"While many countries have committed to net-zero emissions targets, few have robust plans or policies on how to achieve CDR."

Chapter 5 | Policymaking

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Where examples of dedicated Carbon Dioxide Removal governance exist, they are found primarily at the level of individual countries and the European Union. Guidance and incentives from the United Nations Framework Convention on Climate Change and other multilateral initiatives are limited in comparison.

Box 5.1 Key findings

- More than 120 national governments have set a net-zero emissions target, yet only a small minority explicitly integrate Carbon Dioxide Removal (CDR) into their climate policy.
- Four case studies (European Union, United Kingdom, United States and Brazil) show tangible progress and policymaking dedicated to CDR. However, even in these cases no explicit removal targets or robust plans on how to achieve them exist.
- Policymakers' focus to date has been on conventional CDR on land, through forestry and agriculture. Attention on Bioenergy with Carbon Capture and Storage, Direct Air Carbon Capture and Storage and other novel CDR methods is rising in all four cases, especially in the UK and the US.
- The UK and European Union mainly refer to CDR as an option to counterbalance residual emissions in the context of a net zero target. In the US and Brazil, reducing emissions in the short term plays a larger role. None seriously considers reaching net-negative emissions.
- Understanding the conditions that influence upscaling of CDR will continue to require case studies that take into account countries' respective political contexts.

5.1 Growing recognition of Carbon Dioxide Removal in climate policy

More than 120 national governments have a net-zero emissions target, which implies Carbon Dioxide Removal (CDR).

Governments' approval of the recent Intergovernmental Panel on Climate Change (IPCC) Working Group III report shows they recognise that alongside deep, rapid and sustained

emissions reductions, CDR can fulfil three complementary roles[1]: further lowering net emissions in the near term; counterbalancing hard-to-abate residual emissions (for example, from agriculture, aviation, shipping and industrial processes) in order to reach net-zero CO_2 or greenhouse gas (GHG) emissions in the medium term; and achieving or sustaining net-negative emissions in the long term if deployed at levels exceeding annual residual emissions (see Chapter 1 – Introduction and Figure 5.1). The global mitigation pathways assessed in the same IPCC report show conventional CDR on land maintained throughout the century, while novel CDR methods scale up over time (see also Chapter 7 – Scenarios and Chapter 1 – Introduction for definitions of "conventional" and "novel").

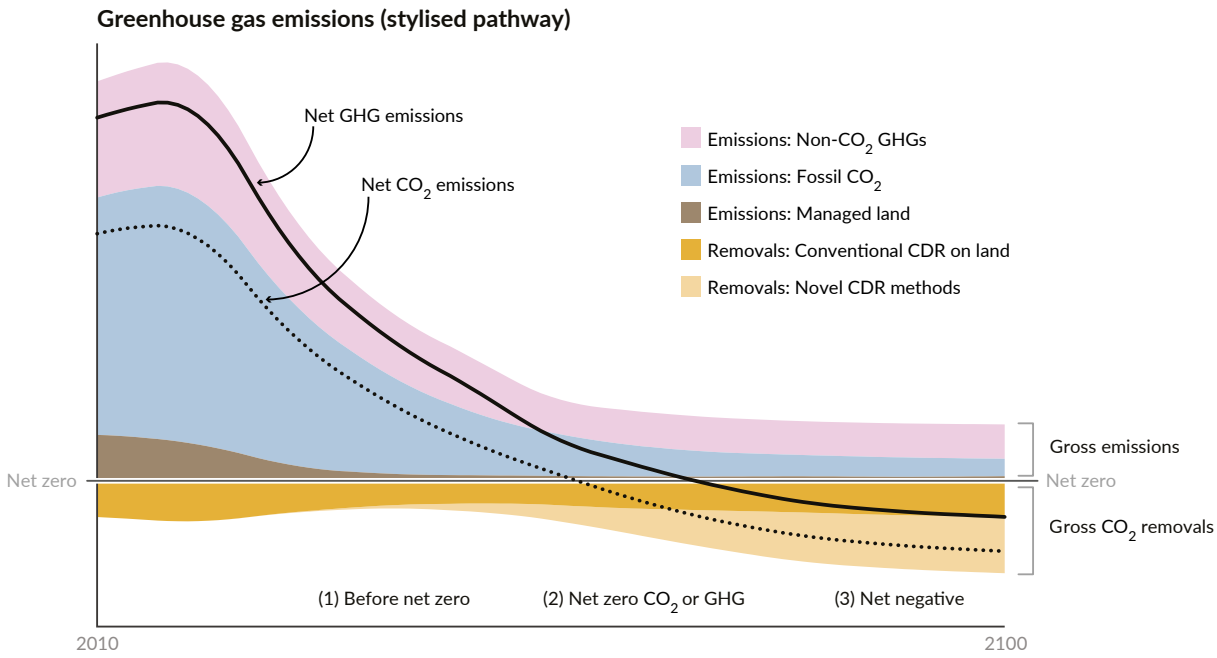

Figure 5.1. *Roles of Carbon Dioxide Removal (CDR) in ambitious mitigation strategies, applicable at national and global level. Basic emission and removal components of mitigation pathways, and the corresponding trajectories for both net carbon dioxide (CO2) and greenhouse gas (GHG) emissions. (Adapted from Cross-Chapter Box 8, Figure 2 in Babiker et al. 2022[13]).*

CDR has climbed up national policy agendas in recent years. While deploying conventional CDR methods on land is already well established (see Chapter 6 – Deployment), governments have now begun to envisage and specify the role of CDR in their domestic climate strategies, either explicitly through CDR-specific policies and strategies, or implicitly through the adoption of national net zero targets. More than 120 governments have set net zero targets to date[2].

5.2 Limited commitment to developing CDR

While few governments have actionable plans for developing CDR, some countries are beginning to integrate CDR into their climate policy, in different ways.

While, in principle, national governments are starting to recognise the strategic role that CDR will have to play in meeting agreed climate targets, governmental action on CDR is falling short. For example, although setting a *net-zero* (rather than a *zero*) emissions target

implicitly indicates that governments are counting on CDR in some form, robust plans for CDR implementation are scarce. Reflecting a more general deficiency of net zero announcements[146], governments usually do not express how large the contribution of CDR should be on reaching net zero, and which CDR methods this might entail.
Examples of dedicated CDR policy and governance are found mainly on national and (in the case of the European Union) supranational levels, and only to a very limited extent in global multilateral initiatives and the United Nations Framework Convention on Climate Change (UNFCCC).

Governance at UNFCCC level

The Paris Agreement stipulates in its Article 4.1 that a "balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases" should be achieved "in the second half of this century" (see Chapter 1 – Introduction). Furthermore, all IPCC mitigation scenarios that likely limit warming to 2°C or lower assume the use of CDR (and almost all that limit warming to 1.5°C assume net-negative CO_2 emissions) (see Chapter 7 – Scenarios). Yet this has not so far been mirrored by corresponding UNFCCC decisions on the global need for large-scale CDR[147,148]. While the negotiations of CDR-specific issues are nascent, recent developments in the context of implementing the Paris Agreement's Article 6 on international cooperation indicate that the UNFCCC could play a more active role in the near term. Additional efforts to develop methodologies for monitoring, reporting and verification (MRV) of carbon flows would be an important step towards operationalising CDR as part of mitigation strategies (see Chapter 1 – Introduction, Table 1.1, for an overview of current MRV guidance).

Governance at the UNFCCC level extends to a request for national governments to submit Long-term Low Emission Development Strategies (LT-LEDS). In contrast to the Nationally Determined Contribution (NDC), submitting an LT-LEDS is not mandatory for parties to the Paris Agreement and no requirements on format or content exist (see Chapter 8 – The CDR gap for further details of the ambiguities of LT-LEDS). By September 2022, there were only 53 LT-LEDS, some of which do contain considerations on preferred CDR methods and modelling data indicating CDR at the intended time of reaching net-zero emissions. But none contains a target for CDR combined with a politically robust plan for how to achieve it[149]. While this might be due to the long-term perspective of these strategies, this also holds true for NDCs, which usually focus on 2030. National legislation is also often more up to date than LT-LEDS, meaning the latter cannot be taken as a primary reference for commitments.

While the NDCs of many countries have been regularly updated since 2015, they usually refer only to CDR through the UNFCCC inventory category *Land Use, Land-Use Change and Forestry* (LULUCF). Detailed reporting on this sector is already mandatory for developed countries and captures emissions and removals on "managed land"[150,151]. However, NDCs referring to conventional CDR on land show a high degree of ambiguity (for example, on the separate contributions of LULUCF emissions and removals) and use widely differing accounting approaches, which is allowed under the Paris Agreement[152,153].
At the level of UN climate negotiations, specific CDR methods such as Bioenergy with Carbon Capture and Storage (BECCS) or net-negative emissions trajectories to deal with temperature overshoot are not yet covered[147,154]. Only a few national long-term mitigation plans or legal acts envision achieving net-negative GHG emissions[149]. For example, Finland, Sweden and Germany include such objectives in national legislation.

National and supranational policymaking

As reporting practices under the UNFCCC currently cover only two facets of CDR governance (target setting via NDCs and LT-LEDS, and accounting for removals via national GHG inventories[151]), exploring paths to scale up CDR requires a closer look at national and supranational policymaking. Unsurprisingly, CDR policymaking is shaped by the dominant ways climate policy works in a given country[155]. Of particular significance are the incentive structures for CDR deployment and the distributive effects of envisaged CDR upscaling (e.g. who bears responsibility for delivering and paying for removals).

Only a small minority of the 120 national governments that have set a national net-zero emissions target have started explicitly integrating CDR into climate policymaking. This exists in various forms, such as setting explicit targets; modelling scale-up of CDR in national mitigation pathways; increasing Research, Development and Demonstration funding for CDR (see Chapter 3 – Innovation); or implementing CDR-specific incentives and policies[156,157]. Comparative case studies have identified different types of CDR policymaking[157]. Here, we provide snapshots of CDR policy in practice via four illustrative case studies. Focusing on the European Union (EU), the United Kingdom, the United States and Brazil, we cover three Organisation for Economic Co-operation and Development (OECD) economies that have started to govern CDR in different ways and one country projected to provide pivotal CDR capacity in modelled global mitigation pathways[158] (see Chapter 3 – Innovation for complementary information on public funding for Research and Development). While all four have recently enhanced dedicated CDR regulation, these case studies reveal important similarities and considerable differences in the way CDR is regulated, which are not apparent in the reporting practices under the UNFCCC.

CDR policy in practice: European Union, United Kingdom, United States and Brazil

European Union

While the EU has been critical of the inclusion of CDR in mitigation strategies in the past, CDR has received new impetus in the context of the European Green Deal. The adoption of a legally binding target of net-zero GHG emissions by 2050 and net-negative GHG emissions thereafter (as yet unquantified) codified the need for CDR[159,160]. In recent years, CDR has become an integral part of the EU's mitigation policymaking. The original economy-wide 2030 goal adopted in 2014 of achieving a GHG emissions reduction of 40% (compared to 1990 levels) had targeted only gross emissions. The European Climate Law passed in 2021 strengthened the 2030 target to at least 55% *net* emissions reductions with a limited contribution of net removals from LULUCF (225 $MtCO_2e$). Furthermore, the European Commission, a few Member State governments and individual Members of the European Parliament have been pushing for the development of CDR incentives and regulation[161,162].

As part of its Sustainable Carbon Cycle initiative, the Commission plans to increase incentives for all LULUCF-based CDR methods (under the term *carbon farming*), expand support for innovation in Carbon Capture and Storage (CCS)-based CDR methods such as BECCS and Direct Air Carbon Capture and Storage (DACCS), and establish a certification framework for a broad range of CDR methods.

The EU Member States and the European Parliament are still in the process of identifying and agreeing on their positions on CDR. Some Member States (for example, Denmark, Netherlands and Sweden, together with closely associated non-EU member Norway) are pushing for the rapid and full integration of CDR into the EU's climate policy architecture, while others have yet to articulate specific preferences. No Member State opposes CDR

outright, and all but a few (such as Ireland, Netherlands and Denmark) have achieved net LULUCF removals over the last decade. Since climate policy is a domain where the competence to act lies mainly at the supranational EU level, the development of an overarching CDR governance structure will be based on a common approach. Yet national differences in CDR deployment are expected to persist due to varying geographies, socio-political preferences and expected compositions of "hard-to-abate" residual emissions[163].

The strengthened LULUCF Regulation establishes a new target of achieving 310 MtCo2e net removals by 2030, which will likely lead to new support and incentive structures for the implementation of conventional CDR on land in the coming years. The EU Innovation Fund (fed through revenues from the EU Emissions Trading System) is so far the main tool to support the development of novel CDR methods, complemented by funding through the EU's research and innovation programme Horizon Europe (see also Chapter 3 – Innovation). One CDR demonstration project is already co-financed through the EU Innovation Fund (*Beccs Stockholm*[88]), in addition to projects that fall under the broader category of "carbon management" (i.e. capture, utilisation, transport or storage of fossil CO_2), which will shape the future expansion of CDR. Industry is beginning to advocate for the development of CDR-related infrastructure, such as CO_2 transport. Companies with large amounts of potentially hard-to-abate emissions are starting to call for cross-border collaboration on carbon management, including CDR.

United Kingdom

CDR is a topic of proactive research and policy development in the UK[157], where it is often referred to as Greenhouse Gas Removal (GGR) to include potential removal of other greenhouse gases. The most recent strategy published by the government emphasises the primacy of ambitious decarbonisation across society, while noting that Greenhouse Gas Removal is essential to compensate for residual emissions[67].

UK climate policy is guided by legislation which requires five-year limits on net domestic GHG emissions (known as "carbon budgets") to be set on the path to at least a 100% reduction in net GHG emissions (i.e. net zero) by 2050. Within these targets, CDR's role is not separated from emissions reduction but is accounted for as fully exchangeable with emissions. The legislation requires the government to regularly publish its plans and policies for achieving these targets. The most recent strategy publication contains an ambition to increase tree planting to 30,000 hectares per year from 2025 onwards, restore 280,000 hectares of peat in England by 2050, increase use of wood in construction, and remove at least 5 $MtCO_2$ per year by 2030 with methods like BECCS, DACCS, biochar and enhanced rock weathering[67]. Currently only CDR reported in the land sector is counted towards UK targets. The government's strategy seeks to amend the legislation to account for a wider range of CDR methods, and explore new regulatory oversight for MRV.

The UK has generally adopted carbon pricing and market-based approaches to support climate change mitigation. Tree planting is incentivised through a government-created system of MRV and credit generation for woodland carbon[164]. Consultations have been launched by the national government in 2022 on business models for CDR methods like BECCS and DACCS[165,166] as well as discussion in the context of developing the UK Emissions Trading System (ETS)[167]. These consultations indicate that the government currently intends to incentivise such methods through contracts guaranteeing a fixed price per tonne of CO_2 removed.

CDR Research and Development is supported in the UK primarily through two programmes. These total £100 million ($113 million) over four years and include a range of demonstration

projects and a research hub (see Chapter 3 – Innovation for further details). A wide variety of methods is supported in these programmes (for example, CO_2 capture from seawater and capture of methane from cattle sheds), in addition to those included for deployment in the national net zero strategy.

Despite this relatively high level of policy ambition in the UK, progress is lagging. The government's official advisory body reports that tree planting and peat restoration are significantly behind targets, while the delays to CCS development in the UK are a particular risk to BECCS and DACCS deployment[168].

United States

The US' NDC aims to cut GHG emissions by at least 50% in 2030 compared to 2005 levels, including LULUCF[169] (annual net removals via LULUCF were roughly 10-15% of total US GHG emissions in the past decade[169,170]). The Biden administration has also announced additional targets, including achieving net-zero GHG emissions economy-wide by 2050. There is no federal legislation with emissions reduction targets consistent with the US NDC, nor to achieve net-zero GHG emissions by 2050. As such, the envisaged contribution of CDR in US climate policy is unclear. Modelling analyses indicate that achieving net-zero GHG emissions in the US will involve a significant role for CDR, on the order of 1 $GtCO_2$ per year by 2050[171].

CDR has received bipartisan support despite the lack of consensus on climate change in US politics[157]. Partly, this is because methods like DACCS and BECCS are seen as technological innovation with broader economic benefits. Methods such as soil carbon sequestration have also received bipartisan support as they may benefit more rural states, which have disproportionately high political representation. Several recent federal bills have CDR components. For instance, the bipartisan Energy Act of 2020, signed into law by the Trump administration, allocated funding for an interagency CDR research programme and set up a technology prize competition for Direct Air Capture (DAC) (see Chapter 3 – Innovation). In 2021, the bipartisan Infrastructure Investment and Jobs Act assigned $3.5 billion to four DAC hubs, including connecting infrastructure such as pipelines and storage. The goal is to achieve 1 $MtCO_2$ capture per year per hub. While these hubs are expected to catalyse investment in subsequent DAC plants, it is unclear to what extent the initially captured CO_2 will be utilised for short-lived products like synthetic fuels, rather than being durably stored.

The Inflation Reduction Act (IRA) of 2022 includes major changes to an uncapped tax credit – 45Q – which supports CCS projects of all kinds. The credit was originally enacted in 2008 for fossil CCS. It has undergone multiple revisions in the past decade. The value of this directly paid credit for DAC combined with geological storage has been increased to $180 per tonne of CO_2. IRA also lowers the threshold to claim this credit from 100,000 tCO_2 captured annually to just 1,000 tCO_2 per year, making the credit much more attainable for current and future DAC facilities. While IRA's investments in fossil CCS do not count as CDR, the associated build-up of infrastructure such as pipelines and geological storage can benefit CDR methods such as DACCS and BECCS. There is also roughly $20 billion in the IRA allocated to methods such as afforestation/reforestation and soil carbon sequestration.

Finally, the US Department of Energy launched the Carbon Negative Shot programme in 2021, which targets innovation across multiple CDR approaches to enable capture and storage at gigatonne scale for less than $100 per tonne of CO_2[73]. Given that MRV with robust standards does not currently exist for many methods – either globally or nationally – the Carbon Negative Shot also targets the development of MRV methods to "ensure effective and permanent CO_2 removal"[73].

Brazil

The deployment of CDR in Brazil is pursued through public and private sector initiatives, particularly in agriculture and nature conservation. In April 2022, the Bolsonaro government updated its NDC, committing to net-zero GHG emissions by 2050 without details on the balance between emissions reductions and removals, and without an explicit CDR strategy. Under the government of President Lula de Silva, the addition of Climate Change to the name of the Ministry of Environment and the proposed creation of a National Climate Security Authority (*Autoridade Nacional de Segurança Climática*) signal a new impetus to climate policy.

In May 2022, the Brazilian government issued a decree to establish sectoral mitigation plans and a national registry that differentiate GHG removals and emissions reductions[172]. Under the current policy trajectory, CDR actions will be subsidiary to sectoral strategies – rather than considering CDR as a new independent sector. In the energy industry, for instance, the revised domestic fuel standard (*RenovaBio*) and tradable certificate system is expected to incentivise the addition of point-source carbon sequestration into biorefineries, with at least one project already announced[173,174].

Companies and NGOs have already developed reforestation and restoration programmes as part of international voluntary emissions compensation schemes. According to the latest inventory data, in 2020 net LULUCF emissions were 637 $MtCO_2e$, amounting to 38% of the national balance[175]. After a decade of progress, the decline of deforestation halted in 2012, followed by a sharp rise after 2018[176]. Unless the deforestation trend is reversed in line with the existing legal framework[177], achieving net-zero emissions is not plausible. However, restoration and reforestation activities are scaling up in biomes affected by centuries-old deforestation[178], as in the Atlantic Forest. These are driven by priorities such as ecosystem conservation, biodiversity protection and water management, rather than CDR. Such activities are enabled by partnerships including environmental NGOs and federal and local governments, with financing from private sources. In these initiatives, CDR is an additional co-benefit.

The most relevant developments have occurred in agriculture, which represents 28.5% of national GHG emissions[175]. Today, business groups participating in global commodity markets are interested in compensating for emissions occurring within the same sector. This was preceded by a decade-old programme called the Low Carbon Agriculture Plan or Plan ABC, to finance the recovery of degraded pastures, the use of crop-livestock-forestry integrated systems, no-till systems and biological nitrogen fixation[179]. In fact, restoration of grazing land, integrated crop-livestock systems and no-till farming were already considered within Brazil's Copenhagen Accord submission and later as part of the country's Nationally Appropriate Mitigation Actions (NAMAs)[180,181]. The convergence of the pre-existing Plan ABC and new business initiatives is best captured by the recent development of a standard for GHG-neutral agricultural commodities. The state-owned Brazilian Agricultural Research Corporation (Embrapa) has developed the protocol which, for example, allows companies to label meat as GHG neutral (Carne Carbono Neutro) when having deployed soil carbon sequestration[182,183]. The results of an ongoing soil census as part of the National Soils Program will provide a benchmark and additional information to accelerate this initiative[184].

Summary of case studies

Specific policy approaches to CDR vary from country to country and are shaped by respective climate policy paradigms and institutional architectures, by political interests, by the relevance of different actors and by the relative importance of different economic sectors, among other factors.

To establish new funding and revenue streams, the US has expanded tax credits as one of the most prominent tools to support CDR deployment, whereas the UK and the EU are investing in innovation funds. In Brazil, there is no major funding for CCS-based CDR methods, but the government has established large programmes to promote CDR in the LULUCF sector. While none of the four cases has adopted an explicit target for novel CDR yet, all are pursuing a deeper integration of CDR into climate policy, including through advancing MRV and standards for removal accounting to further operationalise CDR as an important element of the mitigation toolbox.

Additionally, the different roles that CDR can play in mitigation strategies are not considered equally in the cases presented here:

- In the EU and UK, where much attention is being paid to reaching net-zero GHG emissions, scaling up CDR is mostly seen as a means to counterbalance hard-to-abate residual emissions. The UK has always applied the principle of full and unlimited fungibility to its climate targets (i.e. emissions reductions and removals are treated as interchangeable and mutual substitutes in accounting practices). The EU, on the other hand, has only recently moved to a net emissions logic for its domestic climate targets.

- In the US, where no federal law targeting net-zero emissions has yet been enacted, recent reforms suggest that CDR's near-term role in reducing net emissions is already a key consideration.

- Brazil illustrates a development that is relevant in all four cases but is particularly visible here: CDR policy is shaped by aspects that go beyond climate policy, and a multiplicity of possible justifications for CDR policy exist (e.g. managing interests of important economic sectors like agriculture through promising additional revenue streams).

- None of the case study countries gives any indication of planning for achieving net-negative emissions. The EU is the only case where a formal net-negative GHG target has been adopted, but it does not appear to drive current CDR policy development.

- Policy approaches and integration patterns also vary from method to method in the case studies. While novel methods like BECCS and DACCS tend to be part of new industrial policy initiatives, previous policy designs and governance structures for biological CDR methods that do not involve CCS are shaped by different interests. Conventional CDR on land mainly tends to be addressed by agriculture and forestry governance[185,186].

5.3 Future action

In the near term, innovations in CDR governance and policymaking are mainly expected at national and supranational levels. Tailoring to specific country contexts will be key.

At the UNFCCC level, the main task in terms of CDR policy and governance lies in developing robust accounting rules for CDR and establishing trusted MRV frameworks[151,187], strengthening rules for reporting on land-based biological removals and creating additional guidance for methods like DACCS or enhanced rock weathering[13]. This will be relevant not only for national inventory reporting but also in the context of establishing international carbon trading under the Paris Agreement's Article 6.4 mechanism. Yet UNFCCC inventory rules – currently based on IPCC guidelines from 2006 and 2019 – are unlikely to change without the explicit request of national governments, primarily those that want to have the outcomes of DACCS or enhanced rock weathering recognised in their official national inventories, thereby helping reduce net emissions and fulfilling pledges made in NDCs.

Beyond the UNFCCC process, action at a multilateral level can be expected primarily in fora like the CDR Mission under *Mission Innovation*, established at COP26 in 2021 with an official goal of enabling "CDR technologies to achieve a net reduction of 100 million tons of CO_2 per year by 2030"[188]. While limited institutional capacity may hamper achievement of this goal, this platform co-led by the US, Saudi Arabia and Canada may contribute to enhanced governance and policymaking through facilitating exchange of best practices and mutual learning on technology development and MRV frameworks for novel CDR methods.

Looking closer into case studies and identifying commonalities and differences in governance and policymaking practices will continue to be crucial to understanding the various enabling and constraining conditions that influence upscaling of CDR, including shared physical infrastructure (e.g. for CO_2 transport and storage). This is because even in the hypothetical case that all governments submit LT-LEDS, provide regular updates and use more standardised formats – including more explicit information on intended volumes and types of CDR – there is usually a significant degree of inconsistency between climate policy decisions and actions[189]. This leads to substantial implementation gaps[190]. Capturing real-world dynamics will therefore continue to require case studies that take into account the respective political contexts in which the enhancement of CDR emerges as a sub-domain of climate policy.