbon markets are kind of a busted flush* [something that began successfully but later fails]', leading to '*a dip in the number of new woodland creation projects coming forward*' [C3]. This, in their view, is unwarranted given that scandals were owing to '*REDD+ projects in the tropics, yet it's tainting this market with the same brush*' [C3]. This publicity may have also dampened the enthusiasm to participate in general in the VCM, as argued by one policy professional; '*I think you're seeing that right now with how the previous iteration of the voluntary carbon market was operated, that the challenges in how credits are viewed, issued, and delivered is actually putting a cooling effect* [across the market]' [P2]. For commercial actors, public scandals are not the fundamental explanation of low demand, as explained by one participant, commenting on the WCC, '*we're not having any difficulties where they're citing the Guardian article from early 2023, and the concerns that that created*', rather low demand is best explained by the tightening of corporate finances [C6].

For engineered removals, the actors currently supplying demand through corporate offtake agreements, primarily technology or financial companies, are seen as unique in their high-willingness to pay but disconnected from the residual hard-to-abate emissions that should ideally be mitigated through CDR. They have, in short, '*low emissions and large pockets*' [C8], resulting in *'high-profit philanthropy*' [C13]. These actors, therefore, are among the few that can afford the higher costs associated with engineered projects, though limited in the demand they can ultimately provide. As remarked by one participant '*I don't think the current market scales and the voluntary carbon market starts to fall apart once you exhaust philanthropy effectively*' [C4]. As a result, their role in supplying demand may be none the less useful but time limited, as remarked by one participant '*tech companies and banks are providing the stimulus for CDR at the moment, and that's maybe ok, if they reduce costs in the short term for everybody else*' [P5].

A range of corporate standards guide how corporations should measure their emissions, prioritise mitigation measures and set climate targets (Becker *et al.*, 2024). Amongst the most popular is the Science Based Targets Initiative's (SBTi) Net-Zero Standard, which, amongst other aspects, limits the extent to which carbon credits may be counted against corporate climate targets (SBTi, 2024). Many participants praised the stricter requirements of SBTi, for example, its exclusion of avoided emissions [C6], the accounting of credits only for residual emissions [P6], or their use for 'beyond value chain mitigation', voluntary mitigation that goes beyond near-term emission reduction targets (SBTi, 2024). Others viewed the approach taken by SBTi to be too restrictive. By limiting the role of credits to only residual emissions, SBTi provides no clear incentive to engage with the VCM, and by extension, the need to procure removal credits. This results in limited engagement, as argued by one participant, commenting from the view of corporates '*we don't need to have that removals conversation, because all of our efforts are on our priority to decarbonise* [reduce emissions]*, and that's been the mentality across the private sector for years*' [C13]. Similarly, turmoil in April 2024 within SBTi, related to whether the Net-Zero Standard could be altered to allow for the use of credits to abate scope 3 emissions, was seen as creating hesitancy as to whether corporates should or shouldn't engage with the VCM. As explained by one participant '*demand is not really growing at the moment because of what's gone on with the likes of SBTi's recent announcements and the kind of hesitancy around, well are credits going to be used* [against targets in the Net-Zero Standard]*?*' [C15].

Monitoring, Reporting and Verification (MRV)

The need for credible project MRV was discussed by 20 of our participants. Of particular interest was the issue of permanence (n=17). Engineered methods, such as BECCS and DACCS, owing to their use of geological storage, are seen as more permanent than nature-based removals, meaning that, in the view of participants, these methods carry less risk regarding reversals and greater certainty in MRV. This greater degree of permanence has implications for policy. For example, prioritising engineered methods means '*you'll be able to more easily track and confidently state against carbon budgets… because of their enhanced durability*' [P2]. For others, the permanence of the method dictates whether removal credits should enter carbon markets, particularly if compensating for long-lived fossil CO_2 emissions. As remarked by one policy professional '*anything less permanent or less durable* [than BECCS or DACCS] *makes me very nervous*' [P5]. Others advocated for a broader like-for-like principle within policy, meaning that policies should aim to '*compensate for a source of CO_2…with a removal that has the same type of permanence*' [P4]. Corporate purchases should also be governed by the same principle [C13]. Yet others contested whether permanence should be the premise of policy design. For example, perhaps an overriding principle could be '*whether you can accept a long-term losses or impermanence, as we all strive to reduce emissions in the near term*' [P7].

For select participants, the relative impermanence of nature-based removals can be managed through MRV (n=2). Multiple measures can ensure the effective permanence of nature-based removals, for example, creating buffer pools, or enforcing liability measures for reversals (Burke and Schenuit, 2024). Many participants doubt the effectiveness of these measures, notably those that rely on enforcement. For example, one commercial actor claims that for reversals '*it comes back to the monitoring and compliance. It's a massive issue, "we're permanent, because everybody has to restock* [a woodland]*", if you're not enforcing that, you're not monitoring that*' [C10]. Others doubt whether such measures are practically possible given the length of monitoring periods implied by the permanence. For example, in the view of one policy professional, commenting on biochar, '*some people say this is permanent for thousands of years, other people question how do you track or account for that? Will you keep going back to the farms and monitor them for hundreds of years*?' [P10]. For woodland projects certified under the WCC, the monitoring period can last up to a 100 years (Woodland Carbon Code, 2022). This brings further challenges to monitoring and enforcement, as claimed by one participant '*when you think about the time scales that these projects exist on, that's only going to get murkier and murkier as land changes hands* [ownership]' [C10]. Given the practicalities of monitoring and enforcement, some participants advocate to integrate permanence into the pricing of removal credits, meaning a greater number of credits may need to be purchased to equate to a single permanent credit (n=3).

Permanence is not the only factor impacting upon MRV, participants' concerns also extend to the measurability of the removal, and the costs and resources required. On measurability, participants point to scientific uncertainties, still to be resolved, such as the permanence of biochar (n=2), or to the open properties of a CDR method. For example, as raised by one policy professional '*but the biggest barrier that I can see is that of monitoring, reporting and verification, especially for some greenhouse gas removal methods like enhanced weathering, for example, where you do not have a set amount of carbon dioxide at the end that you can hold in your hand* [quantify accurately] *and then store geologically*' [P9].

On the costs and resources required, participants highlighted a need for a pragmatic balance in MRV between '*creating a really stringent strict standard, but also not again killing* [making uneconomic] *the* [CDR] *industry, because it's so intensive that you need a 10-man team just to get through the standard*' [C1]. Participants highlighted the need to understand the costs of MRV, with the notion that certain methods may be penalised if MRV costs are not covered by policies, for example, in the payments made to CDR project developers under the CfD [P5]. Projects may similarly be penalised if MRV standards are too costly or onerous to comply with compared to the scale and resources of the project (n=3). Similarly, there is a need to reduce the risks that the costs of MRV may change, for example, with increasing costs for verification across the monitoring period of the project (n=2).

With the creation of multiple private standards, participants are keen to see governments intervene, to develop a standard that represents the '*government stamp of approval*' [P2], or to regulate existing private standards, ensuring that project developers are not '*self-certifying whether a code is fit for purpose*' [P7]. This, arguably, would also help address the lack of trust in the VCM, by providing regulatory oversight through the standard [P1]. It may also provide the opportunity for the government to develop its own registry to, for example, provide transparency as to what projects are receiving government subsidies [P2], or to allow for the accounting of all removals within the national greenhouse gas inventory [P9], given their current absence within IPCC Guidelines [P10].

Long-term demand

Many participants set out how CDR policy should be viewed in the longer-term, as the UK decarbonises and approaches its net zero target. For government, the main policy supplying this longer-term demand is the planned integration into the UK ETS (UK Government *et al.*, 2024). The UK ETS is seen as an '*established policy framework*' [P10], familiar to companies [P3]. Integration provides '*a guarantee of longer-term demand*' [P2], whilst pairing removals with '*residual emissions we're unable to abate, which may be from installations in the ETS*' [P2]. Yet integration isn't without its risks, and participants cite concerns spanning the price of allowances and the scheme's design, warranting close attention to how removals will be integrated.

On price, many participants share the view that the current UK ETS price of auctioned allowances, corresponding to the right to emit 1 tonne of carbon dioxide equivalents (tCO_2e) under the emissions cap, is currently too low (n=8). UK ETS allowances in 2023, averaged an auction price of £53 t/CO_2e, far below the cost of many CDR methods, though higher than the historic price for WCUs (Element Energy and CEH, 2021; CCC, 2024; Woodland Carbon Code, 2024). A connected concern is the volatility of the price of allowances, and the need for a sufficiently predictable price to incentivise removals (n=4). Combined, the UK ETS price may not be sufficient to allow for investment in many engineered projects, without the continued support of policies like a CfD. As explained by one policy professional '*market prices in the ETS are too low for many methods, so we need a prior phase of subsidies to bring those costs down so that when integrated into the ETS, those prices do really incentivize technologies*' [P5]. Given the scales necessary and the long lead time of projects, '*we need so much* [engineered removal] *capacity that we need to start building in the 2030s, and the ETS price is not going to be high enough at that point and it's probably not going to be predictable enough*' [P4].

Seventeen of our participants raised concerns around the design of the UK ETS, and how this may impact the demand for CDR. Select participants regard removals as a '*separate use case*' to the UK ETS [P1], which should be principally focused on preventing emissions (n=3). Views are therefore mixed as to whether removals should be integrated to allow fungibility with allowances (n=3) or whether a separate parallel removal trading system may be necessary (n=3). For WCUs, participants remarked that the WCC's current practice of first crediting 'pending issuance units', representing potential removal credits, then validating projects with WCUs as the woodland grows, poorly aligns with the fungibility of allowances and the timescales in the UK ETS (n=2). In the view of one commercial actor '*you are talking about really small volumes entering the market in 15 and 25 years* [time]' [C15].

Many participants detailed what has been described by researchers as the 'ETS endgame', that is, as the emissions cap declines, allowances become increasingly scarce (Pahle *et al.*, 2025). As sites decarbonise in response to fewer allowances and higher UK ETS prices, fewer sites remain in the market, lowering the liquidity, the ease with which allowances can be bought and sold (UK Government *et al.*, 2024; Pahle *et al.*, 2025). As a result '*the ETS should evolve into a trading scheme where you've got net zero as the output, and your cost of emitting is equal to your cost of abating, and then then you'll reach an economy where those two things are in balance*' [C2]. Yet participants anticipate a need for net-negative emissions in the UK (n=5), given the expectations of developing nations towards historic emitters to extend climate ambitions beyond net zero (Schenuit, Geden and Peters, 2024). The implications of a net-negative economy may mean the UK ETS needs to extend beyond the polluter pays principle upon which it is currently based, so that '*some companies have to pay for much more removals than…their emissions are equivalent to*' [P4]. In a net-negative economy, therefore, demand for removals must go beyond compensating for current emissions, by, for example, extending compliance to past emissions [P6], or otherwise expanding the UK ETS to new sectors with likely residual emissions (n=2). The progression to a net-negative economy is thought to be more viable with a separate removal trading system, as a separate system needn't rely on the polluter pays principle [P3]. A separate system leaves open how demand can be met, though three participants favoured the use of mandates levied on specific sectors, such as a Carbon Takeback Obligation, as explored in Jenkins *et al.*, 2021.

For nature-based removals, there remains debate as to whether integration into the UK ETS would be a positive step (n=6). Some participants speculate as to whether the proposal to integrate WCUs into the UK ETS is principally political, given that the government has missed its near-term woodland targets, meaning '*they* [the government] *see the* [UK] *ETS as a way of channelling finance to those technologies or methods, regardless of whether that's actually an optimal approach for incentivizing their deployment*' [P5]. Other participants are concerned by the prospect that current government grants may end, transitioning towards a greater reliance on private finance through markets (n=2), leading one participant to suggest that nature-based removals may need to retain public funding in perpetuity, '*personally, I think it's always going to be a need for the public sector to step in to, to continue to create the interest in the market*' [C3]. The long-term outlook for nature-based removals, therefore, seems less clear. Eight participants, however, are united in the view that long-term demand should be met by compliance-based policies, obligating actors to purchase removals and ensuring demand. This entails a transition from voluntary to compliance policies. As explained by one policy professional '*that transition from VCM to compliance market has to happen, the timing of it is the critical question*' [P5].

Policy approach

Our interviews often went beyond the discussion of discrete areas of policy, towards discussion of the government's wider policy approach, addressing the government's overall strategy towards CDR policymaking. Participants, for example, viewed the UK government's policy approach as slow and overly bureaucratic (n=7). Policies, particularly for engineered removals, are seen as not progressing at the necessary pace. For example, as remarked by one participant '*the biggest issue of the policy, in my view, is it's not moving quickly enough*' [C2]. Another stated '*if we really want to get this stuff off the ground, we need to see it moving a lot faster*' [P1]. The business models developed by the government, such as the CfD, are viewed as adding bureaucracy, requiring the government to initially negotiate individual agreements with project developers, leading to longer lead times to establish the first projects (n=2). Their greater complexity means there are more elements to be designed in consultation, adding to the perceived slow pace of policy development. For example, one policy professional stated that, when commenting on engineered removals, '*these business models are usually seen as a success, but one of their weaknesses seems to be the slow rollout, because they're being perfected, the specific design is being perfected before anything launches*' [P10]. Nevertheless, the speed of policies may, in part, be deliberate. As explained by one policy professional, '*we're* [the UK] *doing things slowly, but we're doing it right*' [P2]. The slower pace allows for fuller engagement from government, learning from the scandals that have reputationally damaged the VCM. For example, '*by going slower and sure, we can create a stable long-term footing for projects to bank off of*' [P2].

To participants, the slow pace is explained by the government's desire to ensure the efficient use of public money. For example, '*we* [the UK] *often overcomplicate our policy design, trying to ring out the most cost and benefit for the taxpayer, we have a preoccupation with that, and it often can slow down efforts*' [P5]. Many participants draw comparisons between the government's CfD and policies abroad, such as Canada's 60% tax credit on capital invested in carbon capture utilisation and storage, or the United States' 45Q tax credit, both of which include eligibility for DACCS (n=4). These policies are viewed as both simpler to administer and more immediate to the financing needs of project developers, addressing the financing gap between pilot and commercial scales, such as the scales eligible for the government's business models. Without addressing this financing gap, participants believe the UK may not be competitive, with the policy framework seen as more demanding than rewarding for project developers. As remarked by one participant commenting on the prospect of reverse auctions to award CfDs; '*You know, why would you move to the UK? if you, if you're Carbon Engineering* [a direct air capture technology developer] *and you've got cheap hydro* [hydroelectricity] *in BC* [British Columbia, Canada] *and a big tax credit, you know, that's more compelling than coming to the UK and having to bid into an auction*' [Po5].

No one solution is offered to address this gap. Rather participants propose that the gap could be addressed by; direct grants from government for specific methods (n=2), government support in arranging corporate offtake agreements [P1], or greater coordination between pilot plants and eligibility for support under the business models [P10]. These efforts should seek to improve the ability of companies to secure more conventional means of finance, such as debt financing, as opposed to venture capital, improving a project's 'bankability' (n=5).

Policy design in the UK is made markedly more complex by the need to balance the utilisation of CO_2 with the need for removals. Commercial actors may therefore pursue a strategy that leverages policy incentives for both utilisation and removals (n=3). For example, one company's strategy is to focus '*more on utilization for the short to medium term and waiting for that mass market to come before then really getting stuck into removals themselves*' [C4]. For others, projects are to be designed to utilise multiple revenue streams, flexibly changing between removals and utilisation, or combining them into a single project (n=3). This strengthens the financial security of the project by spreading the risk of low prices across multiple markets, but complicates both the MRV of the project and its eligibility within government policies, given the government's business models use set thresholds for eligibility (DESNZ, 2024c).

For nature-based removals, pace remains a concern, but as the policy incentives are more established, concerns focus on the pace of projects as opposed to policy developments (n=2). Like engineered removals, participants cite concerns over the complexity of the current policy approach, for example, the creation of multiple carbon codes, such as the WCC, Peatland Code, and the similar codes for saltmarshes and soil carbon currently in development (n=6). These are argued to complicate engagement with both credit buyers and landowners. For credit buyers, it can create barriers to access, given each scheme uses its own terminology, reflecting differences in design. As explained by one participant '*What's validation? What's verification? What's a PIU* [pending issuance unit]*? What's a WCU? and if they're having to do that, for every single standard that they're engaging with, you know, it's really going to put companies off…buying different carbon credits from different standards*' [C6].

For landowners, multiple standards can create greater bureaucracy, particularly given that many land holdings may have multiple habitat types, each targeted by a separate code, creating, for example, the need for multiple validations. For example; '*You've got a separate woodland carbon code administered in one way, peatland another. Well, there's land ownerships that have woodland and peatland, and there's agricultural holdings that are woodlands and peatlands, and it actually needs simplification*' [C3]. This, it is argued, could be resolved by merging multiple codes into a single UK standard, administered by a single entity, therefore standardising procedures, such as eligibility, additionality, and validation (n=2). The standard may still include methodologies for each habitat type, but these would be treated as methodologies under a single standard, as opposed to separate standards, as currently practiced [C3].

Many participants raised the issue of state capacity, reflecting the government's own capacity to implement its desired policy approach (n=6). Participants cite a lack of expertise within government (n=4), or unhelpful divisions between government departments (n=6). For nature-based removals, resolving divisions between departments, or fostering means of collaborating, is a necessity owing to the multiple policy objectives to be achieved through land management, spanning biodiversity, flood alleviation, and climate mitigation (n=3). Participants highlighted that, given the variety of methods, and their interaction across multiple domains, CDR largely falls between government departments and regulatory bodies (n=3). Though the Department for Energy Security & Net Zero (DESNZ) considers, within its remit, engineered removals, no single government entity has the specific remit of CDR (n=3). Participants argue this could be resolved by creating, for example, '*a joint unit between Defra and DESNZ*' [P3], or by facilitating greater collaboration between departments [C4].

Discussion

The UK is not alone in implementing CDR policy, nor alone in its explicit policy support for engineered removals (Meissner, 2024). Many countries are now introducing subsidies for engineered projects, ranging from tax credits in Canada and the US, grants in Norway, tenders in Denmark, and reverse auctions in Sweden (Hickey *et al.*, 2023; Fridahl *et al.*, 2024; Meissner, 2024). Both the EU and Japan are exploring the integration of CDR within their own emission trading schemes (CDR.fyi, 2024b; Pahle *et al.*, 2025). Similarly, nearly all countries have an interest in maintaining or enhancing the uptake of CO_2 by land, ensuring that land-use remains a focal point in climate policy (Fyson and Jeffery, 2019; Dooley, 2024). Increasingly, therefore, there exists a need to examine CDR policymaking. To date, research examining CDR policies have been few, and national case studies, where carried out, have largely focused on potential policy design, rather than evaluating the policies introduced (Zetterberg, Johnsson and Möllersten, 2021; Hickey *et al.*, 2023). Our case study into the UK, a country with advanced policy plans for CDR, helps address this research gap.

Our 25 interviews reveal several themes and policy recommendations. Firstly, participants had little trust that the VCM can provide the necessary demand to scale CDR in the near-term, presenting a need for the government to stimulate demand more directly. Criticism of the VCM is common across academia, many of the scandals that have reputationally damaged the VCM originate in academic research that attempts to externally validate the carbon credit claims of projects (Probst *et al.*, 2024). Researchers differ, however, on whether the VCM can be reformed in time to serve the goals of the Paris Agreement (Cullenward, Badgley and Chay, 2023; Kreibich, 2024). To some, scandals reflect flawed incentives that can be readily addressed through market reforms (Reinhard, Planavsky and Khan, 2023; Swinfield *et al.*, 2024). Whilst for others, scandals are evidence of a wider 'identity crisis' in the

VCM, reflecting the priorities of climate policy prior to the Paris Agreement, of reducing the economic burden of achieving only modest emission cuts (Cullenward, Badgley and Chay, 2023; Kreibich, 2024). The VCM is therefore a market in search of a purpose.

The approach taken by the government attempts, in part, to address these criticisms, by, for example, seeking to develop its own government standard for MRV. A development largely supported by our participants. Yet the government's policy approach reflects '*a clear preference in government to go down a market route*' [P6]. The success of the government's CfD for engineered removals, for example, is tied to securing demand through voluntary corporate offtake agreements (DESNZ, 2023d). Similarly, nature-based removals are tied to the success of new nature markets (Swinfield *et al.*, 2024). Our participants suggest this preference reflects the government's desire to protect the taxpayer by mobilising private finance. This is similarly reflected in government communications, consultations on the design of the CfD frequently reference a need to 'maximise value for money' and reduce 'government support over time' (DESNZ, 2023d, 2023c). Yet, without demand, the government may be forced to act as a 'buyer of last resort', and the government is currently exploring whether a 'government offtake backstop' is required in the CfD, to mitigate 'volume risks' to project developers, when a shortfall occurs in market demand (DESNZ, 2023d). For the WCC, the woodland carbon guarantee has acted as a similar backstop (Forestry Commission, 2019).

Participants propose multiple means to stimulate near-term demand. A common proposal for engineered projects is to introduce tax credits similar to the US and Canada, replacing the proposed CfD. This may not guarantee demand, but a more generous subsidy may lead to higher deployment (Element Energy, E4tech, and Cambridge Econometrics, 2022). Participants, however, highlight a need to improve the pace of projects and policy development, whilst improving state capacity. Given the government's prior experience with CfDs, and relative inexperience with tax credits, both the pace of projects and the government's capacity to deliver on its policies may be best served by the continuation of the CfD. For example, the government can leverage existing institutional capacity through the Low Carbon Contracts Company, a private company owned by DESNZ, that currently administers CfDs for renewable energy.

There are, however, proposals that more directly target demand. The government, could, for example, procure removal credits directly, as explored in the US Department for Energy $35 million CDR Purchase Pilot Prize and Canada's $10 million Low-Carbon Fuel Procurement Program (TBS, 2024; US DOE, 2024). This, however, may further delay the introduction of the CfD, as the government cannot both stimulate supply and provide demand simultaneously whilst retaining a CfD. As raised by participants, the government could also facilitate corporate offtake agreements, expanding the voluntary purchase of engineered removals beyond the technology companies that currently dominate purchases (Joppa *et al.*, 2021; CDR.fyi, 2024a). The government should therefore consider ways to stimulate near-term demand for CDR, across both engineered and nature-based removals. Given the future integration with the UK ETS, funds for public procurement or direct grants could come from the revenues generated from the auction of UK ETS allowances, which currently accrue to the general budget, unlike the EU ETS, which uses revenues to fund grants to low carbon technologies through the EU Innovation Fund (EEA, 2024). UK ETS allowances contribute only 0.6% (2023/24) to total government revenue, rerouting less than 1% of this contribution could exceed the procurement programmes of the US and Canada combined (IFS, 2023).

Secondly, the government should implement credible MRV, introducing its own government standard and MRV regulator. This offers the opportunity to build upon existing standards such as the WCC and the Peatland Code, introducing a standard covering all main methods, standardising the means through which permanence is managed. The government has already explored, in past consultations, fungibility measures to address differences in permanence between methods, if multiple CDR methods are integrated into the UK ETS. For example, methods 'that store carbon for shorter periods of time' could be awarded fewer allowances than methods 'that store carbon for longer periods of time and with greater security' (UK Government *et al.*, 2024). The government, however, should assess the impact of these measures on near-term demand. For example, announcing that multiple nature-based removal credits may be needed to be fungible with allowances could be interpreted as a standard that should apply also in the VCM, effectively increasing the price.

The development of a government MRV standard also suggests a need for a regulator to ensure compliance with the standard, offering the opportunity to improve state capacity, a third key theme. Participants highlighted a need for a new cross-government body to oversee the CDR sector. This body should include DESNZ and Defra, given the nature of both engineered and nature-based removals, and, given the role of CO_2 utilisation in, for example, synthetic transport fuels, the Department for Transport (DfT, 2024). This body should aim to build the necessary expertise to regulate the sector.

Finally, participants highlighted a need to set a clear policy direction towards a net-negative economy, ensuring the UK ETS is 'net-negative ready' (Schenuit, Geden and Peters, 2024). The need for net-negative emissions targets will likely animate climate negotiations as the world approaches the 1.5°C limit stipulated in the Paris Agreement (Mohan *et al.*, 2021; Betts *et al.*, 2023). Multiple countries have articulated an ambition to go net-negative after net zero greenhouse gases, including Germany, Finland and Denmark (Dunne, 2024). In scenarios assessed by the IPCC, net-negative emissions are necessary to reverse the temporary overshoot of 1.5°C (Schleussner *et al.*, 2024). The implications of net-negative emissions for climate policy are less clear, though net-negative necessarily entails more removals than emissions. This has implications towards the UK ETS. For example, as the cap declines, the current proposal to substitute allowances with removal credits becomes increasingly untenable, reaching a point where the UK ETS ceases to provide additional demand (UK Government *et al.*, 2024). The government therefore needs to ensure that the 'ETS endgame' is not the end of the UK's climate ambitions, by providing a pathway to a net-negative ETS.

Conclusion

The UK government serves as a useful example for countries aiming to integrate CDR within their climate policy frameworks. Policies and plans in the UK, though still under development, are advanced reflecting multiple rounds of consultation. Through 25 interviews with experts active in UK CDR policymaking, we identify several key themes. Firstly, a scepticism towards the VCM, reflecting a need to stimulate near-term demand. Secondly, a need to implement credible MRV, standardising differences in the permanence of CDR methods. Thirdly, a need to improve state capacity, to be met by a new cross-government body tasked with overseeing the CDR sector. Fourth, a need for 'net-negative ready' policy, ensuring that the UK ETS provides long-term demand for CDR, given the likelihood of temporary temperature overshoot and net-negative emission targets as the next necessary development of climate policy. It remains to be seen whether 'going slower and sure' [P2] will successfully scale CDR. This approach aims to provide stability for the CDR sector, allowing for fuller government engagement. Our interviews, however, suggest even greater engagement and oversight is necessary to ensure this approach continues to support the UK's climate ambitions.

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Supplementary Information

This section further details our interview transcript.

<table>
<tr><td colspan="2">
Prior to interview:
Participants will be invited to identify, ahead of the interview or prior to questioning, the GGR methods they have expertise or familiarity with. This will be through a version of the methods figure (IPCC AR6 WGIII, Chapter 12, Cross-Chapter Box 8, Figure 1). Miro, or a similar system, will be used to visually portray the UK GGR ‘policy system’ and how ‘policy elements’ interrelate. This will be used as a visual aid throughout the main interview. The interviewer will maintain a note of all the areas discussed.
Questions below are intended to be open, non-leading but cognisant of the existing structure of UK CDR policy. The question list is separated into questions asked of all participants and two ‘tracks’ separated by method class.
</td></tr>
<tr><td colspan="2">
Questions asked of all participants:
These questions will be asked of all participants:

‘What is the role of CDR in reaching the UK’s Net Zero target?’
‘What is working well within the UK’s CDR policy system?’
‘What are the main barriers or risks to the UK’s CDR policy system?’

Based on response to methods proceed based on track:
</td></tr>
<tr><td>
Nature-based removals track

In current UK plans, the UK government intends to rely less on nature-based methods than engineered methods, what are some of the benefits and risks to this approach?
How might policies and plans in other connected areas affect UK efforts to incentivise nature-based methods? For example, biodiversity policy or demand for biomass?
How should nature-based methods be incentivised in the long-term?
What changes would you recommend be introduced to help reduce the risks or attain the benefits you’ve identified?

</td><td>
Engineered removals track

In current UK plans, the UK government intends to rely more heavily on engineered methods than nature-based, what are some of the benefits and risks to this approach?
How might policies and plans in other connected areas affect UK efforts to scale engineered methods? For example, carbon capture and storage projects, CO_2 pipeline networks, or other aspects of industrial decarbonisation?
How should engineered methods be incentivised in the long-term?
What changes would you recommend be introduced to help reduce the risks or attain the benefits you’ve identified?

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