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The formative phase of German carbon dioxide removal policy: Positioning between precaution, pragmatism and innovation

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ABSTRACT

Since net-zero greenhouse gas emissions targets have become a keystone of European and German climate policy, a debate about the need to actively remove carbon dioxide from the atmosphere in addition to drastically reducing emissions has emerged. Although still relatively scarce, empirical studies on the emergence of carbon dioxide removal (CDR) on the political agenda have shown that variations in the constellations and positions of policy-relevant actors play a key role in shaping patterns of CDR policymaking. The German and wider European Union (EU) CDR policy space is emergent, and political actors are just beginning to position themselves. Building on our previous work which established a typology of CDR policy integration patterns and developed a discourse analytical framework for mapping CDR-policy-relevant speaker positions, we present the first fine-grained empirical reconstruction of CDR-policy-relevant actors and their positions in the German context. Our analytical approach aims to improve understanding of patterns in CDR policymaking by showing that on the EU, national, and subnational levels, a multitude of institutional actors may adopt differing positions as the CDR policy space evolves. In addition to identifying fine-grained 'ideal types' of positions that policy actors may adopt in the formative phase of German CDR policy, our analysis provides an empirical 'map' of CDR policy-relevant actors and explores hypotheses about emerging discourse coalitions and potential conflict cleavages.

1. Introduction

Since net-zero greenhouse gas emissions targets have become a keystone of European and German climate policy, there has been a broadening debate about the need to actively remove carbon dioxide from the atmosphere to counterbalance hard-to-abate residual emissions [1,2]. Although still relatively scarce, empirical studies on the emergence of carbon dioxide removal (CDR) - defined as "anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products" [3] - onto the political agenda have shown that variations in the constellations and positions of policy-relevant actors play a key role in shaping patterns of CDR policymaking [4–8]. The European Union (EU) and German CDR policy space is emergent, and actors at all political levels are just beginning to position themselves. The European Commission has been leading the way in the debate, but the Member States and the European Parliament, which ultimately share responsibility for adopting CDR policy, are following suit [9]. German climate policymaking is highly embedded in and dependent on EU climate policymaking [10].

This formative phase of political positioning on CDR policymaking is accompanied by demands formulated by environmental NGOs, industrial lobby groups and other political interest groups. The way CDR is emerging as an object of climate policy is being shaped by specific types of discourses and the actors (re)producing them. At this early stage of the policy formation process, mapping emerging actor positions and discourse coalitions can help to critically anticipate future governance developments [4]. Such mapping can also contribute to assessing the political feasibility of carbon removal by moving beyond questions of institutional frameworks, policy designs and instruments to include key actor groups (e.g., governments, parliaments, political parties, organized civil society, and industry), and their respective positions on CDR.

Building on our previous work which established a typology of CDR policy integration patterns [11] and developed a discourse analytical framework for mapping CDR-policy-relevant speaker positions [4,5], we present the first fine-grained empirical reconstruction of key CDR-policy-relevant actors and their positions in the German and wider EU

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context. This work builds on and complements the rapidly emerging field of CDR governance and policymaking research that explores existing and possible governance architectures, policy instruments, and CDR pledges [8,12–15], the public perception of CDR as an element of mitigation strategies [7,16,17], and the embeddedness of CDR governance in low-carbon transitions of societies more generally [18–21].

Our analytical approach improves the empirical understanding of CDR policymaking by showing that on the EU, national, and subnational levels institutional actors may adopt differing positions as the CDR policy space evolves. By identifying fine-grained 'ideal types' of positions that policy actors may adopt in CDR policymaking processes, our analysis provides an empirical 'map' of CDR policy-relevant actors and explores hypotheses about emerging discourse coalitions and potential conflict cleavages. In doing so, we contribute to a shift from conceptual to empirical social science investigations of CDR discourses by providing a framework for studying the formation of coalitions and critically anticipating their effects on policy developments.

The following sections first provide background information on the emergence of CDR in the German and EU climate policy context (2), outline our analytical approach (3) and methods (4), present the results of our organisational and substantive actor mapping (5), link our work to wider literature on CDR governance (6) and outline key conclusions and next steps (7).

2. CDR in Germany and the wider EU context

Despite initial restraint, German policymakers started to include CDR through targets for enhancing the land use, land-use change and forestry (LULUCF) net carbon sink in the 2021 revision of the German Climate Law [22]. This law includes a target of achieving 40 million tons of CO_2 equivalent (40Mt CO_2eq) net removals in the LULUCF sector by 2045 (Art. 3, KSG), which would amount to a level of residual emissions of only 3 % of Germany's greenhouse gas (GHG) emissions in 1990. Other CDR methods are not addressed in the Climate Law, despite the fact that carbon capture and storage (CCS)-based CDR methods are perceived to be required to achieve net-zero GHG emissions in Germany in all five major national modelling studies [23]. The German federal government that took office in late-2021 declared that it will develop a long term strategy on how to deal "with the approximately 5 percent of unavoidable residual emissions" and acknowledges the need for "technological negative emissions" [24]. Given the typically corporatist nature of climate policy design and implementation in Germany [25], CDR-related positions of key actors will play an important role in the upcoming processes of translating this commitment into actual decision-making.

Since German climate policy is highly integrated into that of the EU, an overview of German climate policy would be incomplete without addressing its embeddedness in the wider EU context. It is important to note that CDR is not entirely new to the EU's climate and energy governance architecture; it had been implicitly governed through the LULUCF Regulation before [26], but Member States usually did not account for net negative LULUCF balances towards their climate targets. The adoption of the net emissions reduction target of −55 % by 2030 and a net-zero GHG target for 2050 under the European Green Deal [27] led to CDR becoming an explicit and integral element of EU climate policy and politics [1]. According to the Commission's mitigation scenarios [28], about 10 % of 1990 emissions (ca. 500 $MtCO_2$eq) would need to be counterbalanced in 2050 to achieve net zero GHG emissions. The scenarios also indicate that afforestation and other ecosystem-based CO_2 removals alone will not achieve this amount of CDR, especially if storage potential and permanence are reduced by advancing climate change.

Since the publication of its draft long-term strategy "A clean planet for all" [28], the EU Commission has positioned itself as a frontrunner in the CDR debate. Subsequently, the Communication "Sustainable Carbon Cycle" laid out its vision for CDR and its regulation in a dedicated policy document [29]. The EU plans to take a sequenced approach to CDR policy, first implementing modest reforms for the time period until 2030 in the context of the Fit-for-55 legislative package, with a particular focus on proposing incentives to enhance the net removals from LULUCF. Secondly, establishing a certification scheme for carbon removals (CRC-F, [30]) and, once this tool has been established, undertaking more substantial CDR-related reforms of climate policy instruments in the next climate and energy governance framework for the 2031–2040 period. The co-legislators - EU Member States and the European Parliament - are currently in a formative phase of establishing their positions on CDR. Member States differ considerably in the degree to which and how they address CDR in their national climate policies [31]. There are, however, new alliances emerging, for example Sweden, Netherlands, Denmark plus Norway who are pushing for proactive CDR policies. Due to differences in the potential for different CDR methods in varying national geographies, as well as variations in socio-political preferences, the level of ambition for climate action and the expected composition of residual emissions, national positions on CDR are expected to be contested in the coming years [9].

Almost all actors in the EU climate policy making space now agree that CO_2 removal capacities need to be enhanced. Positions on what policies are needed, however, differ. Environmental NGOs mostly focus on so-called "nature-based solutions", highlighting their co-benefits and risks for biodiversity, as well as calling for split targets and high integrity of monitoring, reporting and verification instruments. Industry representatives rather emphasize innovation funding, incentive structures and including CDR in the EU Emissions Trading System (ETS). Thus, a great deal of disagreement about the concrete design of CDR policy instruments and options for counterbalancing hard-to-abate emissions is to be expected.

As the largest and arguably most powerful EU Member State with the highest GHG emissions, a comparatively energy- and CO_2-intensive industrial sector, and high climate policy ambitions, the position Germany's policy makers and policy-relevant stakeholders will take is of great importance for the implementation of EU CDR policymaking. The investigation of emerging speaker positions and discourse coalitions in the German debate therefore includes links to the EU debate and actors.

In this rapidly emerging and changing multi-level policy domain, new actors are positioning themselves relative to those already active in the space, others are changing their former positions. In order to analyse this evolving field, we take a novel analytical approach to policy actor mapping.

3. Analytical approach

We employ an analytical approach which combines elements of two frameworks we previously developed to explore CDR policy development processes: a socio-technical typology of CDR policy integration patterns and a discourse analytical framework for mapping CDR-policy-relevant speaker positions. Schenuit et al. [11] created an analytical framework that bridged insights from the Multi-Level Perspective (MLP) on socio-technical transitions [32,33] and the literature on CDR policy and governance [13,34,35] to conduct a case study comparison and develop a typology of CDR policy integration pathways. This framework allows analysts to provide synthesized snapshots of existing institutional settings and actor constellations relevant for CDR policy making and governance, and thus to assess emerging patterns. However, as the framework is designed to allow comparison across countries, the empirical approach is quite aggregated and abstract. In this paper, we therefore focus primarily on one aspect and provide a deeper dive into the role of actors and coalitions in the CDR policy space. By zooming in on this element in one specific country context, we contribute a finer grained understanding of emerging speaker positions that actors are adopting or may adopt on pathways towards the integration of carbon removal into German climate policy.

To map these emerging positions we apply elements of a discourse

analytical framework developed by Boettcher [4,5] to identify CDR policy-relevant speaker positions and discourse coalitions. The framework is based on the premise that all governance debates have a limited range of 'legitimate/authoritative' speaker positions which can be adopted by societal actors engaging in the debate. Consequently, the identification of speaker positions is not the same as identifying the actors themselves, but rather the discursive templates which allow social actors to legitimately and authoritatively engage in a given policy debate. Mapping the speaker positions available in a specific debate allows the range of possible positions to be identified and, through their adoption of these positions, social actors to be discursively located. Groups of social actors who share speaker positions by (re)producing analogous discursive elements (such as governance rationales) create discourse coalitions [4,5,36–38]. Mapping speaker positions can thus help identify coalitions forming around certain governance rationales, identify complementary and conflictual positions, and understand which voices are being privileged and marginalised in policy debates. Premised on the understanding that discourse is constitutive of governance practices and infrastructure – meaning that discursively constructed, societally meaningful 'systems of thinking about the nature and practice of governance' shape the emergence of formal and informal governance – we believe such mapping can help expose and critically reflect upon the contingent and inherently political nature of ongoing CDR policy development processes. In the same vein, we believe our approach can also help those involved in the debate critically anticipate plausible future CDR policy developments [4,5].

4. Materials & methods

The materials for our analysis consist of a pool of documents from EU and German institutional and non-state actors currently engaging actively with the topic of CDR governance. The documents were sourced from *Polit-X* key-word searches of EU and German Parliamentary documents, from stakeholder feedback submitted to the online EU Commission consultation process on the proposal for a regulatory framework for the certification of carbon removals, and from the websites of non-state actors who have engaged publically with the topic of CDR policy - such as environmental NGOs, industrial organisations and CDR advocacy organisations.

We split the analysis into three stages: The first assesses how actors in the CDR policy space are positioned and connected organisationally, and the second how they are positioned substantively with relation to the *what*, *why*, and *how* of CDR policy. The third step then uses the analytical lens developed by Schenuit et al. [11] to zoom out and assess how the emerging constellations of German CDR policy actors may fit into wider patterns of CDR policy integration. Finally, we situate and interpret our results in the context of existing literature on CDR governance.

4.1. Organisational mapping

As the basis of the organisational mapping, keyword searches were conducted in the *Polit-X* database of documents from EU Institutions (e.g. EU Commission, Parliament and Council) and the German Bundestag using both German and English keywords: "Kohlendioxid-Entnahme" or "CO_2-Entfernung" or "CO_2-Abscheidung" or "CO_2-Speicherung" or "Negative Emissionen" and "carbon dioxide removal" or "carbon removal" or "carbon capture" or "negative emissions". The time period specified for the searches was: 09.11.20–09.11.21 (German) and 10.11.20–10.11.21 (English). Both broad and exact searches were conducted. The 'broad' search looks for the root word as well as all word compounds and diverse grammatical forms. With the 'exact' search, the exact spelling of the term is searched for, e.g. upper and lower cases are also taken into account. The resulting data pool contained 701 documents. Next, a Named Entity Recognition algorithm was run over the documents identified. The results included:

- Entities/Actors: all the extracted entities, with relevant tags (e.g. Organisation, LAW, EVENT, PERSON, GeoPoliticalEntity). When an organisation was detected to be the subject of the sentence, the relevant verb/adverbial modifier was also extracted to give some context.
- Count: A list of all unique extracted entities, and the frequency with which they were mentioned.
- Count_root: The unique combinations of subjects and their respective verbs. This helped to identify how actors were described in terms of what they do in the policy process (advising, agenda setting, executing, etc.).

In a separate step, website scraping was conducted to extract the submissions to the EU Commission online consultation process on a proposal for a regulatory framework for the certification of carbon removals (231 submissions) [39].[1] The submissions were sorted according to the type of actor making the submission. These processes were supplemented by a qualitative review of recent key CDR policy documents.

The key actors identified in the above processes were then subject to a basic, qualitative network analysis. We first manually created a matrix of relevant CDR policy actors which listed: (1) their (expected) role(s) in the CDR policy process; (2) their relevance for either marine CDR, terrestrial CDR or both; (3) the political level on which they are located (non-state, national; German state, national; non-state, transnational; EU; intergovernmental); (4) the type of connections between them (advising, advocating, executing policy for, funding, gatekeeping, planning policy, representing national interests, norm setting, agenda setting). With the help of statistical computing language *R*, this matrix was then used to create a graphic visualisation of the network containing all the individual actors and their associated connections (see Supplementary Fig. 1).[2] This visualisation allowed us to filter and highlight actors' positions and how they are linked with each other.[3] We used this visualisation to help us identify key actors or emerging central 'nodes' in the CDR policy network. We additionally calculated the average length of shortest paths between the nodes using the package *tidygraph* for *R* [40], and the assortativity of the network using the *R* package *igraph* to assess the level of the level of homophyly of the network, or how linked nodes are to nodes of similar types [42]. Finally we calculated the K-core using the *R* function *node_coreness* to evaluate the center-periphery relationships in the network [40].

4.2. Substantive mapping

To identify the emerging substantive positioning of CDR policy actors, we employed qualitative discourse analysis techniques. This involved the systematisation of the textual data using an 'open coding' approach to inductively organise the elements identified in the documents into categories with the help of the text analysis program MAXQDA. This means we did not have a pre-defined 'code book' of words or terms prior to the analysis, but rather the categories emerged during the analysis itself. The next step involved using axial coding methods to identify recurring rules with which discursive elements were related. These included – for example – repeated usage of specific terms and logics, patterns of classification and differentiation, as well as relationships of equivalence and contrariety between elements of the discourse. This recursive process involved several iterative loops in which preliminary findings were compared to further empirical material

[1] See Supplementary File 1 for the scraping script used.

[2] R-packages used for the analysis and visualisation of the network: [40,41].

[3] It is possible to filter Supplementary Fig. 1 to reduce complexity – i.e. to show actors only relevant for mCDR or tCDR, or to filter according to kinds of links between actors. To do this, click on the 'Layers' symbol on the far left of the PDF, then deselect elements you want to hide/select those you wish to highlight. Then use the 'FILTER 100' option to filter.

from the data pool, and where necessary the categories created in the initial coding were revised. Speaker position categories thus emerged from the data itself during the iterative coding process of working backwards and forwards between the texts and the categories, allowing the constant dynamic development of the category system (see Fig. 1, [4,5,43]). The result of this mapping process was the identification of a range of speaker positions and the actors adopting them, and how they are positioned relative to each other within the discursive structure of

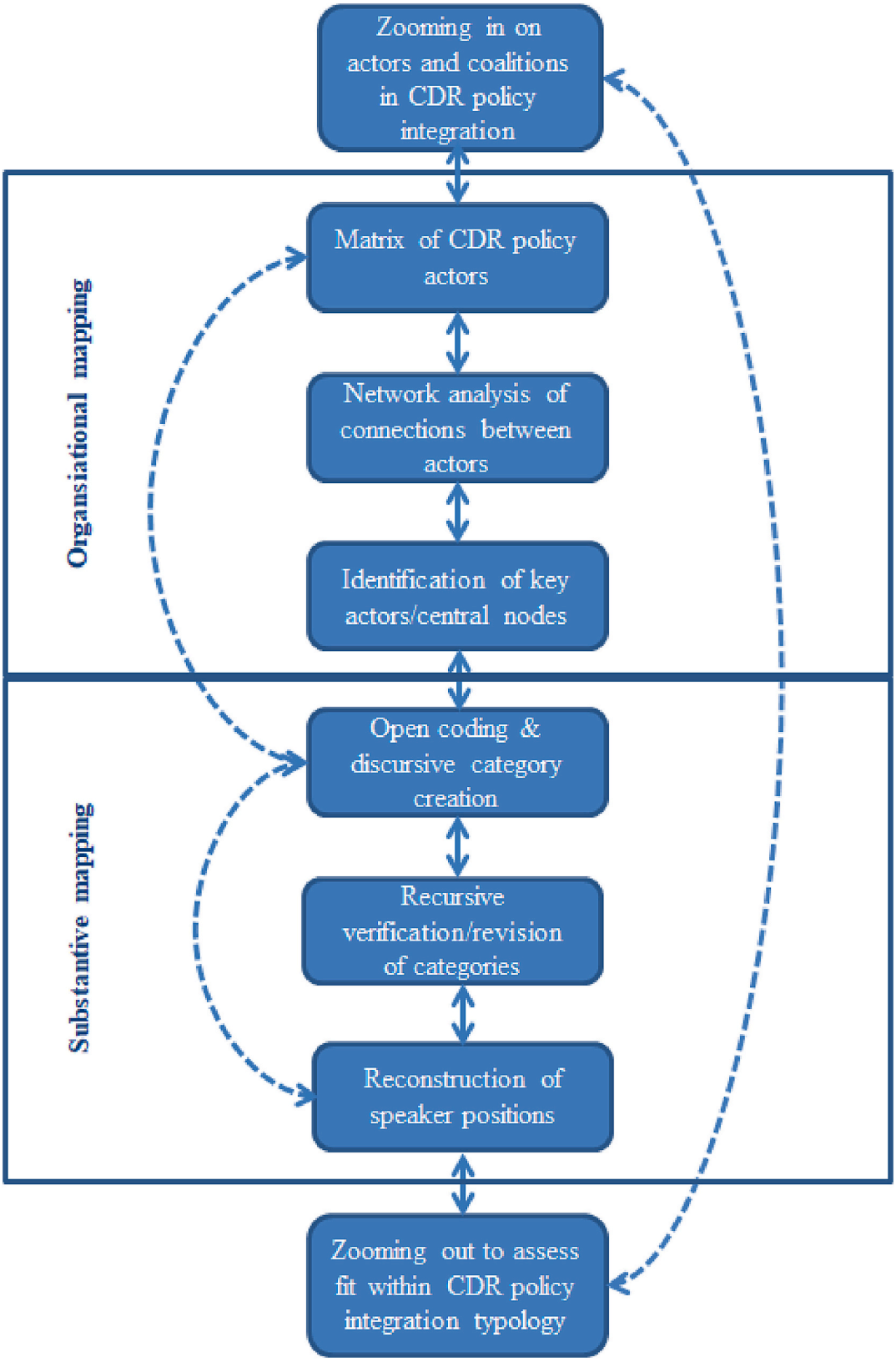

Fig. 1. Iterative analytical approach to mapping.
(Source: own diagram based on Boettcher 2020)

the CDR policy debate.

5. Results

5.1. Organisational mapping

The first step of the mapping process identified how CDR policy-relevant actors on the German and EU levels are linked organisationally. In addition to listing the range of state and non-state actors involved in the CDR policy space from the sub-national to the EU level, we also categorized the types of organisational connections between them.

This network analysis process primarily showed that the CDR policy actor landscape is complex, especially when adding marine policy actors. Given that earlier studies on CDR debate in Germany identified reluctance of policymakers, NGOs and industry to address the full portfolio of CDR [11,44,45], this observation points to a rapid formation and development of the policy space. While some actors are primarily relevant for only marine or terrestrial carbon removal policy, a larger percentage of those actors we surveyed would be relevant for both (see Fig. 2). Although our results show that some institutional and non-state marine organisations are starting to engage with the topic of marine carbon removal, actors with interests in terrestrial carbon removal are much more numerous and central, while mCDR actors are more peripheral in the network (see Supplementary Fig. 2). Agricultural, forestry and other actors engaged in land-use policy are recognizing the potential opportunities and risks presented by terrestrial CDR to their activities and interests. Industrial advocacy actors who see a potential for new revenue generation are also engaging in the space (e.g. the cement and lime industries).

Our network analysis also showed that linkages between levels (sub-national/national/EU) for climate and marine policy are largely parallel and not connected horizontally. The assortativity score of the network - which measures the extent to which actors are linked to other actors of a similar type - was a small negative value, indicating that there is a lack of connection between actors engaging on climate policy and those engaging on marine policy. A similar disconnection was evident in the average path lengths between nodes in the network, which showed that mCDR and tCDR-relevant actors are further apart from one another than the average node in the network, and thus that tCDR and mCDR-relevant actors are largely not directly linked to each other. Developing robust marine carbon removal policy would require coordination between these two separate actor groups – analogous to the connections currently being established between climate and agriculture and forestry policy-actors (see e.g. EU Commission Communication on Sustainable Carbon Cycles [29]). Hence the current disconnected marine and climate policy landscape may present a barrier to the near-term development of marine carbon removal policy. Our results showed that the most frequent type of links between actors at this early stage of the policy-development process appear to be 'advocating', 'advising' and 'agenda setting'. Types of linkages which remain relatively under-represented thus far are 'funding' and 'implementing policy for' (see Fig. 3).

Mapping emerging linkages between different actor types on different levels of the German-EU climate policy landscape also shows that certain actors may be becoming central 'nodes' on the various levels of the emergent CDR policy network (see Supplementary Figs. 1 & 2). On the EU-institution level, the European Commission is a hub of linkages. An example of a very well-connected non-state CDR advocacy organisation is Bellona, and a cautionary counterpart is the Climate Action Network (CAN). On the German federal level, the newly amalgamated Federal Ministry for Economic Affairs and Climate Action (BMWK) is one of the key actors. Based on the number of linkages an actor had, which – in combination with our experience observing the field – we took as an indication of how 'key' or 'central' they are to the emerging CDR policy network, these actors were selected to be the focus of the second, substantive mapping process. Despite its relative lack of centrality in the network, the German Marine Research Alliance (DAM), as one of the few examples of an actor providing policy-relevant advice on marine CDR in Germany, was also included in the analysis.

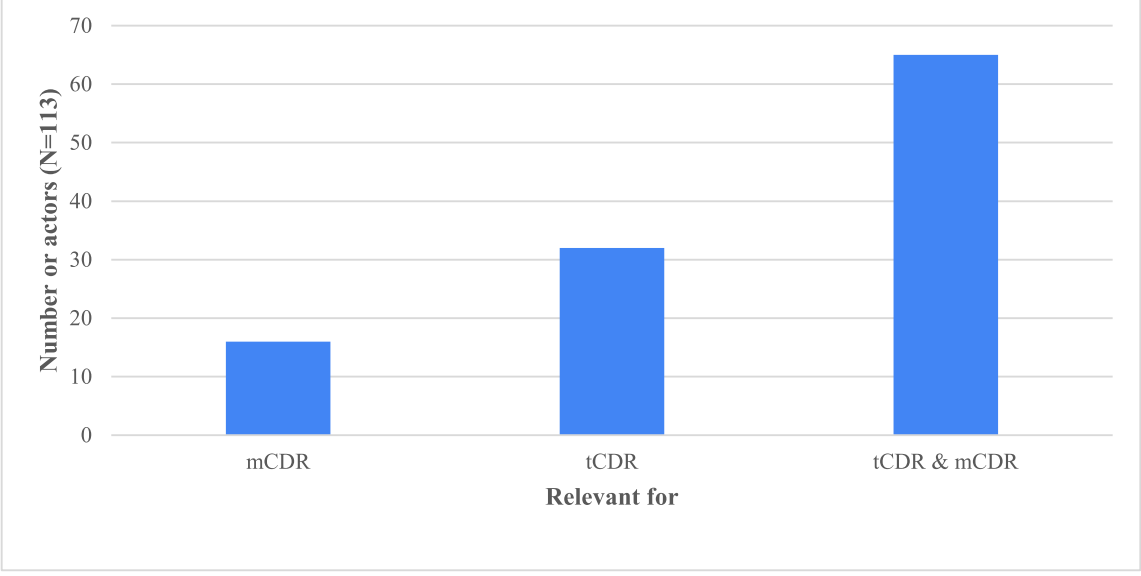

Fig. 2. Number of actors relevant for marine or terrestrial CDR.

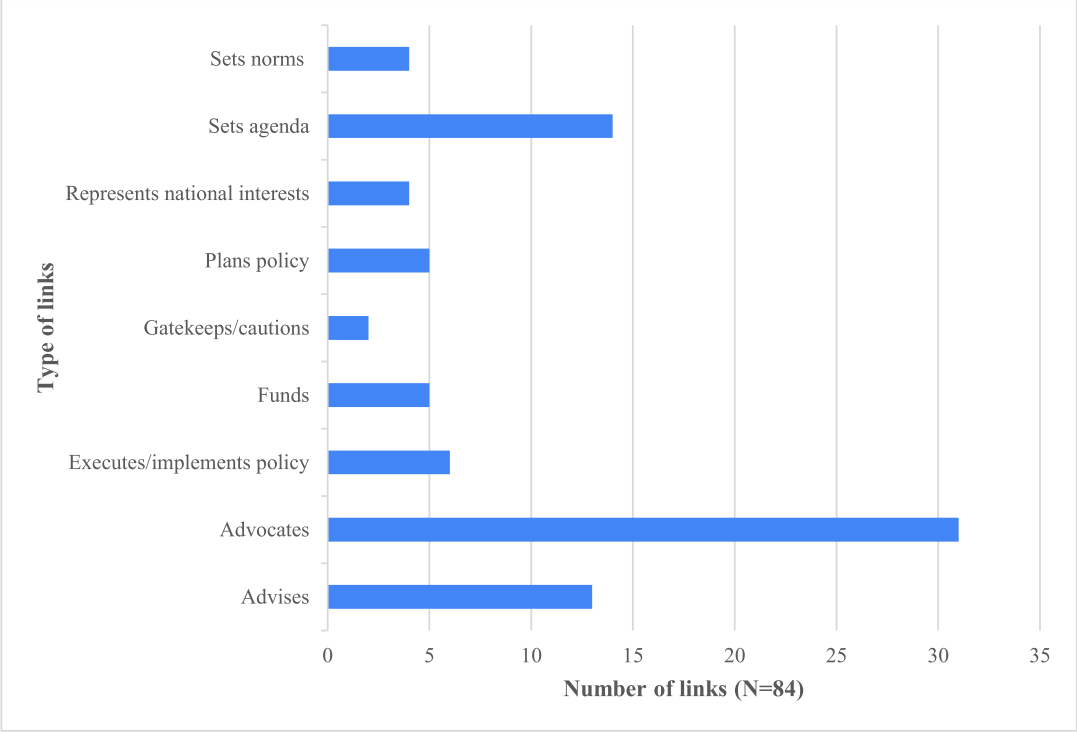

Fig. 3. Overview of type of linkages between actors.

5.2. Substantive mapping

The second analytical step revealed how these five key actors - the EU Commission, Bellona, CAN, the BMWK, and DAM - are positioning themselves *substantively* with relation to the *what*, *why*, and *how* of CDR policy, and allowed the identification of key emerging speaker positions within the German and wider EU CDR policy sphere. Each of the sections below first gives an overview of the actor's main functions in the CDR and wider climate policy space, then outlines how they have so far positioned themselves towards marine and terrestrial CDR, before highlighting the elements of the discursive speaker positions each of them are adopting. The key elements of each speaker position are summarized in Table 1, and example quotes which show these being adopted by the key actors are provided in both in the respective sections below and in Supplementary Table 1.

5.2.1. European Commission

The European Commission plays a key role in EU climate policy, in which German climate policy is embedded to a high degree. The Commission is usually perceived as the 'engine' of EU climate-policy development [46]. Although the co-legislators, the Council of the EU and the European Parliament, eventually make decisions in the EU's ordinary legislative procedure, the Commission plays a key role in setting the agenda and pre-structuring debates in the EU climate policy space. Recently, this role became visible in the context of the European Green Deal, which the Commission initiated and framed as a "new growth strategy that aims to transform the EU into a fair and prosperous society" [47]. The Commission not only established the overarching narrative of the Green Deal, it also initiated numerous simultaneous legislative procedures which have made it hard for all other actors involved - both legislators and stakeholders - to keep up, thereby strengthening its own leading role [48]. The Directorate-General for Climate Action (DG CLIMA) became more important in the current Commission that took office in 2019 under Ursula von der Leyen, with Executive Vice President Frans Timmermans leading it and the European Green Deal being identified as priority number one for the Commission. The Commission sought to position the European Green Deal and its climate policy goals as not being undermined by fundamental crises such as COVID or Russia's invasion of Ukraine, but as key elements of policy responses to such crises.

In the CDR policy space, the Commission has acted as a driving force [9]. The proposed long-term strategy in 2018 laid the ground for a new target structure under the EU Climate Law that includes a ratcheted 2030 target (from 40 % gross emissions reduction to −55 % net emissions reduction). In addition, a net-zero and a net-negative GHG emissions target have been adopted (see Section 2 and Regulation (EU) 2021/1119, Art. 2 and 4). In the aftermath of adopting these targets, the Commission proposed several CDR-relevant policy initiatives. Key examples are the proposal to enhance the LULUCF net removal target to 310 Mt CO_2eq in the Fit-for-55 legislation [49], and processes related to the Communication on Sustainable Carbon Cycles, such as consultations, stakeholder engagement (e.g. Conference on Sustainable Carbon Cycles) and a Commission proposal for regulating the certification of removals [29,50]. The latter is a key effort by the Commission to prepare and pre-structure the political debate on CDR governance. By pursuing the three issues of carbon farming, industrial capture, use and storage of carbon (including the CDR methods Bioenergy with Carbon Capture and Storage [BECCS] and Direct Air Carbon Capture and Storage [DACCS], and the certification of carbon removal methods), the Commission sketches out the main pillars of CDR policymaking and puts itself into the role of a proactive agenda-setter for terrestrial CDR policy. For marine CDR, the Commission's position is less pronounced. The Sustainable Carbon Cycle Communication includes references to the "blue carbon economy" and "carbon farming through nature based solutions for example on coastal wetlands as well as seaweed and mollusk regenerative aquaculture and marine permaculture" [29], but the proposals by the Commission are less concrete compared to carbon farming for agriculture and forestry. Geochemical approaches to marine CO_2 removal (e.g. increasing the alkalinity of the ocean), have - except for the provision of EU research funding - not yet been addressed by the Commission.

The Commission is thus adopting an entrepreneurial and intellectual

Table 1
'Ideal types' of speaker positions identified in substantive mapping.[a]

Speaker position	What (object)	Why (rationale)	How (instruments)
Agenda-setting innovator	CDR as promising climate policy tool	To achieve politically negotiated climate targets	EU certification standards for CDR, expanding existing EU climate policy to include CDR
Pragmatic integrationist	CDR as a way to compensate for unavoidable residual emissions	To honour dual political mandates (climate & industry)	Long-term strategy for residual emissions, integration of CDR into existing national (climate/industrial) policy
Utilitarian solutionist	CDR as an effective carbon management solution	To address climate change while maintaining industrial competitiveness	National German Carbon Management strategy, robust EU certification standards for CDR
Precautionary gatekeeper	CDR as a potentially risky distraction	To prevent harm to and ensure justice for vulnerable communities and ecosystems	Binding EU regulations and standards for CDR, scientific research to ensure adequate policy guidance
Responsible information provider	CDR as a (marine/climate) management option with benefits and risks	To facilitate knowledge production to assess benefits and risks	Regulation to enable responsible scientific research and identify potential courses of action in which benefits outweigh risks

[a] For examples of actors adopting/(re)producing elements of these speaker positions, see Supplementary Table 1.

leadership role on the issue of CDR that might help facilitate a constructive and open debate, political positioning, and potential agreement on different ways of addressing CDR in EU climate policy. However, the Commission's ability to facilitate ambitious CDR policies will depend on how the CDR debate unfolds in each Member State and how contentious the issue becomes.

The EU Commission is putting CDR forward as a potentially promising additional climate policy tool (*what*) to help achieve its politically negotiated target of climate neutrality that requires CDR (*why*), and is trying to expand existing EU climate policy to include CDR regulation and incentivisation frameworks (*how*). In sum, the European Commission is currently adopting a speaker position that combines *ambitious agenda-setting and politically catalyzing CDR innovation* (see Table 1 for an overview of the discursive elements of this speaker position and Supplementary Table 1 for examples of it being adopted).

5.2.2. Federal Ministry for Economic Affairs and Climate Action (BMWK)

In the past ten years, the German Ministry for Economic Affairs and Climate Action (BMWK) has substantially increased its competencies in the climate policy space. Since 2013, the Ministry has had the main responsibility for the complex topic of energy transition. After the 2021 federal elections, the new governing coalition agreed that the BMWK - now led by a prominent politician from the Green Party and vice chancellor of the government - would also assume responsibility for climate action competencies from the Ministry of the Environment (BMUV). This pooling of competencies for energy and climate policy makes the BMWK the decisive player in German CDR policymaking. In addition, the BMWK is in charge of the process of developing a long-term strategy for residual emissions and removals, a task the parties forming the current government agreed on when negotiating their coalition agreement [24].

In Germany, the issue of CDR has only been incrementally taken up in public policy processes, especially with regard to CDR methods that require CCS [11]. The BMWK, however, has dealt with the issue rather pragmatically as a subject of both industrial and energy/climate policy. For example, in 2018, in a report evaluating the CCS law, a reporting exercise inscribed in the Carbon Dioxide Storage Act §44, it mentioned DACCS and BECCS as possible methods to achieve negative emissions, highlights that their implementation must not obstruct emission reduction efforts, and addresses possible limits in feasibility and sustainability as well as high costs for land and biomass (for BECCS) and energy (for DACCS) [51].

This position was refined in the National Energy and Climate Plan (NECP), a document EU Member States had to submit in the context of the EU's Regulation on the Governance of the Energy Union and Climate Action. The document was prepared by the BMWK's predecessor, but reflected the position of the whole government and addressed both "natural" CDR (covering what is called "plant growth") and "technological" CDR ("direct air capture") as CDR methods that will be required to "close the carbon cycle" [52]. In the NECP, it is noted that CDR research will be increased [52]. Furthermore, the considerable attention CDR has received in Germany since the publication of the IPCC's Special Report on 1.5 °C is highlighted. In 2022, the German Government submitted a new long-term strategy to the United Nations Framework Convention on Climate Change (UNFCCC) which highlights that "negative emissions […] are necessary for the climate targets to be achieved […] [as] a complement to and not substitute for emissions reductions." The long-term strategy also stipulates that "technical negative emissions will be necessary to offset unavoidable residual emissions […]" [53].

Dedicated CDR policies do not yet exist in Germany. However, in addition to large research programs initiated by the previous government's Ministry for Education and Research, the current government - and the BMWK in particular - is working on establishing new incentive structures relevant for CDR. Recent developments indicate that CDR-relevant questions will be addressed under the umbrella term 'carbon management' that also covers CCS and CCU. One example is the joint statement between the Norwegian Prime Minister and BMWK Minister Robert Habeck which refers to a joint "leading role in managing carbon emissions" [54]. Since competencies for LULUCF-related CDR options lie with the environment (BMUV) and agriculture ministries (BMEL), most efforts identified in BMWK statements and documents refer to CCS-based options, often labeled as "technological negative emissions" [55,56]. Marine CDR is currently not being addressed in policy documents by the BMWK.

These developments indicate that the BMWK is adopting politically pragmatic arguments for the development of a long-term strategy to gradually integrate CDR into German and wider EU climate but also industrial policy (*how*). CDR is seen as a practical means to achieve the climate target of net-zero GHG emissions (*what*) in a way that facilitates both climate and economic policy goals (*why*). In sum, the BMBK is thus adopting a *pragmatic integrationist* speaker position in the CDR policy space (see Table 1 and Supplementary Table 1).

5.2.3. Bellona

Bellona Europa is an advocacy organisation which "endeavours to identify and implement sustainable solutions to the world's most pressing environmental problems". From its head office in Oslo, as well as international offices in European capitals such as Brussels and Berlin, Bellona promotes a "solution-oriented approach to environmental challenges", collaborating with industry partners to "jointly work out the best social and environmental solutions, and make these financially profitable/viable" [57,58].

Bellona contributed feedback on the EU Commission's Sustainable Carbon Cycles Roadmap in October 2021 and made a submission during the consultation on Carbon Removal Certification in May 2022 [58,59]. In addition to these direct inputs into policy development processes,

Bellona has published multiple reports, open letters and op-eds calling for political action and clear regulations to enable industrial carbon capture, carbon removal, and storage (see e.g. [60–62]).

The organisation has historically focused on advocating for carbon capture and storage (CCS), but in the last five years have expanded their mandate to advocating for CDR - predominantly those approaches linked to CCS, such as BECCS (which they call Bio-CCS) and Direct Air Capture (DAC) with CCS. They primarily discuss terrestrial carbon removal approaches, but have also made reference to the marine environment's capacity for offshore storage of CO_2 [63]. The organisation also indicated in their response to the EU Commission consultation on Carbon Removal Certification their belief that coastal marine ecosystem restoration and preservation should be among the carbon removal solutions to be incentivized by EU climate policies as soon as possible. However, the feedback also emphasized the lack of permanence of storing carbon in the biosphere and argues for policy prioritisation to be given to geological storage 'solutions' [64].

Bellona works with "companies that are strategically placed in relation to (Norwegian) industries" [58]. The organisation advocates for 'climate solutions for industry', arguing that industrial partners;

> "[C]an be as much a part of the solution as the problem, but are important allies in political processes; they have the necessary expertise and knowledge in their field, and commonly share the willingness to position themselves as pioneers that identifies and demonstrates new solutions [58]."

The organisation sees CCS and CDR as part of the (technological) solutions to climate change, which at the same time provide the opportunity to protect existing industries. Their position on CDR policy revolves around calling for the clear definition of what counts as removal, the need for consistent Monitoring, Reporting and Verification (MRV) standards and accounting systems to enable the economic viability of removals. Bellona wants to see the rapid 'operationalisation of net-zero accounting' on the EU level, calling for clear regulations and certification standards for CDR, with a focus on permanence of storage as a core metric [59,61,62,64]. The recent opening of its Berlin office allows Bellona to engage directly with the role of CCS and CDR in climate policy in the EU's largest Member State, as a way to influence EU policy more broadly. The organisation's engagement with the issue within the German policy debate places emphasis on the need to maintain industrial competitiveness relative to other countries (e.g. the Netherlands). They have called for a coordinated strategy and cross-border cooperation to develop CO_2 (transportation/storage) infrastructure for German industry, which would be part of a national German Carbon Management strategy, including a 'Carbon Management Department' at the BMWK [64,65].

In sum, Bellona adopts utilitarian rationales for CDR policy to enable financially profitable solutions to climate change. The organisation predominantly reproduces economic cost-benefit and win-win framings of the advantages of integrating CDR into German and EU climate policy. Within this economic logic, CDR may be an effective tool (*what*) to help solve the climate change problem by managing carbon while at the same time protecting existing sectoral and national economic interests (*why*). It follows that policy instruments are needed to operationalise and regulate carbon removal standards so as to ensure the economic viability of the approaches (*how*). Bellona thus adopts what we term a *utilitarian solutionist* speaker position within EU and German CDR policy debates (see Table 1 and Supplementary Table 1).

5.2.4. Climate Action Network (CAN) Europe

Climate Action Network (CAN) Europe is Europe's leading NGO network on climate and energy issues. With over 140 member organisations active in more than 35 European countries, CAN Europe works to "prevent dangerous climate change and promote sustainable energy and environment policy in Europe" [66,67]. All major German environmental NGOs are members of CAN, which endeavors to speak with a united voice on EU climate policy issues. The proclaimed vision of CAN is "a world striving actively towards and achieving the protection of the global climate in a manner that promotes equity and social justice between peoples, sustainable development of all communities, and protection of the global environment" [67]. The organisation aims to;

> "[B]uild bridges with partners and stakeholders across the climate movement and beyond to pressure governments to take bold and urgent climate action to end the era of fossil fuels and address the needs of the most vulnerable people impacted by the climate crisis [67]."

The members of the organisation claim to be "working towards a participatory and inclusive just transition and that centres around the needs of the most vulnerable, the most marginalised and that protects nature" [66,67].

CAN Europe contributed feedback on the EU Commission's Sustainable Carbon Cycles Roadmap in 2021. The organisation has also published multiple reports and open letters calling for political caution in relation to CDR, while emphasising the need for holistic solutions to address the loss of biodiversity, provide sustainable livelihoods as well as the need to adapt and mitigate climate change. The organisation works primarily with and for environmental movements, with a focus on vulnerable communities, aiming to promote the protection/prevention of harm to communities and ecosystems, calling primarily for "rapid and deep emission reductions." They accordingly take a precautionary stance on CDR, warning against unwittingly promoting "false climate solutions that might do more harm than good" [68,69].

In line with this argumentation, CAN Europe is not completely opposed to CDR, but cautions against the potential risk of "decarbonisation delay" or distraction posed by the promise of carbon removals, along with potential risks (i.e. land-use competition, food security) posed by ecosystem based removal projects to vulnerable communities [70]. Correspondingly, the organisation calls for separate targets for removals and emissions reductions, and places a strong emphasis on the issue of regulation and monitoring of CO_2 storage in the land-use sector. The organisation has taken no explicit stance on marine CDR approaches so far, but has elsewhere emphasized the need to "maximise the potential of marine ecosystems to sequester and store carbon" [68]. The organisation's focus is again on the protection of marine environments with blue carbon storage potential. CAN has also called for more research into carbon storage capacity of marine ecosystems such as kelp forests and algae, saying;

> "[M]ore in-depth understanding of the sequestration potential of these blue carbon ecosystems through scientific research is needed to ensure adequate policy guidance building on sound scientific data is developed [71]."

Overall, CAN Europe emphasises protection and precaution as key rationales for developing CDR policy. The organisation regularly refers to the precautionary and prevention of harm principles, emphasising the need for the integration of principles of equity and justice into decision-making around climate change response strategies. This precautionary framing is mirrored in both the organisation's calls for "binding regulation" of CDR before it is implemented to ensure that development and use of CDR does not negatively affect vulnerable communities and ecosystems and its call for scientific knowledge about CDR approaches to be improved before appropriate policy guidance be developed. CAN Europe is thereby taking on what we term a *precautionary gatekeeper* speaker position (see Table 1 and Supplementary Table 1, c.f. [5]).

5.2.5. German Marine Research Alliance (DAM)

The German Marine Research Alliance was initiated in 2019 by a group of 23 German marine research institutes, together with the federal government and the northern German states of Mecklenburg-Western Pomerania, Lower Saxony, Schleswig-Holstein, Bremen, and Hamburg. DAM states that it;

> "[A]ims to strengthen the sustainable use of coasts, seas and oceans through research and transfer, data management and digitalisation, and by coordinating the infrastructures. To this end, the DAM is working together with its member institutions to develop solution-oriented knowledge and to communicate potential courses of action to politics, business and civil society [72]."

In 2021, DAM launched two research 'missions', one on the 'Protection and Sustainable use of Marine Areas', and the other entitled 'Marine carbon sinks in decarbonisation pathways' (CDRmare), the first large (27 Million Euro) research program on marine CDR in Germany. The stated aims of the CDRmare mission are to "investigate whether and to what extent the ocean can play a significant role in the removal and storage of CO_2 from the atmosphere" and to establish "a Marine Carbon Roadmap for the sustainable use of marine carbon storage at regional to global scales" [73]. Although DAM is ocean-focused, the DAM-led CDR research mission is linked to terrestrial carbon removal research through an equally large BMBF-funded program named CDRterra [74].

In the lead up to the acquisition of federal (BMBF) funding for the mission, and subsequent to its launch, DAM has been actively engaging with German state and federal policymakers on issues related to mCDR (research) policy - for example by organising discussion round-tables with parliamentarians. CDRmare (not DAM itself) contributed to the consultation on Carbon Removal Certification, emphasising that;

> "[I]t is indispensable to put instruments, measures and policies in place that push and support every potential [mCDR] option forward from its current readiness level. We cannot afford an either-or approach but need a simultaneous, rapid and transparent exploration of all options that may help to reach net zero emissions in time to reach promised climate goals."

In addition, the DAM research mission members supported the development of an EU CDR certification framework that would "guarantee and display transparency [sic] of the benefits and costs of carbon removals" [75].

While DAM itself has not publicly engaged in detail with questions of what instruments CDR policy should entail beyond calling for the creation of enabling regulatory conditions for responsible research, the organisation bases its rationales for CDR policy-making on a risk-management logic; if scientific research and assessment shows that a certain mCDR approach's benefits outweigh its risks, it follows that that approach should be enabled through policy. Through its marine carbon removal and storage research mission, DAM explicitly aims to "provide important decision-making aids [sic] for continuing to develop Germany's climate strategy." [76] Rationales for enabling scientific engagement with CDR put forward by DAM focus on the need for unbiased scientific knowledge to inform decision making on climate policy. In this way, DAM primarily adopts a *responsible information provider* speaker position (see Table 1 and Supplementary Table 1 c.f. [4,5]).

5.2.6. Speaker positions

The substantive mapping outlined above shows the variety of different speaker positions at play in the emerging German and wider EU CDR policy debate. Table 1 summarizes the results of our substantive mapping by highlighting the *what*, *why*, and *how* of these speaker positions and how they play out in the emerging CDR debate.

The *agenda-setting innovator* speaker position combines rationales of ambitious agenda-setting and politically catalyzing CDR innovation. From this position CDR is seen as promising policy tool to help achieve politically negotiated climate targets. Policy instruments that would help facilitate this, and which are thus called for by actors adopting this speaker position, include EU certification standards for CDR methods and expanding existing EU climate policy to include CDR.

In comparison, from the *pragmatic integrationist* speaker position, CDR is seen primarily as a practical way to compensate for unavoidable residual emissions and achieve the net-zero GHG emissions climate target – thus functionally addressing climate change while supporting the national (industrial) economy. Policy instruments primarily called for by those adopting this speaker position include developing a long-term national strategy for residual emissions, and the gradual integration of CDR into existing climate and industrial policy.

The *utilitarian solutionist* speaker position incorporates economic cost-benefit and win-win framings of the benefits of integrating CDR into German and EU climate policy. Within this utilitarian logic, CDR may be an effective tool to help solve the climate change problem by managing carbon while at the same time protecting existing industrial productivity and competitiveness. It follows that policy instruments are needed to operationalise and regulate carbon removal standards so as to ensure the economic viability of the approaches.

In contrast, the *precautionary gatekeeper* position emphasises protection and precaution as key rationales for developing CDR policy. Those adopting this speaker position refer to the precautionary and prevention of harm principles, emphasising the need for the integration of equity and justice into decision-making around climate response strategies. This precautionary framing is mirrored in both in calls for binding regulation of CDR to ensure it does not negatively affect vulnerable communities and ecosystems and for scientific knowledge about CDR approaches to be improved before appropriate policy guidance be developed.

The fifth and final position is the *responsible information* provider. Actors adopting this speaker position base their rationales for CDR policy-making on a risk-management logic that emphasises that if scientific research and assessment shows that a certain CDR approach's benefits outweigh its risks, it should be enabled through policy. Rationales for creating enabling regulatory conditions for responsible research on CDR focus on the need for unbiased scientific knowledge to inform decision-making.

Although there is a shared focus on the need for a clear regulatory framework, different understandings of *what* CDR is useful for, differing rationales for *why* CDR policy is needed and varying proposals for *how* policy instruments should be implemented are being put forward by those adopting different speaker positions. While the *agenda-setting innovator*, the *pragmatic integrationist* and the *utilitarian solutionist* speaker positions all emphasize the potential of CDR, there are differences in the way they conceptualise CDR and its purpose. 'CDR as a promising climate policy tool' (*agenda-setting innovator*) emphasises the *political* utility of CDR– it can be effective simply as a political *promise*. CDR as 'a way to compensate for residual emissions' (*pragmatic integrationist*) is based on *functional* understanding of CDR's utility – it is a *practical* way to counterbalance residual emissions that would otherwise be technically difficult or impossible to abate. CDR as an 'effective carbon management solution' (*utilitarian solutionist*) is based on an *economic* logic – CDR is seen as an *economically effective* solution to ensure the continued competitiveness of national (carbon-dependent) industries. These rationales are all arguably reproducing variations of *green governmentality*, but they imply the need for differing *modes and instruments* of governance (see also Section 6). While the *ambitious agenda-setter speaker position* calls for top down, centrally coordinated, expert and politically-led integration of CDR into climate policy with close links to adopted climate targets, the *pragmatic integrationist* speaker position focuses on *functionally managed* national or sectoral policy integration, and the *utilitarian solutionist* speaker position calls for a primarily *market-led* policy mode. By highlighting these nuances, our mapping presents a fine-grained understanding of the speaker positions being adopted, and their potential implications for future CDR policy debates and developments in the German policy sphere.

It is important to point out that the speaker positions outlined in Table 2 are *'ideal types'*, elements of which are being reproduced by actors engaged in the German/EU CDR policy debate. These speaker positions are not taken to be exhaustive, nor mutually exclusive - but represent *stylised conceptual categories*. They can be adopted by different types of social actors, and individual social actors can adopt a range of

Table 2
Three modes of integrating CDR into climate policy.

	I. Incremental modification	II. Early integration & fungibility	III. Proactive CDR entrepreneurship
CDR in mitigation targets	Strictly separated	Fungible	Fungible
View of CDR among actors of the incumbent regime	Restrained integration	Proactive integration	Proactive integration
CDR methods addressed	Ecosystem-based only	Focus on ecosystem-based	Proactive technology support
Relation of CDR policy instruments to broader climate policy-mix	Incremental opening	Full integration	Specific instruments
Government support for developing CDR niches	Limited support	Limited support	Nurturing & empowering

Source: Schenuit et al. 2021.

speaker positions. Using these 'ideal types' as a reference, it is possible to compare speaker positions in this sphere of the debate with broader discussions of CDR and climate policy. Such a mapping is always a snapshot - in the current formative phase, where key actors in German climate policy are still in the process of developing their positions on CDR, e.g. NGO coalitions and large business associations, ideal-type speaker positions could change over time.

5.3. How speaker positions align with modes of CDR policy integration

To contextualise our results in the broader discussion of the role for CDR in climate policymaking, we link these findings back to existing work on different modes of CDR governance. We use the analytical lens developed by Schenuit et al. [11] to zoom out once more, contextualise the identified speaker positions in the broader debate, and assess whether and how they align with one of the idealized integration modes. Bridging insights from the Multi-Level Perspective (MLP) on socio-technical transitions and CDR governance literature, the typology put forward by Schenuit et al. provides a heuristic for exploring emerging CDR policy pathways, identifying five dimensions of CDR policy-making which can manifest differently in three ideal-type CDR policy integration modes: (a) early integration and fungibility, (b) incremental modification, and (c) proactive CDR entrepreneurship (see Table 2 for an overview of key characteristics). The synthesis of nine cases studies shows that the idealized CDR policy integration modes differ with regards to the 1) accounting of CDR towards mitigation targets, 2) actor positions towards CDR in the incumbent regime, 3) the type of CDR methods that are being addressed, the 4) type and embeddedness of policy instruments in a wider climate policy context, and 5) government support for niche developments (see Table 2 for details).

To better understand patterns of emerging CDR policymaking, its commonalities and differences to other elements of climate policy-making, as well as to identify enabling and constraining conditions for responsible CDR governance, each of these dimensions and their interactions require more in-depth operationalization and empirical case study work. Our actor mapping aims to contribute this for the dimension "view of CDR among actors of the incumbent regime", conceptualized as moving on a continuum between *proactive integration* and *restrained integration*. By linking these overarching modes with the identified speaker positions, we can contextualise the identified speaker positions in the broader CDR debate and thus inform the process of exploring and anticipating emerging discourse coalitions in the German CDR and wider EU debate. Second, we can further operationalise the continuum between proactive integration and restrained CDR integration modes and provide a starting point for future case studies and conceptual work.

The mode of early integration and fungibility outlined in Table 2 does not apply in the German case, since governance structures in climate policy did not integrate CDR early and do not allow the substitution of removals for emission reductions (as is the case in e.g. New Zealand or Australia) [11]. The speaker positions are rather located between those seeking proactive policy entrepreneurship (especially the *agenda-setting innovator* and the *utilitarian solutionist*) and the incremental modification of climate policy to incorporate CDR, taking into account restraint and concerns (especially the *precautionary gatekeeper*). The *pragmatic integrationist* and the *responsible information provider* are located between those two ends of the continuum (see Fig. 4 for an overview).

6. Discussion: from conceptual to empirical social science on CDR

The differences between speaker positions in the German CDR debate reflect key aspects identified in different strands of the academic debate on CDR and its governance more generally.

First, they can build upon findings put forward by a conceptual strand of CDR research that raises concerns about mitigation obstruction/deterrence [20,77], and the equivalence of emissions reduction and carbon removal in mitigation efforts [78]. While this work raises awareness of potential political risks of CDR deployment in the wider context of decarbonisation, empirical observations of how and where these dynamics can be identified in actual climate policymaking are scarce. We argue that the reconstruction of CDR discourses and the speaker positions they offer is a first step in this direction and that discursive mapping can improve understanding of what discursive and political strategies are enacted to either reduce pressure on emissions reductions through CDR or lower the mitigation obstruction effects of CDR policies.

Second, the role of Integrated Assessment Models (IAMs) in the rise of CDR post-Paris has received a lot of attention in social science [79–82]. As strategies for integrating CDR become more concrete, a new field of research is opening up for the social sciences: Empirical case studies offer the opportunity to work out *why*, *where* and *how* CDR becomes a part of climate policymaking, *who* is involved and whether it results in weakening or strengthening climate action. The empirical policy actor mapping we have undertaken here provides more nuance and contextualizes these debates, showing how CDR is being addressed in real-world climate policy debates. Such empirical analysis is a key contribution to studying the current feasibility of CDR within a given political context, as well as to anticipating future barriers and enablers for responsible CDR policymaking.

6.1. Providing policy-relevant nuance: identifying emerging discourse coalitions and conflict cleavages

Our work also builds upon existing discourse analytical and speaker position mapping work in wider spheres of the CDR governance debate which have shown the importance of empirically studying emerging discourse coalitions to help critically anticipate policy developments [4,5,7,44,83,84]. Comparing the range of speaker positions available in Germany to those identified in wider spheres (e.g. in other countries) of the CDR governance debate can help identify what types of voices may be being privileged or marginalised in the German CDR policy debate, and thus help think through plausible future coalitions and conflicts.[4]

[4] It should be noted that the characteristics of these speaker positions are not necessarily unique to the issue of CDR. It is beyond the scope of this paper to compare it to other elements of low-carbon transitions and already existing discourse coalitions [38,85]. We note, however, that such comparison would be a valuable subject for future research that could provide instructive insights on how CDR governance and policymaking might develop in the broader context of climate policy and politics to achieve net-zero and net-negative emissions.

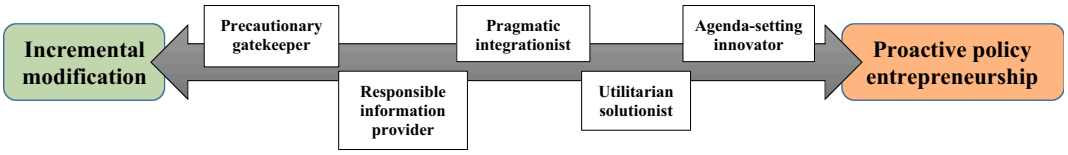

Fig. 4. Conceptual overview of speaker positions on the continuum of two different types of CDR policy integration. (Source: Own diagram based on [11])

Such a comparison shows that - while there is some overlap between the speaker positions identified here and those mapped within wider spheres of the CDR governance debate - there is evidence of *expanded/combined* positions being adopted in Germany and the wider EU context, which could indicate there is the basis for *an emerging discourse coalition* around what constitutes 'appropriate' CDR policy.

For example, the *ambitious agenda-setter* speaker position being adopted by the EU Commission seems to be a combination of the political 'ambitious leader' and economic 'innovation catalyst' speaker positions identified in the UK: The 'ambitious leader' speaker position involves taking the lead on CDR by setting an example and establishing governance standards for the world [4]. The 'innovation catalyst' speaker position provides a template for governance roles that include economically incentivizing CDR research, development and deployment [4]. Likewise the *utilitarian solutionist* speaker position being adopted by Bellona combines elements of the 'Self-benefit maximizer' which provides a template for social actors to push for CDR governance which maximizes their own financial benefit, and the 'innovation catalyst' speaker position that focuses on bridging the CDR policy gap by driving innovation through investment. Similarly, the *pragmatic integrationist* speaker position adopted by BMWK also combines economic and political logics by calling for CDR policy to protect Germany's political and industrial interests, particularly relating to energy security and economic stability [5]. In addition, the *precautionary gatekeeper* speaker position being adopted by CAN Europe deals with issues of (economic) distributive justice as well as procedural justice, making it broader than the scope of a similar speaker position identified in the UK, which focused primarily on procedural justice aspects of CDR policy [4].

Thus, by combining political and economic logics, the *broadened* speaker positions in the German and wider EU debate may offer social actors shared ways to approach CDR policy. However, there are also differences between the 'ideal type' speaker positions in the German CDR debate that may lead to future tensions. Mapping speaker positions allows us to develop hypotheses about conflict cleavages that may emerge between these positions and actors adopting them. For example, despite seeming to share an broad understanding of what constitutes 'appropriate' CDR policy in Germany/the EU, actors adopting differing speaker positions put forward seemingly diverging suggestions for policy integration modes: For example, calls for top down, centrally coordinated, expert and politically-led integration of CDR into climate policy with close links to the adopted climate targets (EU Commission/*ambitious agenda-setter speaker position* on the right of spectrum in Fig. 4), might conflict with a more pragmatic, functional, market-led policy integration mode (Bellona/*utilitarian solutionist* and BWMK *pragmatic integrationist* speaker positions), and both these could also clash with a precautionary, and incremental integration mode (CAN/*precautionary gatekeeper* speaker position on left of spectrum in Fig. 4). These conflict cleavages mirror the three competing 'meta discourses' that have been shown to underpin climate governance more broadly. 'Green governmentality' which is based on a hierarchical, administrative logic, aligns with the ambitious agenda-setter speaker position, the market-led logic of 'ecological modernisation' overlaps with elements of the *utilitarian solutionist* and *pragmatic integrationist* speaker positions, and 'civic environmentalism' which is built upon a logic of democratic participation, has similarities with the *precautionary gatekeeper* speaker position [85,86]. Discursive logics which have historically competed to shape wider climate governance are thus seemingly being reproduced by actors adopting speaker positions on CDR policy in Germany.

These underlying tensions can thus be expected to play out in ongoing political processes, both in Germany domestically and at the supranational level in the EU. For Germany, a key political process will be the development of national strategies on carbon management and unavoidable residual emissions. Spurred on by the pragmatic integration mode of the BMWK, which has the potential to clash with the precautionary mode advocated by CAN Europe and the German NGOs who are members of this coalition, this process is likely to lead to heated debates between actors adopting the identified speaker positions - not only between representatives of business or organized civil society, but also between policymakers in government and various ministries.

Furthermore, it is expected that attempts to translate key aspects of the carbon management strategy into actual regulation might intensify debates; establishing market-led policy instruments to incentivise CDR, reforming the German Climate Change Act and CCS Act accordingly, or implementing CDR projects on the ground may provoke conflict between those adopting speaker positions which advocate a market-led CDR policy integration mode and those which call for more precautionary and incremental integration.

At the EU level, legislation on CDR Monitoring, Reporting and Verification (MRV) is likely to accelerate position formation and trigger a debate on the credibility of CDR as an element of mitigation strategies and those adopting the speaker positions identified here will likely take differing stances within this debate. Actors adopting speaker positions calling for top down, centrally coordinated, and politically-led integration of CDR into climate policy would seem more likely to support strict EU-wide MRV guidelines as a precondition for integrating CDR in mitigation policy. In contrast, actors taking a pragmatic position and calling for market-led CDR policy integration may be expected to push for starting the integration through existing policy instruments such as the EU ETS as soon as possible [87], in combination with strong (financial) incentives for deploying CDR.

In addition, the 2040 emissions reduction target that the European Commission is likely to propose in 2024 will stimulate a debate on how emissions reduction and removal relate to each other on the path to net-zero emissions. It is likely that actors adopting the various speaker positions, ranging from precautionary gatekeepers to innovative agenda setters, will take different positions on how strictly removals and reductions will be separated or considered fungible when counting towards the target. Given the integrated character of EU and German climate policy, it is to be expected that this debate will spill over into Germany, at the latest when European decisions on CDR have to be implemented on the national level.

7. Conclusions & outlook

We are currently observing the formative and rapidly changing phase of CDR policymaking in Germany and the wider EU. New actors are beginning to position themselves relative to those who have been engaging with the issue for longer, while actors who have historically taken a certain stance on the issue can be expected to change their former positions as new voices join the debate. The way CDR policy is emerging is being shaped by specific types of discourses and the actors (re)producing them in an inherently political process.

Our snapshot of the current CDR debate shows that certain actors are currently central 'nodes' in the emergent CDR policy network - the European Commission, Bellona, the Climate Action Network (CAN) Europe and the Federal Ministry for Economic Affairs and Climate Action (BMWK). In addition, one of the few examples of an actor engaging on marine CDR in Germany is the German Marine Research Alliance (DAM). This list of actors is not comprehensive, other key actor groups can be expected to become relevant stakeholders in related policy processes. Industrial organisations, for example, are beginning to engage more actively, particularly in the terrestrial CDR debate, as the new German coalition government provides greater opportunity for industry involvement in the development of climate change response options. In comparison, environmental NGOs have so far been rather reticent in engaging with the issue. However, the repositioning of the German government and new political dynamics are also putting pressure on them to (re-)position themselves.

Our organisational mapping showed that the most frequent types of links between actors at this early stage of the CDR policy-development process are 'advocating', 'advising' and 'agenda setting'. Types of linkages which remain relatively under-represented thus far are 'funding' and 'implementing policy for', highlighting the formative phase of CDR policies and related debates. In addition, we showed that CDR-relevant climate and marine policy actors are largely not linked. The currently disconnected marine and climate policy landscape may thus present a barrier to the near-term development of comprehensive terrestrial and marine carbon removal policy. Generally, it is currently difficult to identify emerging differences in the (organisational and substantive) actor 'maps' for terrestrial and marine CDR, apart from noting that actors are not yet positioning themselves as much on mCDR as they are on tCDR. Future work should explore plausible scenarios for how marine CDR might enter climate policymaking.

Our substantive mapping showed that although different rationales for *why* CDR policy is needed and *how* it should be implemented are being put forward by actors adopting different speaker positions, there is a shared focus on the need for a clear regulatory framework for carbon removal. In addition, our analysis showed that a combination of *economic and political* speaker positions may be forming an emerging discourse coalition around the issue of CDR governance. This may be evidence of the continued influence of 'green governmentality' on the Green Growth paradigm underpinning broader EU climate policy [8,85,86]. However, there are still potential conflict cleavages between the modes of CDR integration supported by actors adopting different speaker positions. They range from *agenda-setting innovators* who seek proactive integration, to *precautionary gatekeepers* who advocate incremental change. Our snapshot shows that there is substantial heterogeneity in speaker positions, which may pose the risk of a polarized debate on CDR. Upcoming political processes, including the development of the proposed national strategies for carbon management and unavoidable residual emissions and the debate on the EU's 2040 mitigation target, will offer actors involved the opportunity to reconsider or consolidate their positions on CDR. In this vein, our results provide an empirical 'map' to inform CDR stakeholders and decision-makers; showing them which speaker positions are currently at play, thus allowing them to reflect on their own positioning and how it relates to others in the emerging German (and wider EU) CDR policy space.

These findings also highlight several issues meriting further research to gain a better understanding of the emerging CDR debate and its implications for the development of German and EU climate policy. First, our analytical approach to identifying 'ideal type' speaker positions can be extended to analyse further data sources and broader sets of actors. Thus we envisage this work as a starting point for developing a broader typology of speaker positions within the German/EU CDR policy space. Ongoing work on the emerging debate will also provide the opportunity to trace how the debate unfolds; key questions would then be whether speaker position heterogeneity increases or decreases over time, and thus whether certain speaker positions are becoming discursively dominant and shaping policy action.

Secondly, our analytical perspective can be used to develop more fine-grained hypotheses about emerging discourse coalitions and potential conflict divisions that may arise between these ideal positions and the actors adopting them. For example, it would be illustrative to explore the differences/commonalities between CDR speaker positions and those which emerge within discussions about emissions reduction. Key questions could be; are the emerging coalitions the same, are discursive coalitions and conflict cleavages which have historically shaped wider climate governance being reproduced by actors adopting speaker positions on CDR policy, or is CDR a reason for cracks to form in existing discourse coalitions? Does the issue of CDR 'weld together' existing political alliances, or may it rather enable the formation of new discourse coalitions? These types of hypotheses will be critical to guiding future social science research on the political feasibility of CDR deployment, as well as on the political economy and distributional impacts of this relatively new facet of climate policy.

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CRediT authorship contribution statement

Miranda Boettcher: Conceptualization, Data curation, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Felix Schenuit:** Conceptualization, Data curation, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Oliver Geden:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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