BOUNDED POLICY RELEVANCE
KNOWLEDGE POLITICS OF THE IPCC SPECIAL REPORT ON 1.5 °C AND CARBON DIOXIDE REMOVAL

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“If this is your 1648, you will need to do more
than nudge the managerial class to wise leadership —
or protest the powers that be.

To rethink and remake the world will require
a thousand struggles on the plains where
knowledge and power are forged and parcelled out.

Perhaps I will see you there.”

David Kennedy
A World of Struggle – 2018

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Berlin, im November 2022

Felix Schenuit

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- Schenuit, Felix (2023). Staging Science: Dramaturgical Politics of the IPCC's Special Report on 1.5 °C. *Environmental Science and Policy*, 139: 166–167. https://doi.org/10.1016/j.envsci.2022.10.014.

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- Schenuit, Felix, Rebecca Colvin, Mathias Fridahl, Barry McMullin, Andy Reisinger, Daniel L. Sanchez, Stephen M. Smith, Asbjorn Torvanger, Anita Wreford, and Oliver Geden. 2021. "Carbon Dioxide Removal Policy in the Making: Assessing Developments in 9 OECD Cases." *Frontiers in Climate* 3: 1–22. https://doi.org/10.3389/fclim.2021.638805.

- Schenuit, Felix, Elina Brutschin, Fei Guo, Aniruddh Mohan, Ana Carolina Oliveira Fiorini, Sonakshi Saluja, Roberto Schaeffer, Oliver Geden, and Keywan Riahi (*manuscript*): Taking Stock of CDR Governance in Brazil, China, and India

- Schenuit, Felix, and Oliver Geden (*in press*). Carbon Dioxide Removal: Climbing Up the EU Climate Policy Agenda. In: Rayner, Tim, Szulecki, Kacper, Jordan, Andrew and Oberthür, Sebastian. *Handbook on European Union Climate Change Policy and Politics*. Edward Elgar Publishing Ltd.

Summary

This thesis explores the research question of how – through which mechanisms, strategies, and struggles – the expertise of the Intergovernmental Panel on Climate Change (IPCC) becomes policy relevant. To answer this question, it combines approaches from science and technology studies and those from political science. Using novel analytical frameworks of dramaturgical policy analysis and comparative case studies, the thesis examines policy relevance in practice. In particular, the IPCC's Special Report on Global Warming of 1.5 °C and the issue of carbon dioxide removal (CDR) are examined in depth. Both the report and the issue of CDR have received considerable attention in the aftermath of the Paris Agreement and are therefore relevant case studies to examine the policy relevance of the IPCC. The thesis shows that the IPCC's expertise, the focal point of climate science-policy-politics interfaces, is mobilized for different, sometimes contradictory, political purposes. A variety of different expectations are placed on the IPCC, creating tensions within the organization. The case studies of CDR governance and policymaking in 12 countries show that IPCC knowledge plays a very different role in national climate policy, depending on the previous state of CDR policy and socio-political contextual factors. The thesis concludes that the policy relevance of the IPCC is always bounded by the socio-political context and the agency of actors – its expertise is not policy relevant per se, but must be made policy relevant. Since these processes are highly context-dependent, the following three questions should be answered when claiming and studying policy relevance: policy relevance of what, by whom and for what reasons, and where.

Zusammenfassung

Diese Arbeit geht der Forschungsfrage nach, wie – durch welche Mechanismen, Strategien und Auseinandersetzungen – die Expertise des Intergovernmental Panel on Climate Change (IPCC) politikrelevant wird. Um diese Frage zu beantworten, werden Ansätze aus den Science- and Technology Studies mit Ansätzen aus der Politikwissenschaft kombiniert. Durch Analyserahmen aus dramaturgischer Politikanalyse und vergleichenden Fallstudien können empirische Erkenntnisse gewonnen und die Politikrelevanz in der Praxis untersucht werden. Insbesondere der Sonderbericht des IPCC über die globale Erwärmung von 1,5°C und die Frage der CO_2-Entnahme werden eingehend untersucht. Sowohl der Bericht als auch das Thema CO_2-Entnahme erhielten im Anschluss an das Pariser Abkommen große Aufmerksamkeit und sind daher relevante Fallstudien, um die politische Bedeutung des IPCC zu untersuchen. Die Arbeit zeigt, dass die Expertise des IPCC an der Schnittstelle zwischen Wissenschaft und Politik für verschiedene, zum Teil widersprüchliche politische Zwecke mobilisiert wird. Eine Vielzahl unterschiedlicher Erwartungen wird an den IPCC gerichtet, was zu Spannungen innerhalb der Organisation führt. Darüber hinaus zeigen die Fallstudien zur CO_2-Entnahme-Governance und -Politik in 12 Ländern, dass das Wissen des IPCC in der nationalen Klimapolitik eine sehr unterschiedliche Rolle spielt, je nach vorherigem Stand der CO_2-Entnahme-Politik und den sozio-politischen Kontextfaktoren. Die Arbeit kommt zu dem Schluss, dass die politische Relevanz des IPCC immer durch soziopolitische Faktoren und Agency von Akteuren eingeschränkt ist – seine Expertise und Berichte sind nicht per se politisch relevant, sondern müssen politisch relevant gemacht werden. Diese Prozesse sind stark kontextabhängig, weshalb die folgenden drei Fragen beantwortet werden sollten, wenn politische Relevanz für wissenschaftliche Expertise beansprucht oder untersucht wird: Was genau ist politisch relevant, von wem geht sie mit welcher Motivation aus und wo ist sie zu beobachten.

1 Introduction

It has continuously been contested in global and national politics whether and how climate change is perceived as a political issue and what possible strategies and policies should be used to address it (Hulme, 2009; Rayner and Malone, 1998; Weingart et al., 2000). Since the preparations for multilateral climate governance under the United Nations Framework Convention for Climate Change (UNFCCC) in the late 1980s, the Intergovernmental Panel on Climate Change (IPCC) has been "instrumental in issuing warnings, setting agendas, and turning climate change from a scientific into a political problem" (Beck, 2012, p. 2) – and thus played a crucial role in identifying and describing climate change and its impacts (Dahan-Dalmedico, 2008; Jasanoff and Wynne, 1998; Vardy et al., 2017). As policy debates have gradually evolved from *whether* climate change should be tackled to *how* to tackle it, expectations towards the IPCC and its products have changed. While the IPCC was initially referred to as a resource of knowledge about the existence and seriousness of the climate change challenge (Hulme and Mahony, 2010), it has increasingly been faced with expectations to move towards more solution-oriented assessments (Edenhofer and Kowarsch, 2015; Jabbour and Flachsland, 2017; Schubert, 2021).

In preparation for and after agreeing on the Paris Agreement, the IPCC declared its intention to become more solution-oriented (Lee, 2015; Tollefson, 2015), provoking quite some attention in the scientific community (e.g., De Pryck and Wanneau, 2017; Hulme, 2016; Kowarsch et al., 2017). This new push towards solution orientation raised essential questions about the role of the IPCC and its formal mandate of providing "policy-relevant but not policy-prescriptive" assessments (IPCC, 2021a). Questions and struggles related to this mandate and its inherent ambiguity have been well researched already before the adoption of the Paris Agreement and accompanied the IPCC since its inception. There are two different strands of literature on the IPCC. One the one hand, Science and Technology (STS) scholars, as observers of the processes, have provided in-depth studies of IPCC's assessment practices and its role in science-policy interfaces.[1] One the other hand, researchers who have held senior positions in the IPCC shared their experiences and the trade-offs inscribed in the ambiguity of the mandate.[2] One facet of these debates that has received increasing attention in recent years will be highlighted in the following: the question whether IPCC assessments are perceived as *narrowing down* or *opening up* the solution space.

[1] See e.g., Agrawala, 1998; Beck and Mahony, 2018; Beck and Oomen, 2021; Grundmann and Rödder, 2019; Hermansen et al., 2021; Livingston and Rummukainen, 2020; Miller, 2004; Pryck and Hulme, 2022.

[2] See e.g., Edenhofer and Kowarsch, 2015; Edenhofer and Minx, 2014; Hulme et al., 2010; Schneider, 2009; Victor et al., 2014.

Solution orientation: Opening up or narrowing down?

There are two different views regarding the IPCC's new solution-orientation and how it translates (or should translate) into assessment production and the IPCC's role in climate policy-making. From one vantage point the IPCC is meant to work and understand itself as a "mapmaker" of the solution space (Edenhofer and Kowarsch, 2015). This understanding already guided the contribution of Working Group 3 on Mitigation during IPCC's fifth assessment cycle (AR5) in which the IPCC aimed at providing a "comprehensive exploration of the solution space in the field of climate change mitigation" (IPCC, 2014a, p. IX). In this view, the IPCC explores the solution space and provides the maps for navigators (i.e., policymakers) and therefore facilitates an *opening up* of the decision-making processes and debates on solutions to address climate change (see e.g., Edenhofer, 2012).

On the other hand, scholars from STS have highlighted the IPCC's increasing importance as a "player in making futures – not just forecasting them" (Beck and Mahony, 2017, p. 313). By pointing to the performative power of the IPCC, they highlight the IPCC's practices of *narrowing down* the solution space by acting as a "corridor maker" (Beck and Oomen, 2021). This strand of the literature particularly problematizes the importance of the role of Integrated Assessment Models (IAM) in IPCC assessment processes and products with their overly optimistic assumptions regarding novel technologies, such as carbon dioxide removal (CDR). Scholars criticize the reliance on these technologies for "pre-empt[ing] political consideration of alternative futures" (Beck and Oomen, 2021)[3].

Both conceptualizations of IPCC's turn towards a solution-oriented approach – opening up and narrowing down – are important contributions to the debate of what role the IPCC has in climate governance and policy. They raise crucial questions about science-policy-politics interfaces, especially about IPCC's fidelity to its mandate of providing policy-relevant but not policy-prescriptive assessments. However, most studies that address the role of the IPCC in the new climate regime address it at a conceptual level or examine it empirically within the IPCC processes. In this thesis, I argue that this research should be complemented by empirical studies that systematically examine *whether* and *where* the IPCC becomes policy-relevant in actual processes of collectively binding decision-making in order to understand whether it has an *opening up* or *narrowing down* effect. To do so, this thesis aims to bring together STS research with approaches from political sciences.

[3] See also, Beck and Mahony, 2018; Dooley et al., 2021; McLaren and Markusson, 2020.

Studying policy relevance in practice

In addition to the need for more of empirical studies mentioned above, there are two conceptual arguments that support turning towards studying policy relevance in practice.

Hermansen et al. (2021), who describe IPCC's policy relevance as being "relational" and based on practices of "relevance-making," argue that the specific political context matters in these relational processes and show differences across political levels. Their analysis shows that policy relevance cannot be generated within the IPCC processes, but is embedded in specific political contexts and arises indirectly, i.e., "created through processes involving many actors, institutions, and types of knowledge." (p. 6). This call for contextualization of IPCC's policy relevance fits well Mahony and Hulme's (2018) notion of "epistemic geographies" of IPCC expertise. They highlight the "uneven geographies of scientific authority" (p. 396) by pointing out that "'global' knowledge has distinctive geographies, shaped by histories of exploration and colonialism, by diverse epistemic and material cultures of knowledge-making, and by the often messy processes of linking scientific knowledge to decision-making within different polities." (p. 395). Building on Jasanoff's notion of "civic epistemologies" (Jasanoff, 2005), Mahony and Hulme consider different political contexts as an important element of understanding the distribution of the IPCC's scientific authority and postulate more generally that a "geographic sensitivity can enrich our understanding of the climate knowledge politics" (p. 396).

Building on these perspectives on policy relevance and IPCC's knowledge politics, which will be introduced in more detail in section 2.1, this thesis studies different modes of relevance-making in actual processes of collectively binding decision-making in varying contexts. It aims to find answers to the following research question:

> How – through which mechanisms, strategies, and struggles – does IPCC expertise become policy-relevant in climate policymaking processes?

Strategies, mechanisms, and struggles – studying different modes of relevance-making

Before presenting the cases that will be empirically examined, it is important to introduce the key terminology used in this research question. First, on policy relevance: The term is often used without a specific definition, usually implying that knowledge could potentially be relevant for policy makers. Here, I would like to provide a more detailed definition and use the term policy relevance in a way that takes public policy and governance processes, and the

politics therein, seriously: Thus, IPCC products and expertise are considered policy relevant if: 1) their publication is embedded in policy processes, 2) legislative outcomes refer to them, 3) they are mobilized to put particular issues or framings on the policy agenda, 4) they are used to lend legitimacy to particular policy positions, or 5) they are the subject of political contestation.

Furthermore, the three terms *mechanisms*, *strategies*, and *struggles* are used in the research question as umbrella terms for different modes of relevance-making. They have been identified in different strands of the existing literature on science-policy-politics interfaces from STS literature and will be introduced in detail in the chapter 2. Briefly summarized, *mechanisms* describe more institutionalized interactions between the IPCC and public policy and governance processes at different levels and during the assessment, production and approval, as well as after the publication (see e.g., Dahan-Dalmedico, 2008; Livingston and Rummukainen, 2020). *Strategies* refer to deliberate efforts to mobilize IPCC expertise to (un-)substantiate or (de-)legitimize a specific policy position (see e.g., Dooley and Gupta, 2017; Littoz-Monnet, 2017). *Struggles* encompass contestations over IPCC expertise in public policy and reflect that these are part of broader political contexts (Aykut et al., 2019; Hughes, 2015; Kennedy, 2018). It is important to note that this is a conceptual differentiation and that no clear-cut distinction exists in the real world. However, introducing the differentiation in the overarching question helps exploring the relational character, the agency of different actors at science-policy-politics interfaces, and how IPCC's policy relevance is contextually bounded (see chapter 2 for details). To provide empirical analyses of these three modes and contextualize policy relevance, this thesis combines conceptual insights from STS with first, dramaturgical policy analysis to explore the IPCC's role in the context of the UNFCCC and second, comparative case studies in different countries. Why and how these two approaches have been identified will be introduced in chapter 2 on conceptual background of the thesis.

Contextualising IPCC's policy relevance of course requires a clear research subject – it cannot be studied for the IPCC as such. This thesis explores in detail the IPCC Special Report on 1.5 °C of Global Warming (SR15) as the first IPCC publication after the adoption of the Paris Agreement published in 2018. Second, it examines in a comparative research design how the issue of carbon dioxide removal (CDR) policymaking in governance in different countries has been influenced by the publication of the report. The selection of these two research subjects and related research sub-questions will be introduced in the following.

The Special Report on 1.5 °C

Since the adoption of the Paris Agreement in 2015, UN climate governance has been in transition (Jordan et al., 2018) and faced several institutional uncertainties, such as the with-

drawal of the United States (van Asselt and Zelli, 2018) and the failure to deliver Nationally Determined Contributions (NDCs) on time by 2020 (Röser et al., 2020), among others. In this transitional phase, the IPCC's SR15 report, released in 2018, is seen as an important resource that brought new momentum to climate policy and politics in 2019 (Boykoff and Pearman, 2019). It is thus a relevant case study for investigating the policy relevance of the IPCC post-Paris. Existing research on science-policy-politics interfaces related to the first special report on a genuinely political target provides in-depth analyses of the report's knowledge politics (Guillemot, 2017; Livingston and Rummukainen, 2020; van Beek et al., 2022).

However, the existing research primarily focuses on IPCC-internal processes, procedural interactions between IPCC and UNFCCC, or conceptual aspects. Examples of studies that focus on the strategic political mobilization of the report or empirical studies in different political contexts are scarce (for an exemption, see Hermansen et al. 2021). One set of contributions to this thesis, therefore, aims at examining mechanisms, strategies, and struggles different actors have applied in the context of knowledge production and validation processes of SR15 to mobilize SR15 strategically. This first pillar of the thesis investigates the following research sub-question:

> How have SR15 and related knowledge production and validation processes been strategically mobilized and contested in climate science, policy, and politics?

Since the IPCC reports cover numerous issues, each with its knowledge politics, this first pillar is complemented by a second strand of research focusing on one specific issue.

Carbon Dioxide Removal: A new tool in the mitigation toolbox?

Since the Paris Agreement's adoption, the issue of CDR[4] has received rapidly growing attention in climate science and policymaking (Fuss et al., 2020). There are two main reasons why the deliberate removal of CO_2 from the atmosphere through ecosystem-based or geochemical-based methods[5] is a relevant case to examine SR15-related knowledge politics.

[4] This thesis works with the IPCC definition, which according to the IPCC SR15 (IPCC, 2018a) and the recent AR6 Working Group 3 report (IPCC, 2022) reads as: "Anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage, but excludes natural CO_2 uptake not directly caused by human activities." The definitional politics inscribed in this definition will be addressed in section 2.3).

[5] For a detailed discussion of different categories of CDR methods and terminology, see chapter 4.

First, it is usually perceived as a comparatively new issue on the agenda of scientists and policymakers. The issue of large-scale CDR, included methods based on carbon capture and storage (CCS) diffused from small expert circles to broader climate community (Tavoni and Socolow, 2013) in the aftermath of IPCC's 5th Assessment Report published in 2014. After the scenarios in the published AR5 included large amounts of bioenergy plus carbon capture and storage (BECCS), the associated land requirements and assumptions about the large-scale use of this CDR method generated strong criticism in the scientific community (Anderson and Peters, 2016; Fuss et al., 2014; Geden, 2015). Since then, however, the rise of net-zero targets facilitated growing attention for CDR from policymakers, businesses, and science. CDR is now often seen as one tool of the mitigation toolbox to achieve the net-zero target (Rogelj et al., 2021).

Secondly, this reliance on CDR in the models and the growing attention in policy circles stimulated an increasing amount of social science research on the anticipatory politics related to these technologies (Beck and Mahony, 2018; Low and Schäfer, 2020) the bias towards technological promises (McLaren and Markusson, 2020) and calibrating processes between IAMs and climate policy (van Beek et al., 2022). Throughout the rapid career of CDR, scholars have warned about the moral hazard associated with CDR. They have argued that the promise of future deployment of yet unproven technologies risks the deterrence or obstruction of emission reduction efforts (Anderson and Peters, 2016; McLaren et al., 2019; Morrow, 2014) and other sustainability trade-offs are not taken into account properly (Dooley et al., 2021).

Given this rather new, contentious debate CDR qualifies as a relevant case for an empirical case study of how the SR15 was taken up in policy and governance. Exploring how CDR entered climate policy allows to trace how relevance-making through strategies, mechanisms, struggle unfolds in practice. The following research sub-question guided the research of the second pillar of the thesis.

> What are patterns of CDR governance and policymaking, and what role did IPCC's SR15 have in domestic climate policymaking?

Before chapter 2 provides more details on the conceptual background and the research design, the following section provides a very short overview of the six chapters (see also Figure 1.1). More details of what each chapter contributes to answer the research questions will be provided in chapter 4 and the discussion and conclusion chapter 11.

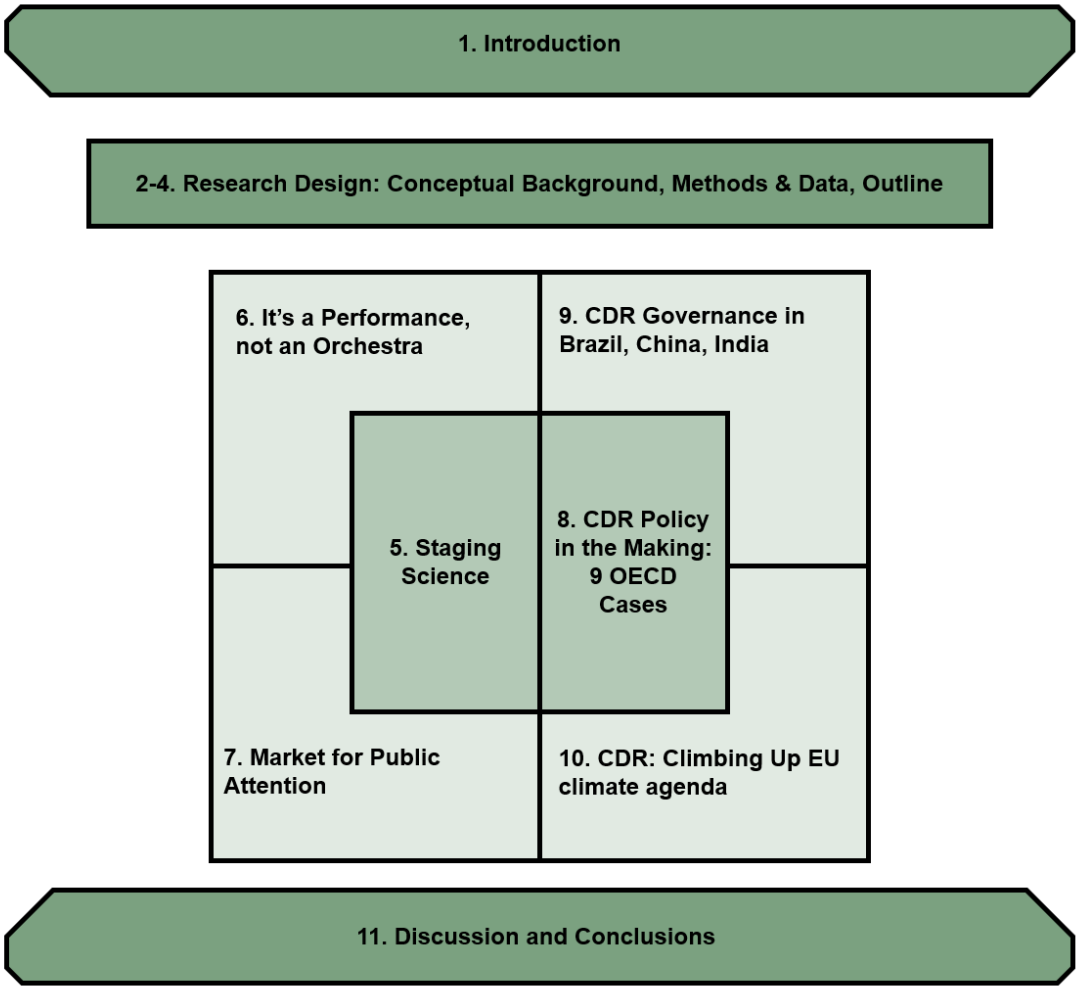
Outline and Structure

This cumulative dissertation consists of six stand-alone publications (chapters 5-10) conducted to provide answers to the research questions identified above. They are divided into two pillars, the first focusing on SR15 knowledge politics in climate science and UN climate governance (chapters 5, 6, 7). These contributions show that the SR15 is strategically mobilized for different political purposes (chapter 5) in the context of the new importance of soft modes of coordination in UN climate governance (chapter 6). Furthermore, chapter 7 shows that social practices and biased incentive structures within science must also be considered when studying science-policy-politics interfaces and relevance-making.

The second pillar explores developments in CDR governance and policymaking on the ground. Based on comparative case studies from 11 countries and the supranational EU, the chapters examine how CDR policy evolved since the adoption of the Paris Agreement and the role the SR15 has played in the national debates (chapters 8, 9, 10). In addition to 9 OECD cases (Australia, European Union, Germany, Ireland, Sweden, New Zealand, Norway, the United Kingdom, and the United States, chapter 8), three emerging economies (Brazil, China, and India in chapter 9) have been studied in cooperation with country experts. Chapter 10 provides a deep dive into the EU's CDR policymaking.

Each pillar builds on a core article that develops a novel analytical framework (chapters 5 and 8). Furthermore, two complementary chapters apply or develop the new analytical framework further (chapters 6 and 9) or provide a deeper insight into a more specific topic relevant to answering the research questions (chapters 7 and 10). The remainder of this framing chapter presents the conceptual background and approach of the thesis (chapter 2), the methods and data used in the different s (chapter 3), and a detailed overview of the publications and their contribution to answering the research questions (chapter 4). Finally, the discussion and conclusion chapter (11) will synthesize the findings, link them back to the overarching research questions and situate them in the ongoing debate on knowledge politics and CDR governance.

Figure 1.1: Overall structure of the thesis and overview of contributions



2 Conceptual approach

The introduction already referred to the aim of bringing together two different strands of social science literature – science and technology studies and political science – to examine the IPCC's policy relevance in practice. This chapter presents the conceptual approaches and background on which this work is built and discusses how different concepts are operationalized as analytical frameworks for empirical analyses.

In the first step, a brief overview of existing work on the policy relevance of the IPCC is provided (2.1). Subsequently, the three modes of relevance-making (mechanisms, strategies, struggles) will be briefly introduced (2.1.1 - 2.1.3), and considerations on "bounded policy relevance" are presented (2.1.4). Sections 2.2 and 2.3 introduce the conceptual approach and background to answering the two research sub-questions. These sections include background information on the two research objects, SR15 and CDR, and the presentation of the analytical frameworks developed for the two pillars of the thesis.

2.1 Studying IPCC's policy relevance in practice

Within the growing body of STS research, particular attention has been paid to the knowledge politics of the IPCC, a first-of-its-kind intergovernmental assessment body and a boundary organization established in the late 1980s. Since establishing the IPCC in 1988 and the UNFCCC in 1992, scholars have observed strong linkages between climate science and climate diplomacy under the UNFCCC (Beck and Mahony, 2018; Dahan-Dalmedico, 2008; Jasanoff and Wynne, 1998).[6] Instructive in-depth case studies of the IPCC have identified patterns of knowledge production and validation as well as insights on inscribed politics and provided valuable insights on the IPCC's challenge to provide policy-relevant but not policy-prescriptive assessment reports.[7] Since 2015, the IPCC has been affected by the transition of the international climate regime, and changes in organizational processes and assessment practices are taking place (Hermansen et al., 2021; Livingston and Rummukainen, 2020; van Beek et al., 2022). As outlined in the introduction, the shift towards solution-oriented assessments raises new questions about the IPCC's role in a hybrid climate regime, where more attention is directed to national and sectoral climate policymaking (Beck et al., 2022; De Pryck and Wanneau, 2017; Jabbour and Flachsland, 2017; Tollefson, 2015).

Since the adoption of the Paris Agreement, the analyses of "performativity" or "world-making" power of the IPCC, i.e., the power of "IPCC assessments to shape fields of political possibility—to put certain policy options on the table, while potentially obscuring others" (Beck and

[6] See de Pryck and Hulme eds. (2022) for a comprehensive and up-to-date summary of existing research.

[7] See e.g., Grundmann and Rödder, 2019; Gustafsson and Lidskog, 2018; Lahn, 2020; Lahn and Sundqvist, 2017; Mahony, 2013a; Miller, 2001.

Mahony, 2018, p. 2), gained traction in STS scholarship on the IPCC. Questions of how anticipation, prediction, and forecast shape governance and policymaking have been a prominent subject of STS in general (Aykut et al., 2019; Nelson et al., 2008; Oomen et al., 2021). Scholars argue that anticipatory expertise "has become an indispensable core ingredient of contemporary attempts to govern complex problems" (Aykut et al., 2019). In the IPCC-related research on this topic – as already shown above – the critical role of the IAMs in the assessment report has been traced, debated and problematized in this context (see e.g., Beck and Mahony, 2018; Cointe et al., 2019; McLaren and Markusson, 2020; van Beek et al., 2022). This call for critical reflection on the "anticipatory politics" inscribed in IPCC assessment processes and IPCC-relevant strands of climate science has been specifically linked to the importance of carbon removals (see also, Carton et al., 2020; Dooley and Gupta, 2017).

However, the critique of the IPCC and IAM's world-making power is usually either articulated at the conceptual level or focuses on the IPCC's assessment and knowledge production processes. While these insights are essential to make sense of recent developments and question power structures inscribed within the IPCC, empirical studies on the performativity of specific policymaking processes are scarce. This thesis, therefore, aims to show that empirical case studies of how IPCC knowledge affects actual processes of collectively binding decision-making are important complementary research. Studying these developments empirically helps understand whether this performative capacity plays out in climate policymaking and whether the IPCC has a narrowing down or opening up effect.

This turn towards studying policy relevance in different contexts builds on – as described above – two different strands of existing work. First, the work by Hermansen et al. (2021) in which policy relevance is conceptualized as a relational process and second, the work on "epistemic geographies" by Mahony and Hulme (2018) who also highlighted the embeddedness of IPCC's policy relevance into local contexts. Taken together, they can be read as a call for a greater focus on context specificity and the agency of different actors in the study of policymaking processes, something that this thesis seeks to reflect in its research design and its contributions.

To further operationalize this objective for empirical research, the following section elaborates on the three modes of relevance-making already mentioned in the introduction: *mechanisms*, *strategies*, and *struggles*. These will be briefly introduced by pointing to existing research on the IPCC and knowledge politics more generally.

2.1.1 Mechanisms: Procedural embeddedness and government engagement

Mechanisms of relevance-making describe institutionalized interlinkages and interfaces between the IPCC and its audiences. Especially the links between the IPCC and the UNFCCC and those with government representatives within IPCC processes are well studied, and two main aspect of this mode of relevance-making can be identified. First, attempts to make the IPCC relevant by embedding it in UNFCCC processes. The links between the two have always been close, especially with regard to Subsidiary Body for Scientific and Technological Advice (SBSTA), leading Dahan-Dalmedico (2008) to describe the relationship as "IPCC-SBSTA tandem." Since the adoption of the Paris Agreement, the IPCC is more embedded in the processes, notably through the SR15, but also through efforts to align future assessment cycles with upcoming Global Stocktake[8] processes (see Livingston and Rummukainen, 2020, see also chapter 3). This procedural embeddedness ensures that IPCC reports are considered in official negotiations and are thus dealt with by policymakers in national UNFCCC delegations.

The second type of mechanism described in the literature is relevance-making through engaging governments in IPCC processes (ranging from funding, over review process to the approval plenary, see e.g. De Pryck and Hulme, 2022). These processes have often been analysed through the lens of "co-production" and "boundary-work" (for reviews of research related to these two notions, see Bremer and Meisch, 2017 and Beck and Mahony, 2018). This engagement is one of the defining features of the intergovernmental body. It aims to engage national administrations with the content of the report and organize their "buy-in" through line-by-line endorsement, and is therefore a critical mechanism for the relevance of IPCC reports.

2.1.2 Strategies: Between mobilizing and ignorance

A second mode encompasses strategies of relevance-making. Strategies here refer to efforts of using the scientific authority attached to knowledge produced and validated by the IPCC to provide legitimacy for specific goals, solutions, or other policy positions. In the following, I highlight three different facets of these strategies. First, efforts of strategically mobilizing knowledge: Littoz-Monnet (2017) observed these practices in international bureaucracies like United Nations Educational, Scientific and Cultural Organization (UNESCO), which strategically mobilized expertise on bioethical standards to "give epistemic authority to their actions,

[8] Global Stocktake is key component of the new Paris regime which "facilitates the assessment of global collective progress on three thematic areas: mitigation, adaptation, means of implementation and support", https://unfccc.int/topics/global-stocktake#Background. It was preceded by an initial stocktake process, the Talanoa Dialogue in 2018. For details on how SR15 was aligned with this process, see Livingston and Rummukainen (2020).

endow their organization with the capacity to act, and depoliticize debates" (p. 585). Scholars identified similar practices in the context of climate governance and described efforts of "governing expertise" (Dooley and Gupta, 2017) in the context of accounting for land-based mitigation in the post-2020 climate agreement. These observations are in line with the warning that the often-claimed approach "evidence-based policymaking" can turn into "policy-based evidence making" (Geden, 2015; Strassheim and Kettunen, 2014).

The second facet concerns the strategic staging of existing scientific expertise and experts. Hilgartner (2000) emphasized that scientific experts are being put and performing on stage. He analysed scientific advice in the United States by applying Goffman's (1959) metaphors and shows that science experts are well aware that they are 'on stage' and act strategically in terms of their self-presentation. Hajer (2009) echoed this perspective when he developed a dramaturgical view of how authority is generated in governance processes. Livingston (2018) showed how this line of thinking and the terminology can be fruitfully applied to the IPCC to explore its role in multilateral climate governance.

Finally, a third facet covers a very different form of strategies. Rayner (2012) has shown that different strategies exist for how organizations deal with what he called "uncomfortable knowledge". Since the term policy relevance as defined in this thesis also covers the contestation of knowledge, the four strategies of "denial, dismissal, diversion, and displacement" are also crucial when studying policy relevance in practice. Also considering these types of strategies is particularly important in the context of SR15, which caused diplomatic turmoil after its publications (see chapter 5 for details).

2.1.3 Struggles: Expertise as a contested resource

The third mode of relevance-making identified in the literature concerns struggles and IPCC expertise as a contested resource in climate governance and policymaking. For this mode, three main facets have been identified. The first concerns struggles related to expertise as a resource. Fischer described expertise a "key resource for the governance of modern society" and that policymakers "seek out advice that supports their own policy choices and overlook counsel which does not" (1990, p. 28). With regard to the IPCC specifically, Geden (2015) formulated that "policy-makers view the IPCC reports mainly as a source of quotes with which to legitimize their preferences" (p. 28). Starting from a similar perspective on the selective use of knowledge and expertise by policymakers and stakeholders, Kennedy (2018) conceptualized science-policy-politics interfaces as struggles over legitimate expertise and pointed to the importance of competing interests at science-policy-politics interfaces.

A second facet of struggles as a mode of relevance-making concerns the embedding of expertise in broader political struggles between competing groups of actors (Aykut et al. 2019). This is to reflect that there may be motivations for contesting IPCC expertise that are not directly related to the IPCC and the product at hand, but are expressions of an approach to climate diplomacy more generally or other political rationales. This shows that relevance-making should always be explored in the broader political context where policymakers and stakeholders have to manage incommensurable expectations by stakeholders and several other political problems to deal with.

Finally, the third facet of struggles consists of the dialectic relationship between the politicization of science and the scientization of politics (Weingart, 1999). Previous struggles related to the IPCC, most prominently ClimateGate but also other incidents (Pryck and Hulme, 2022), clearly showed that risk of science losing credibility and politics losing legitimacy is real (Weingart et al., 2000, p. 280). Since the allegation of lack of credibility was part of the SR15 debate as well (Livingston and Rummukainen, 2020) and elevated to high-level political negotiations under UNFCCC, exploring this facet of relevance-making should also be considered.

2.1.4 Contextually bounded policy relevance

This short overview of relevance-making practices identified in the literature pointed to the importance of context-sensitivity of policy relevance (see Table 2.1 for an overview). In addition to socio-political contexts, the different modes also pointed to the importance of different actors. To reflect this embeddedness, the term of "bounded policy relevance"[9] will be used in this thesis to indicate that IPCC reports or expertise cannot be policy-relevant per se. Whether and how they become policy relevant depends on the context and agency of actors involved in making it relevant for public policy processes. Details on how these different modes played out in the context of SR15 and CDR will be discussed and summarized in chapter 11. The following sections provide an overview of the conceptual background for the two main pillars of this thesis and introduce the analytical tools applied to explore the research questions.

[9] Terminology inspired by Herbert Simon's "bounded rationality" (1957). For more details see chapter 11.

Table 2.1: Modes of relevance-making and different facets identified in the literature

Modes	Mechanisms	Strategies	Struggles
Types (identified in the literature)	through embeddedness in UNFCCC processes (e.g. Dahan-Dalmedico, 2008) engaging governments in IPCC process; boundary work (e.g. Beck 2012; Mahony 2013)	Mobilization of knowledge (Littoz-Monnet 2017) Putting science on stage for specific political purposes (Hilgartner 2000; Livingston 2018) Construction of ignorance (Rayner 2012)	Expertise as political contested resource (Fischer 1990; Kennedy 2018) One currency in a broader political environment (Aykut et al. 2019) Politicization of science and the scientization of politics (Weingart et al. 2000)

2.2 Climate governance post-Paris: Toward dramaturgical analysis

More than 30 years after the multilateral agreement establishing the UNFCCC, emissions are still rising (Friedlingstein et al., 2022). This is despite the fact that the new climate regime created by the Paris Agreement has unlocked the gridlock in climate negotiations (Keohane and Oppenheimer, 2016; Victor, 2011). In Paris, consensus was achieved through a new approach of combining bottom-up elements to promote flexibility and participation together with top-down elements to promote ambition and accountability (Depledge, 2022; Rajamani and Bodansky, 2019). New climate ambition pledges by numerous countries in the past years led to narrowing the “ambition gap” between declared targets and decarbonisation pathways consistent with the stringent climate targets agreed to in Paris. However, the “implementation gap” is still significant (IPCC, 2022). Major barriers prevent it from being closed, even in countries that perceive themselves and are perceived to be leading the way (Perino et al., 2022).

So far, neither the temperature target of “well below 2 °C above […] pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels” (Art. 2.1. a, Paris Agreement) nor the goal of “achieving a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century […]” (Art. 4.1, Paris Agreement) are plausible to achieve (Stammer et al., 2021). While the targets are still out of reach, it is important to note that the years of transition and implementation toward a new UN climate regime have had a significant impact on international and national climate policies and politics (Skjærseth et al., 2021). Furthermore, court decisions (Preston, 2021) and initiatives by sub-national actors, including businesses (Hale et al., 2021) have been instigated and shaped by the new climate regime.

Many academic studies have accompanied these developments in climate governance. To understand the broader political context of SR15 in the post-Paris climate regime, the following section summarizes two key strands of climate governance literature that have emerged

in recent years. Building on this, an analytical framework is presented that was applied in the first pillar of this thesis. The contribution to this first pillar will provide answers to both the research sub-question about strategic mobilization and the overarching research question on mechanisms, struggles, and strategies related to the IPCC's policy relevance.

2.2.1 The polycentric regime

Inspired by Elinor Ostrom's work on polycentric governance (2009), governance scholars taking a functionalist perspective on global collective action have described post-Paris governance as polycentric (Dorsch and Flachsland, 2017; Jordan et al., 2018) with the governance mode of orchestration playing a pivotal role (Abbott, 2018; Hale, 2016; Hale and Roger, 2014). The UNFCCC Secretariat is usually seen at the center of these orchestration efforts (Saerbeck et al., 2020), facilitating the "strategic ordering of polycentric governance" (Abbott 2018) through "chains of orchestration" (Abbott et al., 2015). Scholars have highlighted the "catalytic and facilitative model" (Hale 2016) on which climate governance under the Paris Agreement is based and have pointed to the importance of "norm cascade dynamics" and "'catalytic institutions' that work to shift actors' preferences and strategies toward cooperative outcomes over time" (Hale, 2020, p. 73).

However, critics have pointed to the limitations of collective action theory (Aklin and Mildenberger, 2020), and empirical contributions to this debate suggest that the high expectations of the impetus for actual climate action enabled by orchestration have not been met (Chan et al., 2022; Mai and Elsässer, 2022). Most of the criticism points to problems with what has been described the 'Achilles heel' of the climate regime: compliance (Bang et al., 2016). Critical questions are particularly pressing in the context of the politically controversial enhanced transparency framework, which is associated with the ratcheting-up design and accountability issues (Gupta and van Asselt, 2019; Weikmans et al., 2020).

Moreover, scholars have pointed out that studying climate governance from a polycentric perspective does not typically interrogate and examine the "black box of power" (Morrison et al., 2017) inscribed in these processes. As a response to this knowledge gap in polycentrism research, scholars identified three distinct types of power that are important in these contexts and should be further explored in the future: (i) power by design, (ii) pragmatic power, and (iii) framing power (Morrison et al., 2019)[10]. Putting more emphasis on these power dynamics is particularly relevant in the ongoing implementation phase of the Paris regime, in which they "influence not only the emergence and design of polycentric governance structures but

[10] Morrison et al. describe *power by design* can be used to "design rules and incentives across centers of authority"; *pragmatic power* to "interpret and implement rules across centers of authority"; and *framing power* to "frame problems, set norms and influence discourse across centers of authority" (p. 4).

also decisions about policy choices and the way policy outcomes are assessed within those structures" (Morrison et al. 2019, p. 5).

Despite these limitations, the functionalist perspective on UNFCCC climate governance is valuable for examining how particular organizations, processes, and specific issues – in this thesis, specifically SR15 – are formally embedded in the governance structures of the new regime. Tracing this embeddedness can also be informative in identifying procedural path dependencies in negotiation tracks and alliances of actors pushing for particular issues or new forms of cooperation. However, to examine the knowledge politics and other power structures around the SR15 and to explore how strategic mobilization unfolded and affected the IPCC as an organization, the following second perspective offers a different crucial angle on post-Paris climate governance.

2.2.2 The performative regime

Since the adoption of the Paris Agreement, global climate governance scholarship from a constructivist perspective has gained traction. By focusing on the discursive and symbolic elements of climate governance, this perspective aims at studying soft modes of coordination in climate governance by focusing on communicative techniques, performances, signals, and discursive elements of "incantatory governance" in a "performative regime" (Aykut et al., 2021; Foyer et al., 2017). This work builds on previous efforts of highlighting the discursive and symbolic elements of climate governance. For example, Death (2011) and Little (1995) have provided an insightful analysis of the earlier discursive elements and dramaturgy of climate negotiations. However, the new character of the post-Paris regime gives new importance to the discursive and symbolic aspects of climate governance under the UNFCCC (Aykut et al. 2021).

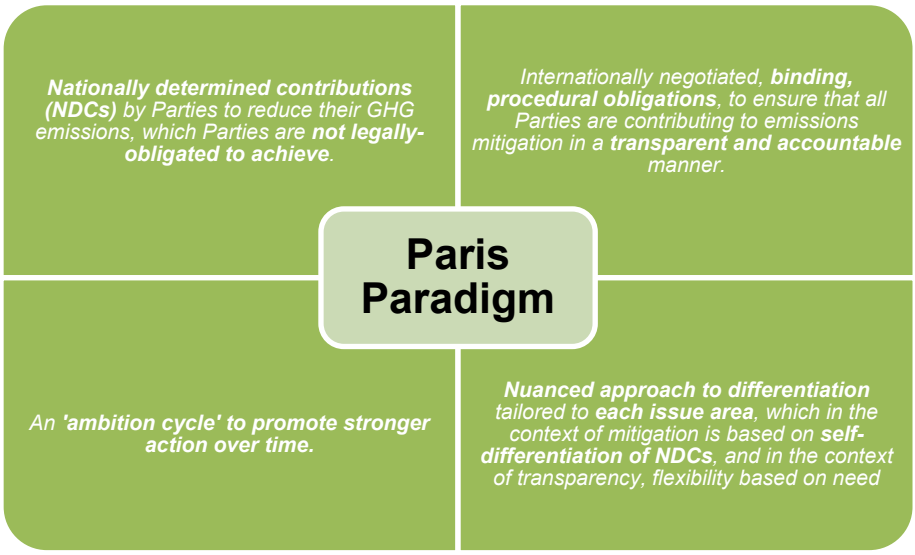
This new importance is particularly evident if one looks at the main characteristics of the Paris regime. Rajamani and Bodansky (2019) provide an instructive analysis of the key elements of climate governance of the Paris regime. They describe the "Paris Paradigm" with four essential requirements and processes that were established in Paris to govern and balance the main issues of UN climate governance "that never die" (Bodansky and Rajamani, 2018) and caused substantial political struggles in the past.[11] Figure 1 summarizes these four critical elements of the Paris Paradigm. All four elements point to national discretion carefully paired with accountability and reporting infrastructure that aims to build trust among partners. However, Rajamani and Bodansky (2019) also note in their analysis that: "Together, these re-

[11] They identify the following three issues: "(1) How legally binding should the United Nations (UN) climate change regime be? (2) How prescriptive should the UN climate change regime be, and how much should it leave to national discretion? (3) To what extent should the rules of the UN climate change regime be common or differentiated" (Bodansky and Rajamani, 2018, p. 184).

quirements and processes are intended to generate the pressure and momentum necessary to scale up ambition over time" (p. 1026). This new importance for momentum to scale ambition over times highlights increasing importance of practices behind maintaining momentum – a fact also confirmed by senior negotiators of the Agreement (Ourbak, 2017; Ourbak and Tubiana, 2017).

This argument on the new importance for momentum is in line with a new characteristic of global climate governance described as "incantatory governance" (Aykut et al., 2021). Scholars describe this development as a "performative turn" in global climate governance that establishes a new approach to global governance to "aligning actors' expectations on the prospect of a low-carbon future" through "'soft law' approaches and communicative techniques" (Aykut et al., 2021, p. 519).

Figure 2.1: Overview of key building blocks of the "Paris Paradigm"



Based on: Rajamani and Bodansky, 2019, p. 1025 (emphasis added)

The first pillar of this thesis aims to empirically analyse the new incantatory governance by focusing on symbolic and discursive practices and the strategic mobilization of SR15. This perspective is particularly relevant in a political environment where COPs have become mega-events accompanied by significant public relations efforts (Obergassel et al., 2022), e.g., in the context of often ambiguous net-zero commitments by countries and non-state actors (Fankhauser et al., 2022). It allows examining how and by whom discursive "moments" and "signals" are generated within the hybrid governance approach, offering a more

nuanced view of global climate governance after Paris and – as I will show in the next section – an analysis of dramaturgical politics of IPCC's SR15.

2.2.3 Towards an analytical framework for dramaturgical analysis

To explore the research question of how SR15 and related knowledge production and validation processes have been strategically mobilized in the context of post-Paris climate governance, an analytical framework for dramaturgical policy analysis was developed. It reflects the critical insights from research on Paris Agreement as a performative agreement and builds on and further develops existing work on a dramaturgical perspective on "authoritative governance" (Hajer, 2009). According to Hajer, studying governance from a dramaturgical perspective adds a relevant dimension to existing approaches of discourse analysis: "Whereas discourse analysis analyses the dynamics of what people say, the dramaturgy of politics analyses how they say it, where they say it, and to whom" (p. 65). Attempting to overcome the "rationalist bias" (p. 75) in policy studies, it conceptualizes politics as "a sequence of staged events in which actors interact over the meaning of events and over how to move on" (p. 66).[12]

Since one objective of the thesis is to better understand how, where, and by whom the SR15 was brought to the stage, the analytical framework takes Hajer's work as a starting point. It proposes to operationalize it for empirical case studies further. To conduct such empirical analysis, this thesis builds on the notions of *scripting, staging, performance,* and *settings* which have been modified and arranged in an analytical framework for the stand-alone articles in chapters 5 and 6.[13] Detailed definitions and descriptions of how this approach was applied will be provided in these chapters.

In this framing chapter I would like to highlight one added value of this perspective and raise limits of the approach. While the framework enables to study the politics inscribed in efforts the generate signals and momentum, it can also be seen as an attempt to avoid the rationalist bias often inscribed in policy studies and governance research (Morrison et al., 2017;

[12] It is important to note that this perspective does not use the metaphor of staging to suggest that it would be about fakes or simple public relations strategies. On the contrary, it aims to take the symbolic and dramaturgical facets of processes of authoritative governance seriously as a key element of authoritative governance. There is a long tradition in sociology of focusing on the performance and dramaturgy of social interactions more generally (Benford and Hunt, 1992; Burke, 1969; Goffman, 1959). Also scholars from political science and anthropology developed and applied perspectives that focus on the performance and dramaturgical dimension of politics (Edelman, 1985) and social movements (e.g., Chaffee, 1993; Miles, 1989). More generally, this argument of taking the performance dimension serious is in line with the observation of political sociologists that the production of public policy processes, collectively binding decisions, and governance structures are inextricably linked to their performance (Luhmann, 2000).

[13] It was initially developed for chapter 3 and later also applied in chapter 4. Given the broader focus of that article and the joint research, the research design slightly differs. The general idea of studying dramaturgical politics, however, is the same (for details on the differences, see chapters 3 and 4).

Wesselink et al., 2013). It helps to study a facet of power struggles inscribed in the new regime that cannot be addressed through the functionalist climate governance perspective mentioned earlier.

At the same time, this perspective has several limitations that should be addressed openly. First, dramaturgical policy analysis cannot replace but only complement an in-depth study of formal governance structures and processes. Since the sequences analysed by dramaturgical analysis are always only a small part of a broader policy context, the analysis of procedures, policy initiatives, and new collaborations between new alliances is key to embedding the observations that this perspective can contribute. Second, the empirical material poses a key challenge: For the research conducted here, it was crucial to "be there" at the COPs and observe first-hand how the dramaturgies unfolded. While the strategy of collective ethnography and participant observation (see chapter 3 for details on methods) worked well in this study, access is of course limited as the researcher cannot access all negotiations and processes (the IPCC sessions being a prime example, see Mahony, 2013). It is therefore vital to bear in mind that only a limited number of public performances can be studied and actors may have a portfolio of strategies in different settings and also choose other performance patterns on stages that are not observed.

In the next section, I turn to the second pillar of the thesis and provide details on the conceptual considerations and methodology behind the comparative case studies on CDR governance and policymaking.

2.3 Tracing policy relevance: Comparative case studies on CDR policymaking and governance

The second pillar of this thesis aims to provide case studies on CDR policy and governance to investigate the role SR15 played in the relevant processes empirically. This section presents three overarching conceptual considerations for this approach. First, the conceptual background in the political science literature for studying of climate governance and policymaking on the ground. Second, it specifies what exactly CDR means, provides background information on the definitional politics of the term, and embeds the topic in the longer developments of climate governance by highlighting the main continuities and discontinuities in the CDR debate. Finally, this section briefly presents the analytical framework developed building on the socio-technical transition literature and the emerging CDR governance literature to examine CDR policy and governance in a comparative case study design. Together this conceptual background forms the basis for the analysis of the second research sub-question:

what are the patterns of CDR governance and policymaking, and what role did the publication of SR15 play in the national debates and decision-making?

2.3.1 The detached regime: Studying climate policy and politics on the ground

While the previous section highlighted the polycentric and performative character of the new regime, a third perspective on the new regime emerged in the wake of the Paris Agreement. Political scientists have highlighted that national and sectoral climate policies and politics are gaining importance (Aklin and Mildenberger, 2020; Oberthür et al., 2021; Victor et al., 2019). Rather than highlighting new forms of cooperation and participation (polycentric) and the importance of signals and momentum (performative) facets of UNFCCC climate governance, this strand of the literature seeks to focus on, among others, distributive effects (Mildenberger, 2020), strategic state capacity (Meckling and Nahm, 2021), experimentalist governance (Sabel and Victor, 2022) in sectors and countries. Following this strand of literature, one could argue that the Paris Agreement is rather a “detached regime” and conclude that national case studies are needed to understand how specific issues (do not) progress. In the following, a brief introduction to the detached characteristics of the Paris regime is provided.

After the failure of the Copenhagen COP in 2009, the negotiations' focus and climate governance scholarship shifted to various forms of cooperation and strategies to improve climate action “beyond the UNFCCC” (Moncel and van Asselt, 2012). Although there was agreement on the diagnosis of “gridlock” (Victor 2011), the literature proved fragmented (Aykut, 2016). During the transition and implementation phase of the new regime it became clear that current governance structures of the Paris Agreement may not be adequate to facilitate rapid emissions reductions (Allan, 2019). Since then, the focus shifted from the multilateral UNFCCC processes to "undiplomatic action" (Victor and Jones, 2018) in sectors and smaller alliances of countries as enablers for transformation toward deep decarbonisation. Victor and Jones propose the notion of “episodic multilateralism” to capture the importance of the momentum created in 2015 by the adoption of the Paris Agreement and the challenge of facilitating and sustaining cooperation by focusing on niche developments, innovations, and small groups that can drive action (p. 3). This perspective of not focusing solely on the Paris Agreement is also reflected in new efforts to explore new ambitions in different economic sectors (Oberthür et al. 2021), explore ideas for an additional international agreement on fossil fuel production (van Asselt and Newell, 2022), and renewed efforts to align climate and trade policies (Jakob et al., 2022; Mehling et al., 2022), among others.

In addition, a rapidly growing strand of literature on climate governance calls for contextualizing the commitments, strategies, and policy initiatives of different actors by examining the multidimensional and diverse political economy challenges. Aklin and Mildenberger (2020) criticize the idea of free-riding as the main feature of global climate politics: They show that

free-riding does not necessarily hinder climate action and instead emphasize the importance of economic winners and losers as the main obstacle and call for a better understanding of these struggles in national and sectoral contexts. This perspective on winners and losers is also a key component of the concept of strategic state capacity proposed by Meckling and Nahms (2021), which focuses the analysis on the state's ability to use various strategies to overcome vested interests hindering ambitious climate action. This perspective fits well with recent efforts to identify commonalities and differences in climate policy across countries (Boasson et al., 2022), which empirically underscore the importance for a contextualized perspective on low-carbon transitions that take into account techno-economic, socio-technical, and political perspectives (Cherp et al., 2018). These perspectives have in common that they highlight the importance of a bottom-up perspective in examining the conditions for low-carbon transitions and that the local contexts are crucial to exploring the politics of the transition to deep decarbonization.

Studying the overarching question of how IPCC knowledge becomes policy-relevant when it comes to CDR thus requires taking a bottom-up perspective and studying patterns of CDR policymaking and governance on the ground. Before section 2.3.2 presents the analytical framework applied in this thesis to conduct comparative case studies, the following section provides a clarification of both what is being covered by the term “carbon dioxide removal” and reconstructs the continuities and discontinues of the issue that did enter climate politics and science well before the adoption the Paris Agreement.

2.3.2 Carbon Dioxide Removal: A not so new tool of the mitigation toolbox

To specify CDR as the case for studying the policy relevance of the IPCC, the following section provides a brief overview of CDR, including a more general introduction (2.3.2.1), a summary of details of the definitions, and related struggles in the context of the SR15 (2.3.2.2). To contextualize the debate and to not make the common mistake of presenting CDR as an entirely new element of mitigation politics (Carton et al. 2020), section 2.3.2.3 will provide an analysis of the continuities and discontinuities of the CDR debate after the adoption of the Paris Agreement.

2.3.2.1 Net-zero as new mitigation target and new attention for CDR

During the Paris Agreement negotiations, climate targets were one of the most contentious issues. Not only the temperature target and the struggle about 1.5 °C instead of 2 °C codified in Art. 2 caused substantial disagreement between delegations. Also the mitigation target in Article 4 was subject of intense negotiations (Dooley and Gupta, 2017; Guillemot, 2017). After intense negotiations on the exact wording, Article 4.1 was included in the final text of

the agreement, stating that the signatories to the agreement aim to: “achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty” (Art. 4.1, Paris Agreement).

This wording on balancing emission and removals in Art. 4.1 laid the groundwork for the rise of *net-zero emissions targets* observed in the past years (Höhne et al., 2021). Scholars argued that the SR15, in particular, had played a critical role in translating the diplomatic wording mentioned above in the short-hand “net-zero” and stimulated the rise of the target in domestic climate pledges and policymaking (Fankhauser et al., 2022; Net Zero Tracker, 2022; Patt et al., 2022). However, it has not only been the SR15 alone, of course, Sweden and the UK, for example, acted as frontrunners and legislated net-zero targets in domestic climate policymaking. Sweden already adopted a climate policy framework in 2017 that sets a net-zero GHG target for 2045 (Government of Sweden, 2017). The UK Committee on Climate Change called for a net-zero target for national climate policy and to operationalize its possible implementation in 2016 (The Committee on Climate Change, 2016) and the UK Government adopted the target in 2019 (UK Government, 2019). Since then, more than 136 countries[14] have adopted a net-zero target – with varying and often a low levels of comprehensiveness and ambition.[15]

Instigated by this wave of net-zero targets and pledges, the debate about CDR has gained traction (Bellamy and Geden, 2019; Fuss et al., 2020). The SR15, with one of its key messages that CDR is required to both counter-balance hard-to-abate residual emissions and reverse overshoot to keep 1.5 °C within reach, is perceived to have played a role in this growing attention to CDR (Mohan et al., 2021; Rogelj et al., 2021). However, whether and how this has affected actual climate policy decisions on CDR has not yet been systematically investigated in different national contexts. Before I present the analytical framework through which the second pillar of the paper has approached answering this question, the following sections first describe what CDR is and then briefly summarize the longer lines of the CDR debate.

2.3.2.2 CDR: A definition, and related struggles

In the final SR15 report, CDR is defined as “[a]nthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. […]” (IPCC 2018, Glossary). This definition encompasses a portfolio of CDR methods, including soil carbon sequestration, enhanced weathering, afforestation and reforestation, biochar, bioenergy plus carbon capture and storage (BECCS), direct air capture plus storage

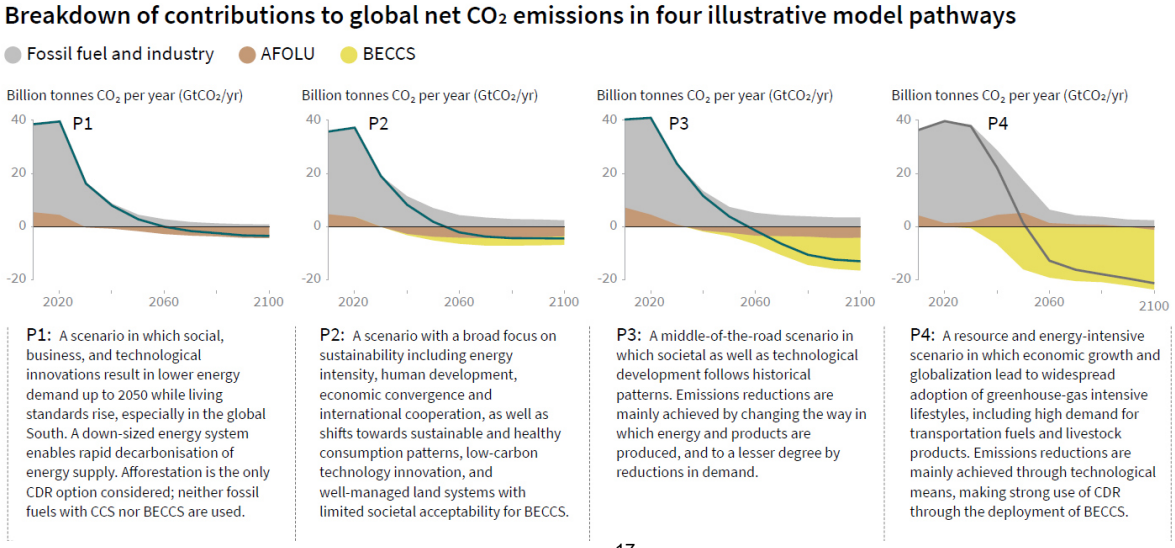
[14] According to Net Zero Tracker (2022), as of August 2022.
[15] See Climate Action Tracker assessments of net-zero targets: https://climateactiontracker.org/methodology/net-zero-targets/.

(DACCS) (see Fuss et al. 2018 for the underlying literature review).[16] The key finding of the report on the importance of CDR for limiting global warming was highlighted in the SPM and communicated proactively by the IPCC leadership after the publication of the report:

> "All pathways that limit global warming to 1.5 °C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 GtCO2 over the 21st century. CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5 °C following a peak (high confidence). CDR deployment of several hundreds of GtCO2 is subject to multiple feasibility and sustainability constraints (high confidence). Significant near-term emissions reductions and measures to lower energy and land demand can limit CDR deployment to a few hundred GtCO2 without reliance on bioenergy with carbon capture and storage (BECCS) (high confidence). {2.3, 2.4, 3.6.2, 4.3, 5.4}" (IPCC 2018, p. 17).

Figure 2.3 shows four illustrative model pathways shown in SR15's SPM. They show that all four pathways require CDR, but the amount is varying substantially. Furthermore, P1 only uses land-based CDR and does not require BECCS. It should be noted, however, that there are many more assumptions behind these pathways (van Vuuren et al., 2018)

Figure 2.2: Four illustrative model pathways, extract from figure SPM.3b



Source: IPCC, 2018. Summary for Polcymaker (SPM), p. 16.[17]

[16] It is important to note, however, that only a small fraction of these methods is modelled in integrated assessment models used for SR15. While modelers started working on extending the list of CDR options in IAMs since then (Strefler et al., 2021), SR15 included only afforestation and BECCS.

Right after the publication, this key finding caused substantial debates. NGOs published fierce criticisms, criticizing the significant role for CDR in mitigation pathways and arguing that CDR is geoengineering[18] (for the definition the IPCC chose, see next section). Within the scientific community, publications emerged that explored "mitigation deterrence", the moral hazard stemming from the promise of being able to deploy CDR in the future and related delays in emissions reduction in the near term (McLaren et al., 2019; McLaren and Markusson, 2020). Both criticisms pointed to essential questions about the definition of CDR, which will be explored in more detail in the following section.

Definitional politics in SR15

The process of agreeing on a CDR definition in SR15 definition was contested. Two major struggles stand out here: first, whether CDR is mitigation, and second, how it relates to geoengineering technologies like solar radiation management. In addition to the expert interviews and background conversation conducted for the thesis (see chapter 3 on methods), these struggles can also be traced in publicly available documents the IPCC provides. The different drafts of the Glossary reveal substantial changes across the different drafts (see table 2.1 for an overview of how the definitions changed over time). One key element that changed is the strong emphasis on anthropogenic activities at the start and end of the final definition, which was not part of the previous definitions. Furthermore, the reference to mitigation points to a substantial struggle within the assessment production process.[19] While the first definition includes a direct link, stating that CDR is classified as mitigation, the next version frames it as a "special type of mitigation". In the final version, a direct link to mitigation is missing; it just appears in the cross-references to the mitigation definition – which itself underwent substantial changes, including a less prominent role for CDR in it (see table 2.1).

[17] The importance of CDR as a strategy to achieve global net-zero CO2 emissions by 2050 and reverse overshoot in the second half of the century is even more striking when taking a closer look at the set of scenarios used in SR15. Only 9 out of 90 scenarios compatible with the 1.5°C target assessed for SR15 do not overshoot the target ("peak warming to below 1.5°C during the entire 21st century with 50–66% likelihood"). However, even the no-overshoot scenarios require substantial amounts of CDR in the second half of the century.

[18] See for example the initiative Geoengineering Monitor by ETC Group and Heinrich Böll Foundation: https://www.geoengineeringmonitor.org/2018/11/ipcc_clara_land_use/.

[19] These struggles have been confirmed in the interviews I conducted; Hansson et al. (2021) provide a detailed analysis of CDR-related conflicts identified throughout the review process.

Table 2.2: Overview of definitions for CDR in different SR15 versions

(Glossary only available from 2nd draft onwards)

	2nd draft	3rd draft	Final
Carbon Dioxide Removal	Carbon Dioxide Removal methods refer to **processes** that remove CO2 directly from the atmosphere by either increasing natural sinks of CO2 or using chemical engineering to remove the CO2 from the atmosphere. CDR methods involve the ocean, land and technical systems, including such methods as iron fertilisation, largescale afforestation and direct capture of CO2 from the atmosphere using engineered chemical means. In this report, **CDR is classified as mitigation.** *See also Mitigation (of climate change).* (G-8)	Carbon Dioxide Removal methods refer to **processes** that remove CO2 from the atmosphere by either increasing biological sinks of CO2 or using chemical processes to directly bind CO2. **CDR is classified as a special type of mitigation**. (G-8)	**Anthropogenic activities** removing CO2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage, but **excludes natural CO2 uptake not directly caused by human activities.** ***See also Mitigation*** *(of climate change), Greenhouse gas removal (GGR), Negative emissions, Direct air carbon dioxide capture and storage (DACCS) and Sink*. (G-544)
Mitigation	A human intervention to reduce emissions or enhance the sinks of greenhouse gases, **therefore encompassing also Carbon Dioxide Removal (CDR) options.** *See also Carbon Dioxide Removal (CDR).* (G-35)	A human intervention to reduce emissions or enhance the sinks of greenhouse gases. **Note that this encompasses carbon dioxide removal (CDR) options."** (G-36)	A human intervention to reduce emissions or enhance the sinks of greenhouse gases. (G-554)

Another dimension relevant in the context of the definition of CDR is its relation to the term geoengineering, more specifically, solar radiation management. Before CDR started to climb up the climate policy agenda post-Paris, efforts to remove carbon dioxide from the atmosphere had often been subsumed under the term “climate engineering” or “geoengineering” (Boettcher, 2022). Influential reports (e.g., The Royal Society, 2009), which defined geoengineering as intervention “in the climate system by deliberately modifying the Earth’s energy balance to reduce increases of temperature and eventually stabilise temperature at a lower level than would otherwise be attained” (The Royal Society, 2009), research programs

(Schäfer et al., 2015) and an increasing amount of publications (Oldham et al., 2014) used an umbrella term to address both, CDR and solar radiation management methods.[20]

The SR15 facilitated an important shift in the terminology used by the IPCC. Throughout the assessment production, efforts to split up the umbrella term and avoid the term geoengineering can be observed. Previous versions, as well as the final definitions in the Glossary clearly show these "definitional politics" (Rayner, 2012) playing out. Eventually, the term geoengineering ended up being mentioned only once in the report: "This report refrains from using the term 'geoengineering' and separates SRM from CDR and other mitigation options" (IPCC 2018, p. 347). This is a clear deviation from a former definition used by the IPCC during AR5, where geoengineering had been defined as "Geoengineering refers to a broad set of methods and technologies that aim to deliberately alter the climate system in order to alleviate the impacts of climate change. Most, but not all, methods seek to either (1) reduce the amount of absorbed solar energy in the climate system (Solar Radiation Management) or (2) increase net carbon sinks from the atmosphere at a scale sufficiently large to alter climate (Carbon Dioxide Removal)" (Allwood et al., 2014, p. 1766). In addition to this differentiation, the SR15 changed the term Solar Radiation Management to "Solar Radiation Modification," a term that has been practically non-existent in the scientific literature so far. The scientific and policy debates on CDR and SRM have taken quite different routes since the report's publication. While CDR is on the rise in a rapidly changing policy space (see chapter 8), SRM is rarely discussed in national climate policy circles (see e.g., Boettcher, 2022).[21]

While this background on the recent definitional politics of CDR and its differentiation from SRM and subsuming under the term mitigation has provided important insights into the current twists of the debate, the history of CDR should also be taken into account.

2.3.2.3 Continuities and discontinuities of the CDR debate

Kyoto Protocol and the commodification of carbon removals

In an instructive review of existing literature on carbon removals, Carton et al. (2020) show that the idea of enhancing sink capacity and accounting for it as climate action has been on the political agenda since the inception of the UNFCCC. It is formally enshrined in the Kyoto Protocol and has created considerable political turbulence between actors who favour ambi-

[20] For a comprehensive and in-depth reconstruction of the terminology and debate on climate engineering or geoengineering, see Boettcher, 2022; Low, 2022; Oomen, 2021.

[21] This also has effects on the research landscape. While the literature on CDR governance can analyze the rapidly changing policy space in different countries, SRM research focuses on multilateral initiatives (Boettcher and Kim, 2022), or scenario exercises (Parson and Reynolds, 2021; Schenuit et al., 2021b).

tious emissions reductions and those who want to reduce pressure to transform the economy. The review by Carton et al. complements other review studies and criticizes that the rapidly growing research on CDR does not reflect continuities in the debate and existing knowledge from the social sciences.

Efforts to define land-based CDR, such as afforestation, as mitigation were mainly pursued by countries which aimed at using it to avoid emissions reductions (Carton et al., 2020; Fogel, 2005; Lövbrand and Stripple, 2006). In the Kyoto Protocol negotiations, defining the role of removals through LULUCF sinks was one of the "most controversial undertakings in the Kyoto negotiations" (Lövbrand, 2009), with the Umbrella Group[22] making the inclusion of sinks a condition for agreement and ENGOs, the EU, and many developing countries rejecting it (Dooley and Gupta, 2017; Fry, 2007, 2002; Jung, 2004). After a compromise on limited inclusion, human-induced deforestation (but not avoided deforestation) was eventually recognized as a legitimate component of future mitigation strategies (Lövbrand 2009). Thus, in principle, CDR has been part of the climate change mitigation toolbox since this inclusion, a fact too often overlooked in post-Paris research on the subject.

Political negotiations on operationalizing the inclusion in the new climate regime continued and spilled over to an IPCC special report on LULUCF intended to objectify the highly politicized debate (Fogel 2005). In the context of this report, the IPCC was attacked for its scientific integrity and credibility, but eventually, according to observers, managed to delineate its boundaries through uncertainty management and intense negotiations on specific wordings (Fogel, 2005; Hajer and Versteeg, 2011, p. 90). Following the implementation of the Kyoto Protocol and afforestation under clean development mechanism (CDM)[23] projects and other voluntary offset programs, scientists pointed to the "commodification of 'carbon territory'" (Lövbrand and Stripple, 2006) (illustrated by the term "carbon workers," Fogel 2005). Since then, researchers have identified numerous adverse side effects of these projects on local communities and biodiversity – particularly in the Global South (Fleischman et al., 2020; Seddon, 2022; Stephan, 2014).

This politically polarized Kyoto debate on LULUCF and highly technical and complex discussions about accounting techniques are not resolved but received more attention in the context of more importance for CDR (Dooley et al., 2022). Furthermore, the technical but politically polarized debate expands to a broader set of removal methods, such as BECCS and

[22] The Group consist of Australia, Canada, Iceland, Israel, Japan, New Zealand, Kazakhstan, Norway, Ukraine and the United States.

[23] The clean development mechanism "allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets." UNFCCC https://unfccc.int/process-and-meetings/the-kyoto-protocol/mechanisms-under-the-kyoto-protocol/the-clean-development-mechanism

DACCS (and more methods to come). These unresolved issues and continuities in the carbon removal debate are a reminder that more detailed and technical knowledge alone will not be enough to agree on operationalization of their inclusion or exclusion of mitigation accountings. The current CDR debate can thus be seen as a continuity of debates related to the commodification of LULUCF projects and the meta-discourse of "ecological modernization" (Bäckstrand and Lövbrand, 2006; Low and Boettcher, 2020).[24]

Modelling sink enhancement: CDR in integrated assessment modelling

A second continuity after the Paris Agreement can be observed in integrated assessment models (IAMs), which play a prominent role in IPCC reports and the climate science-policy interfaces (van Beek et al., 2022). Most of the post-Paris literature on CDR starts with the reliance of IAMs IPCC's AR5 or the SR15. To get a complete picture of the carbon removal debate and its (dis-)continuities, it is important to study not only its longer history in climate governance but also its past role in IAMs.

Efforts to integrate deliberate carbon removal into IAM scenarios as a mitigation option date back to the late 1990s (Williams, 1998, Obersteiner et al., 2001; Pedersen et al., 2021) when the issue received attention in the context of the Kyoto Protocol and the IPCC special report on LULUCF (see above). The IAM community started a more detailed and rapidly expanding debate on a broader set of CDR methods in the early 2010s after the IPCC AR4 scenarios featured CDR (IPCC AR4). This development is documented in the special issue "Carbon Dioxide Removal from the Atmosphere: Complementary Insights from Science and Modelling" in Climatic Change (Tavoni and Socolow, 2013) in which the authors are transparent about the fact that including CDR into the mitigation toolbox leads to a reduced effort on conventional mitigation (i.e. emissions reduction) in the models (Tavoni and Socolow, 2013, p. 6) and dun cautiousness in "carrying [these] modeling results into the real world" (Tavoni and Socolow, 2013, p. 7).

Since then, the importance of CDR inscribed in scenarios that reach the climate targets has increased substantially and provoked strong criticism (see above). Since then, the number of scientific studies on CDR grew rapidly (Minx et al., 2018), and research communities have worked to refine knowledge on the geophysical and techno-economic availability of CDR, including its limitations when sustainability goals are considered (e.g., Holz et al., 2018; Roe et al., 2019; Smith et al., 2019; van Vuuren et al., 2018). Furthermore, as a reaction to the strong criticism of relying on CDR as future promises mentioned above, the IAM modeling community aimed to limit the amount of required CDR (Riahi et al., 2021). Although they

[24] In general, this debate on CDR fits well to the analytical lens of "environmental intangibles" (Chiapello and Engels, 2021). While the degree of commodification of carbon removal was not explicitly compared in this thesis, this would be an interesting follow-up work.

managed to avoid global overshoot in the second half of the century, the models still require large amounts of CDR to achieve stringent climate targets (see chapter 7 for details). This brief summary of how the issue of CDR emerged in IAMs shows that the integration of CDR is more of an incremental process which did not start after the Paris Agreement.

Net-zero as a new organizing principle of climate policymaking

One of the critical changes in the global climate regime established with adopting the Paris Agreement is that, as shown above, the long-term temperature targets have been complemented by the target to Art. 4.1, establishing the balance of emissions and removals as a new target under the UNFCCC. Conceptually, the net-zero emissions established the logic of residual emissions that are perceived to be hard-to-abate should be counter-balanced with carbon removals (Geden, 2018). This target logic carries the risks of lack of credibility and vagueness on the scope, fairness, and roadmaps to achieve the target (Rogelj et al., 2021), delays in emissions reductions (McLaren et al. 2019), and lack of ambition (Anderson et al., 2020). At the same time, however, unlike abstract temperature targets, the goal has the advantage of being achievable by individuals, countries, sub-national actors, companies, etc., and is thus the more 'actionable' climate target (Geden 2016).

This addition to the mitigation targets in Art. 4.1 was preceded by the insight in climate science that cumulative emissions are the decisive factor in the course of advancing climate change (Allen et al., 2009; Meinshausen et al., 2009; Zickfeld et al., 2009) and that, based on the finding that “global warming is roughly proportional to the total amount of carbon dioxide released into the atmosphere” (Rogelj et al., 2019, p. 335) carbon budgets can be identified for different temperature levels.[25] The fact that “every ton of CO_2 adds about the same amount of warming, no matter when and where it is emitted” (Knutti and Rogelj, 2015, p. 364) led to a new importance of conceptualizing mitigation targets as the balance between emissions and removals. This has been described as a politically attractive way to find a compromise in a polarized debate of the long-term mitigation target (Dooley and Gupta, 2017).

However, the first attempts to operationalize the concept in policy and corporate decision-making point to the risk of ambiguity (Rogelj et al., 2021; Fankhauser et al., 2022; Smith, 2021), with one of the main problems being the increasing reliance on CDR due to promises of balancing the “net.” The recent net-zero momentum has led other stakeholders to problematize the size of the net in projected net-zero balances, including youth activists calling for “real zero” rather than net-zero, e.g., Greta Thunberg[26], and ENGOs in various policy set-

[25] For a reconstruction of the emergence of the carbon budget concept, see Lahn (2020).
[26] See Greta Thunberg’s speech in Davos in 2020: https://www.youtube.com/watch?v=VsHZPT2E5tg.

tings[27]. At the same time, even strong critics of the idea of using CDR to counter-balance hard-to-abate residual emissions acknowledge the need for debate and use of CDR to achieve net-zero (see e.g., Fern, 2020). An essential discontinuity in the CDR debate is that the new organizing principle of net-zero facilitates the acknowledgement by a wide range of actors that CDR – in one way or the other – will be required to achieve the climate targets. However, the scale, methods and regulation are and will continue to be contested.

Overshoot budget – debt logic in climate policymaking and CDR for net-negative emissions

A second discontinuity in the CDR debate post-Paris concerns the emerging discussion about temporary overshoot of temperature targets and net-negative emissions to reduce cumulative CO_2 emissions in the atmosphere in the second half of this century. As with the net-zero logic discussed above, this shift in the debate is closely related to the scientific finding that global warming increases roughly proportional to the cumulative CO_2 emissions in the atmosphere (Rogelj et al., 2019). Because most scenarios assessed for SR15 assumed an overshoot, so-called “negative territory” (Meadowcroft, 2013) has gained increasing attention, and scientists have called for an open debate on negative emissions (van Vuuren et al., 2018).

The enormous amounts of CDR inscribed in the SR15 pathways have led to an ongoing debate among scholars about the risks and strategies for dealing with overshoot. Among them – based on the link to the financial budget logic – a perspective as a “climate debt.” Asayama and Hulme (2019) used this analogue to the financial crisis, with CDR being compared to a “subprime mortgage,” and described the emerging debate as one about “climate scarcity and control” (Asayama, 2021). Furthermore, scholars have argued to set limits on temperature overshoot (Geden and Löschel, 2017), and started anticipating long-term impacts of deploying large-scale CDR infrastructure and the need to phase it out in the future (Parson and Buck, 2020). This element of overshoot is clearly a discontinuity in the CDR debate. Before the Paris Agreement – in the Kyoto context – CDR was discussed and contested as a tool to avoid emission reductions. Now, the overshoot inscribed in may scenarios adds a new facet to the debate.

All the continuities and discontinuities described in this section highlighted the importance of considering the long lines of CDR policymaking and governance. They also point to complex science-policy-politics interactions that – in line with the conceptual considerations outlined above – are likely to have different characteristics in different national contexts.

[27] See and the statement "Real Solutions not Net zero" signed by 725 groups from nearly 100 countries: https://www.realsolutions-not-netzero.org/.

2.3.3 Towards an analytical framework for comparative case studies

The added value of examining CDR knowledge politics through comparative case studies has already been demonstrated in the introduction and previous sections on the conceptual background. This section briefly presents the analytical framework developed to identify strategies, mechanisms, and struggles related to SR15 knowledge politics in CDR governance and policy-making. It is important to note that SR15's knowledge politics in relation to CDR cannot be studied in isolation. CDR is only one of many issues in climate policy, and scientific expertise is only one resource for policymakers and stakeholders to manage expectations, pursue their goals and strengthen their position. The analytical framework, therefore, aimed not only to provide a snapshot of CDR governance and policy and the role of IPCC knowledge in recent developments but also to provide insights into how CDR policy is embedded in climate policy and politics in general. More details on the analytical framework are part of chapter 8, and the findings relevant to SR15 and CDR knowledge policy are synthesized in chapter 11.

This thesis aimed to develop an approach that would allow for a medium-n set of case studies to be produced jointly with country experts (see chapter 3 for the structure of this process). This comparative case study approach led to the first publications of this kind on CDR governance and policymaking (chapters 8 and 9). While in-depth case studies have been published before (Bellamy et al., 2021; Fridahl et al., 2020b; Fuss and Johnsson, 2021) – research that significantly influenced the design of the framework – there has been no existing framework for a systematic comparison of CDR policy and governance. To stimulate future research, the approach was designed so that future studies could build on it, either by conducting in-depth studies on one of the categories or other sets of countries. In addition to providing a more widely usable analytical tool, the second main objective of this thesis was to expand the literature on CDR policy beyond the OECD cases. Taking initial steps to fill this knowledge gap is not only important to counter the bias against the Global North in climate research in general, but there is also a CDR-specific motivation for doing so: mitigation pathways produced by IAMs assume that a large proportion of CDR will be deployed in Latin America and Asia (for details, see chapter 9; and also Lee et al., 2022; Fyson et al., 2021). To understand the state of CDR governance and policy in these regions, this thesis conducted case studies of key emerging economies in this region (Brazil, China, and India).

The analytical framework developed combines insights from the literature on socio-technical transitions with existing research on CDR governance. Further details on the conceptual background of the Multi-Level Perspective (MLP) as a medium-range theory (Geels, 2011, p. 26, Geels 2019) are provided in chapter 8. Although this perspective has its limitations and other facets are also relevant to transitions (Cherp et al., 2018), the advantage of the MLP perspective is that it provides a “relatively straightforward way of ordering and simplifying the

analysis of complex, large-scale structural transformations" (Smith et al., 2010, p. 441) and is therefore well suited to the research design for medium-n comparative case studies. However, there is one caveat to be noted: the strong focus, sometimes even bias, towards innovation in transition studies should be reflected when gathering empirical material (Pel et al., 2016). Important questions raised by social scientists that should be taken into account are possible "unanticipated consequences" (Merton, 1936, p. 894) and "intended but unrealized effects" (Hirschman, 1977, p. 131). These should, therefore, always be part of the analysis of transition processes.

Table 2.3 summarizes the five categories of the analytical framework; further details on the operationalization and the conduct of the case studies are provided in chapter 8 and the methods chapter 3.

Table 2.3: Overview of dimensions of analytical framework

(1) Institutional setting, actors, and coalitions	• Overall institutional and political setting in domestic climate policy (incumbent regime) • Macro-political developments that influence CDR debate [e.g., Paris Agreement, Sustainable Development Goals (SDGs), …] • Actors and coalitions in CDR-related climate policy making but also in broader societal debate [business/industry, environmental non-governmental organizations (ENGOs), …]
(2) CDR accounting and methods	• Accounting practices of CDR toward domestic climate targets and its relation to gross emission reductions • Methods addressed and differences in accounting • Groupings/separation and framings of different methods (e.g., "technological"/vs. "natural" CDR) • Socio-political prioritization of different methods
(3) Policy instruments	• Policy approach • Timing and broader political circumstances • Political struggles in public policy processes (main critique vs. justification patterns) • Relation to other climate, environmental and sustainability policy instruments and targets (discursively, politically, legally)
(4) Expert bodies and science	• Role for expert bodies and science more generally in societal CDR debate as well as in public policy processes • Role of IPCC reports (esp. 5th Assessment Report, SR1.5 and Special Report on Climate Change and Land (SRCCL) and domestic modeling or technology development
(5) Developments in CDR niches	• Developments with regard to CDR methods in "protective spaces" that shield, nurture, empower (Smith and Raven, 2012) • Emerging business cases • New actors that demand change in incumbent climate policy regimes to integrate CDR

Gathering empirical material along these categories offers insights into the state of CDR governance and policymaking in different countries in general. With Dimension 4, "Expert

bodies and science," observations were collected specifically on the role of scientific expertise and the IPCC's SR15 knowledge within policy processes. The synthesis of this material provided the opportunity to make a conceptual distinction of idealized types of CDR governance and policymaking. This methodological step follows examples from the socio-technical transition literature, where several examples of identifying typologies of transitions to synthesize similarities and differences between case studies can be identified (see e.g., Smith et al., 2005; Geels and Schot, 2007; Geels et al., 2016). Distinguishing between different types not only helps to highlight different approaches and stimulate future work but is also an important reminder that transitions are not "teleological and deterministic, but continuously enacted by and contested between a variety of actors" (Geels et al., 2016, p. 900). This also means that shifts between different types are, of course, possible (Geels et al., 2016), for example when societal power structures and political alliances change (Hess, 2014). A synthesis of the idealized types will be provided in chapter 11.

In the future, more in-depth studies on individual dimensions and/or countries, as well as comparisons between different groups of countries, would help to further develop research on CDR policy and governance. A second way forward is to explore ways to make this unquantified knowledge from case studies relevant for quantified integrated assessment modeling. Chapter 10 already aims to lay the groundwork for this future work, but the conceptual considerations of a possible iterative strategy (Trutnevyte et al., 2019) are beyond the scope of this thesis and will be addressed in future research.

Further details on the conceptual background and operationalization of the analytical framework can be found in the individual chapters. Before turning to the individual contributions in chapters 5-11, the following sections summarize the methods used in each chapter and briefly outline how the chapters contribute to answering the research questions (chapter 4).

3 Methods and data

A variety of different methods and data sources have been used in the stand-alone publications of this thesis. Each chapter (5-10) contains its own description and justification of the methods and data used. This chapter is intended to provide an overview of the methods and data sources on which the work is based, as well as a reflection on the approach. Following a reflection on the research strategy to turn from a “nonparticipant observer” into an “observing participant” (section 3.1), the following sections summarize the four key sources of empirical material: collective ethnography at COPs (3.2), expert interviews, questionnaire and background conversations (3.3), cooperation with country experts (3.4), and document analysis (3.5). While the first pillar with SR15 focus is based on collective ethnography, expert interviews, and document analysis, the second pillar primarily builds on cooperation with experts and document analysis. However, throughout the research process, the different methods and material gathered mutually improved each other, and the combination provided important synergies for the overarching objective of the analysis of policy relevance-making practices. The ethnographic observations helped to identify key experts to interview, and interviews helped to understand what and where to observe. Similar dynamics existed with the document analysis. While observations and interviews helped identify and contextualize specific documents, analysing documents helped make sense of dynamics playing out on stage and the interviews.

3.1 Turning from an “nonparticipant observer” into an “observing participant”

Although the thesis does not claim to be a comprehensive ethnographic study, the research strategy underlying this thesis was inspired and guided by the notion of an “observing participant.” The observing participant approach was described by Ellen (1984) as a “research procedure in which the researcher does not participate in the lives of subjects in order to observe them, but rather observes while participating fully in their lives [...]” (p. 29). My research was guided by the objective of becoming part of the community working on CDR governance and policy making to observe internal dynamics as an observing participant. It is important to note that I did not begin the research as an observing participant. As Lundsteen (1986) describes, the role of the observer goes through a transition from "nonparticipant observer, transient observer, participant observer, and observing participant" (Lundsteen, 1986). This transition from participant observer to observing participant has also been described by Hinshelwood and Skogstad (2000), who developed a methodology for observing organizations in the healthcare sector (p. 17-26).

The research as an observing participant was inspired by Bourdieu's concept of the “field”, “a relatively autonomous domain of activity that responds to rules of functioning and institutions that are specific to it and which define the relations among the agents [...]” (Hilgers and Mangez, 2015, p. 5). While I did not conduct a systematic study based on Bourdieu’s concept, it inspired how perceived the field and my position in it. In contrast to functionalist approaches, Bourdieu placed emphasis on the struggles inscribed in a field, defining it as a “space of social forces and struggles” (Bourdieu and Wacquant, 1992, p. 102) in which “at each moment, it is the state of the relations of force between players that defines the structure of the field" (ibid. 99). The research strategy aimed to incorporate this relational thinking into the various approaches to gathering material.

Through my own publications on CDR governance and policymaking (chapters 8-10), speaking at conferences, and writing reviews for journal articles, I became part of the research community on CDR governance. Participation in this community provided me with the opportunity to observe firsthand some of the dynamics examined in the articles. One important example is the scheduling effect of IPCC reporting deadlines in the scientific communities (see Chapters 5 and 7 for articles on incentive structures in the scientific community). Turning into an observing participant does come with risks. Studying the issue of CDR in this way means being part of the development being explored. At the same time, being perceived as an insider provides privileged access to the field, allowing important insights into the relational nature and strategic considerations of certain actors' behaviour that are not necessarily observable from the outside. This involvement, of course, influenced my research. One important change while working on the dissertation was that the initial interest in how SR15 influences actors' positions on CDR shifted to the more specific question of what role SR15 plays in ongoing CDR policy. In addition, I observed a shift from asking *whether* CDR is seen as a legitimate option for mitigating climate change to a comparative research design asking *how* CDR is governed as mitigation. While I would argue that this shift is evident in the debate on CDR more generally, I included this reflection to be transparent about this shift of my own position in the field.

Concerning the internal processes of the IPCC, I was able to play the role of an observing participant only to a very limited extent. Throughout the research process, I provided comments on various draft reports and participated in the annual meetings of a national focal point, which brings together IPCC authors, delegation members, and stakeholders to discuss results, procedures, and the IPCC's future work program. However, since it was not possible to examine the assessment and validation practices from the inside, this research had to rely on expert interviews, background discussions (Section 2.2.3), and document analyses (Section 2.2.5).

In addition to assuming the role of an observing participant within the research community, I tried to apply the same approach to German and EU policy debates on CDR. The publication of policy briefs and the provision of information on ongoing legislative processes[28] enabled participation in different formats and allowed me to move from a non-participating observer to an observing participant of some non-public discussions, including with NGOs, policymakers and business associations. This role was limited to cases in Germany and the EU and I relied on collaboration with country experts for other countries.

3.2 Studying global mega events collectively: ethnographic research at COPs

While working on this dissertation, I had the opportunity to participate in a research project on collective event ethnography at COPs as part of the Cluster of Excellence on Climate, Climate Change, and Society (CLICCS). The methodological approach of ethnography of collective events has already been applied to COPs (Aykut et al., 2017) and builds on previous efforts to conduct collective ethnographic research (Brosius and Campbell, 2010; Campbell et al., 2014) and to study global summits from an ethnographic perspective (Little, 1995; Death, 2011). This approach proved crucial to develop the analytical lens of dramaturgical policy analysis and gathering firsthand observation of dramaturgical politics playing out. It allowed me to study performances empirically with the aim of moving beyond the rationalist bias of policy analysis shaped by functionalist perspectives (see chapter 5 for this argument). Using this method to study the knowledge politics and relevance-making of SR15 allows to take a bottom-up perspective on science-policy-politics interfaces.

Chapter 5 draws on observations made at COP24 and COP25. Attendance at COP24 in Katowice, the COP following the release of SR15, allowed for observations of the tensions surrounding the welcoming and acknowledging of the report, which are explored in detail in Chapter 5 and proved to be an important resource for the analysis. Chapter 4 is based on collective observation efforts with a team of four researchers at COP25. We conducted preparatory meetings, a two-week observation at COP25 based on standardized observation templates, routines for data sharing and regular exchange of experiences, and follow-up meetings (see chapter 6 for details). Events observed in person or virtually at the various COPs are listed in the supplementary materials for each chapter. Other results of the CLICCS research project have been published in additional publications (Aykut, 2022; Aykut et al., 2020).

[28] Throughout the legislative processes of the German and EU Climate Laws, I gathered the different drafts of the document and provided a table on this website: *Climate Law Tracker*: https://climatelawtracker.wordpress.com/. The material was used for tracking changes in the document on Twitter, leading to exchanges with policymakers, NGOs, experts, and journalists.

3.3 Expert interviews, questionnaire, and background conversations

A second important source for the research were semi-structured expert interviews, a short questionnaire and background conversations. They provided important insights into how stakeholders perceive the dramaturgical dimension of SR15 and how the debate about CDR has developed. Efforts to conduct expert interviews with scientists, policymakers, and journalists began shortly after the release of SR15 and were aimed to explore the overall role of SR15 in post-Paris climate policy, the role of CDR in the report, and the implications of the report for CDR-related climate policy. The experts asked for interviews included scientists working on CDR-related issues, scientists who contributed to SR15 (either on the CDR or in a leadership role), climate journalists covering SR15, climate policymakers, and administration staff. However, the response rate was rather low (8 interviews were conducted), with some responses indicating a reluctance to participate due to the political controversy surrounding SR15 and CDR. Therefore, I changed the strategy by converting the interview guide into a short questionnaire with five open-ended questions that respondents could answer anonymously and in writing. Twenty responses were received, which, together with the 8 interviews, provided instructive insights into the role of SR15 and the CDR debate (see Table 3.1 for an anonymized overview). Since most interviewees and questionnaire participants agreed on condition of anonymity, I refrained from direct quotes in the papers and used publicly available documents or web streams instead. However, the interviews, survey responses, and background discussions conducted during the research project with administration officials, members of parliament, scientists, IPCC authors, and NGO representatives were invaluable to the design and implementation of the research project.

Table 3.1 Survey & Interviewees

Administration	Survey	Author (Lead Author)	Interview
Administration	Survey	Administration national	Interview
Administration	Survey	International Organisation	Interview
Administration	Survey	Member of Parliament	Interview
Author (Coordinating Lead Author)	Survey	Member of Parliament	Interview
Author (WG Co-Chair)	Survey	Member of Parliament	Interview
Journalist	Survey	Member of Parliament	Interview
Journalist	Survey		
Journalist	Survey		
Journalist	Survey		
Journalist	Survey		
NGO	Survey		
NGO	Survey		
Scientist	Survey		
Scientist	Survey		
Scientist	Survey		
Scientist	Survey		
Scientist	Survey		
Scientist	Survey		
Scientist	Survey		

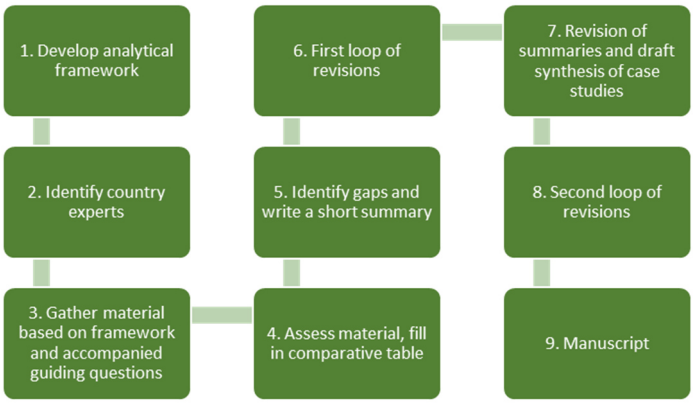
3.4 Cooperation with country experts

For the approach of conducting comparative case studies, collaboration with country experts developed into another major resource. The development of this collaboration for joint publication proved critical to the collection and interpretation of empirical material on countries due to a lack of regional expertise and language skills. The case studies this cooperation resulted in do not only allow to answer the research question on how CDR is addressed differently in different national contexts and the role IPCC expertise played in it, but also lead to the first-of-its-kind comparative work on CDR governance and policymaking. I conducted the in-depth study of CDR-related developments in Germany and the EU together with a colleague, for the case studies on China, Brazil, Ireland, India, Sweden, Norway, the United Kingdom, Australia, New Zealand, and the United States I initiated a collaboration with one

or two country experts to contribute an assessment and become a co-author of a joint publication.

Each expert was provided with the analytical framework developed in Chapter 8 (and further elaborated in Chapter 9) along with guiding questions. Based on these questions, they provided the material for each case study, which was then used to make an initial assessment of the material and complete a comparative table based on the analytical framework. The next step was to identify knowledge gaps and provide a case study summary. This was followed by an iterative exchange between me and the country experts in which missing information or clarifications were collected. The table was then updated based on the feedback received, and a revised version of the summaries and a draft synthesis of the case studies were produced. A second round of feedback was then provided to the country experts, and the final case summary and case study synthesis were prepared for publication as a manuscript. As a result, comparative case studies of 9 OECD cases (chapter 8) and three emerging economies (chapter 9) have been produced. In future research, and with more available resources, a more complex approach should be taken, involving more country experts and sending country cases to a broader group of experts and facilitate workshops.

Figure 3.1: Overview of cooperation process with country experts



3.5 Document analysis

Finally, a fourth data source for the different contributions was the analysis of documents. This fourth source was particularly relevant concerning IPCC, UNFCCC, and public policy processes in individual countries. The documents not only provided relevant information about specific processes within the organizations but also helped to identify contested issues and practices of relevance-making (e.g., UNFCCC decisions on SR15 or IPCC plenary re-

ports) and thus proved critical to answer the research questions. A large number of documents were examined for the UNFCCC negotiations, the preparation of the IPCC Assessment, and CDR-related regulation in the EU and Germany. The way they were used and studied for the different purposes of the contributions varies and is discussed in more detail in the individual chapters. Lists of key documents are provided in the supplementary material.

The documents analysed can be clustered into three groups. First, in examining the UNFCCC processes related to the IPCC's request for the report, the decisions of the UNFCCC were examined. In addition to post-Paris documents, earlier documents related to the 1.5 and 2 °C temperature targets were also considered to explore the longer history of the debates about the 1.5 °C target. An important source to follow and reconstruct the discussions at UNFCCC and IPCC meetings is the Earth Negotiations Bulletin (ENB), a project of the International Institute for Sustainable Development (IISD). However, it is important to always contextualize ENB reports with other official documents and not rely too excessively on this source for analysis.

The second group of documents consists of the IPCC documents. Beginning with the IPCC meetings immediately after COP21, all IPCC meeting reports and decisions, background documents for the decision on the special reports prepared in the sixth assessment cycle, and documents related to the IPCC's new communication strategy and associated progress reports were included in the SR15 analysis (see chapter 5). In addition, the various drafts of SR15 were collected and included (selectively) in the analysis of assessment practices during SR15, along with the publicly available review comments. To get a sense of how CDR was addressed in the report, all three available drafts and the final version were searched and documented using the terms “carbon dioxide removal (CDR),” “negative emissions technologies NETs,” “geoengineering,” and “solar radiation modification SRM”. An initially planned publication on how the text evolved was ultimately not realized due to a greater focus on the case studies.

Finally, a number of official documents from the EU and German legislative processes and other policy documents were examined in detail to identify CDR-relevant aspects of ongoing policy processes. The document corpus includes documents related to the ordinary legislative procedure of the EU Climate Change Act (Regulation (EU) 2021/1119) and the German Climate Change Act (Bundesgesetzblatt I, p. 3905). Detailed comparisons were made for both legislative processes and a website was set up where the different drafts can be compared: www.ClimateLawTracker.wordpress.com. The detailed comparisons were incorporated into the deep dive on EU CDR policy (chapter 10). Other legislative processes that were closely examined include the LULUCF Regulation, the Effort Sharing Regulation, and the EU Emissions Trading System decisions. These three elements of the EU climate policy

have been referred to as the main pillars of the EU climate policy architecture, so chapter 10 closely followed both the 2018 adopted versions and the legislative processes under the Fit for 55 package. Finally, the National Energy and Climate Plans, a strategy document that each Member State had to submit to the European Commission by early 2020 under the Energy Union and Climate Change Governance Regulation (EU) 2018/1999, informed the analysis in chapter 10 and the additional material.

4 Outline of the thesis

This section summarizes what each chapter contributes to answering the research questions developed above and sketches out the content and approach of the six stand-alone, peer-reviewed publications.[29]

Chapter 5: Staging Science: Dramaturgical Politics of the IPCC Special Report on 1.5 °C

Published as:
Schenuit, Felix (2023). Staging Science: Dramaturgical Politics of the IPCC's Special Report on 1.5 °C. Environmental Science and Policy, 139: 166–167.

The first contribution proposes a novel analytical framework to examine the dramaturgical politics and provides an in-depth analysis of SR15. Based on a dramaturgical analysis the contribution examines how, where, why, and in front of what audiences the IPCC was put on stage. The analysis in this article is based on ethnographic observations at COP24 and COP25, expert interviews, background discussions, and document analysis. The key result of the paper is that the IPCC and the knowledge validated by SR15 are being mobilized for diverse and sometimes contradictory political purposes.

Regarding the research questions, this paper lays the groundwork for understanding the procedural embeddedness of the SR15 in the post-Paris climate governance. Furthermore, it identifies major political struggles related to the report and identifies strategies a variety of actors apply to put the IPCC on stage. The article finds that different patterns of performances exist and that the IPCC already has strategies to cope with the diversifying and increasingly incompatible expectations it faces. At the same time, the analysis shows that the IPCC lacks strategies to act on misrepresentation and political conflicts stemming from its report. The study concludes that the production and performance of IPCC reports are inextricably linked and that future research should – addition to the notion of co-production – study IPCC's science-policy-politics interfaces from a perspective of co-*performance*.

[29] See Figure 1.1 on page 15 for an overview and supplementary to chapter 11 for a summary table of findings.

Chapter 6: It's a Performance not an Orchestra! Rethinking Soft Coordination in Global Climate Governance

Published as:
Aykut, Stefan C., Felix Schenuit, Jan Klenke, and Emilie d'Amico. 2022. "It's a Performance, Not an Orchestra! Rethinking Soft Coordination in Global Climate Governance." Global Environmental Politics, 22 (4): 1–24.

As a result of joint research on UNFCCC climate governance post-Paris, chapter 4 explores the broader context of climate governance in the transitional period of the regime and the new role for soft coordination in global climate governance. It is based on a collective event ethnography at COP25 in Madrid and draws on the analytical framework for dramaturgical policy analysis, also used in Chapter 3. Through systematic coding of observation notes, the joint publication provides novel insights into the dramaturgical politics playing out at COPs as mega-events.

This chapter highlights the importance of examining the broader context in which knowledge is strategically mobilized and how discursive and symbolic instruments such as SR15 can become influential tools in a regime that relies on soft coordination. It is a critical contribution for contextualizing and exploring the modes of and policy relevance-making related to the report. Together with Chapter 3, it shows how the new embeddedness of the IPCC in political processes through SR15 was part of an effort to maintain momentum in UN climate governance, a key feature and goal of the new hybrid regime.

Chapter 7: Markets for Public Attention at the Interface of Climate Science and Policy Making

Published as:
Schenuit, Felix, Larissa Koch, Michael Jakob (2020): Markets for Public Attention at the Interface of Climate Science and Policy Making. Environmental Communication, 14(1): 1–5.

Chapter 5 combines a published article (Schenuit et al. 2020) and a brief case study on a contested CDR publication. Applying concepts from information economics, the chapter argues that biased incentive structures at the interface between science, policy, and the media can lead to a "market for lemons" (Akerlof, 1970). It contains examples of how the market for public attention at science-policy-politics interfaces shapes incentive structures within science and can affect the quality of research.

It contributes to answering the research questions by examining the incentive structures internal to science in the context of strategically mobilized, IPCC-relevant, and policy-relevant research. The article raises the problem that many scientific publications use large amounts of (technically and politically) unproven CDR to exceed carbon budget and provide models

that achieve a specific target such as 1.5 °C. The article highlights the importance of establishing guidelines for dealing with scientific uncertainty, incorporating communication of uncertainty, and establishing forums for face-to-face dialogue between researchers and policymakers. In addition to the original publication, the chapter includes a CDR-related illustrative case study of the logics described in the original article. Tracking the debates surrounding the controversial publication "The Global Tree Restoration Potential" (Bastin et al. 2019) provides an instructive example of the biased incentives explored in the original article and how they have influenced the debate on so-called nature-based solutions as part of the CDR portfolio.

Chapter 8: Carbon Dioxide Removal Policy in the Making: Assessing Developments in 9 OECD Cases

Published as:
Schenuit, Felix, Rebecca Colvin, Mathias Fridahl, Barry McMullin, Andy Reisinger, Daniel L. Sanchez, Stephen M. Smith, Asbjorn Torvanger, Anita Wreford, and Oliver Geden. 2021. “Carbon Dioxide Removal Policy in the Making: Assessing Developments in 9 OECD Cases.” Frontiers in Climate 3: 1–22. https://doi.org/10.3389/fclim.2021.638805.

Chapter 6 is the core article of the second pillar of the thesis. It develops the analytical framework based on the literature on socio-technical transition that allows comparative case studies to be conducted. One dimension is the role of scientific expertise and the role of SR15 in recent developments in CDR policymaking. The chapter provides case studies of 9 OECD cases (European Union and three of its member countries: Ireland, Germany, and Sweden, as well as Norway, the United Kingdom, Australia, New Zealand, and the United States. Based on a systematic synthesis of similarities and differences, the paper identifies five key dimensions of CDR policymaking and continuities of observed manifestations and develops a conceptual distinction of idealized types of CDR policymaking: (1) incremental modification of the existing national policy mix, (2) early integration of CDR policies that treat emission reductions and removals as fungible, and (3) proactive CDR policy entrepreneurship with support for niche development.

The empirical case studies are key material for contextualizing SR15’s role in CDR policymaking and governance in different national contexts. These findings reveal that scientific expertise has been key for initiating and developing CDR policies in some countries. The IPCC's SR1.5 and follow-up publications by national science advisory bodies and other organizations elevated the issue of CDR on the agenda of think tanks, policymakers, NGOs etc.

Chapter 9: Taking Stock of Carbon Dioxide Removal Governance in Emerging Economies: Developments in Brazil, China, and India

Manuscript prepared for submission:
Schenuit, Felix, Elina Brutschin, Fei Guo, Aniruddh Mohan, Ana Carolina Oliveira Fiorini, Sonakshi Saluja, Roberto Schaeffer, Oliver Geden, and Keywan Riahi (*manuscript*): Taking Stock of CDR Governance in Brazil, China, and India

Chapter 9 provides case studies on the emerging economies of Brazil, China, and India and further develops the analytical framework from chapter 8. The article shows that IPCC knowledge from SR15 played a substantially different role in these countries, where land-based CDR, such as afforestation, is already a key component of existing climate policy. While the shift to net-zero targets led to new attention for CDR in these countries, policy dynamics are best described repurposing existing policy instruments, a fourth idealized types added to the conceptual differentiation introduced in the previous chapter. It is striking that the SR15 did not play the explicit agenda-setting role it had in some OECD cases, such as the EU. Thus, the article is an important contribution to the exploration of patterns of policy relevance-making – and the lack thereof.

In addition to this finding, the article contributes new knowledge to two existing research gaps. First, the lack of knowledge about CDR-relevant governance structures in the countries studied. The chapter thus extends knowledge about the political economy, path dependencies, and policy design of mitigation strategies in these three countries. Furthermore, this article draws on interdisciplinary collaboration with integrated assessment modellers and aims at doing the first step in an iterative strategy of exploring ways for interdisciplinary co-operation. In particular, the article proposes to combine quantifying top-down integrated assessment findings with bottom-up qualitative case study findings through exogenous CDR deployment narratives and concludes by identifying building blocks for these narratives that would reflect findings from the social science literature on CDR governance and policymaking.

Chapter 8: Carbon Dioxide Removal: Climbing up the EU Climate Policy Agenda

Published as:
Schenuit, Felix, and Oliver Geden (*in press*). Climbing Up the EU Climate Policy Agenda. In: Rayner, Tim, Szulecki, Kacper, Jordan, Andrew and Oberthür, Sebastian. Handbook on European Union Climate Change Policy and Politics. Edward Elgar Publishing Ltd.

The final contribution to this thesis provides a deep dive into CDR-related policymaking in the European Union. Path dependencies for CDR policymaking can be identified by tracing CDR-related aspects of EU climate and energy policy governance structures. Based on an

analysis of the main legislative processes and the role of CDR in National Energy and Climate Plans (NECPs) all 27 Member States had to submit, the chapter provides a reconstruction of the recent push for CDR governance initiated by the European Commission in the context of the European Green Deal.

The chapter identifies early building blocks of the emerging political economy of CDR policy in the EU, including the distributive effects across different member states and sectors through the notion of “geographies of net-zero.” These findings provide evidence for the observation of a rapidly changing CDR debate. While the EU was among the prominent critics of the inclusion of carbon removal as a mitigation strategy in the Kyoto Protocol, the now-established net-zero target has facilitated the normalization of CDR as an integral building block of mitigation strategies to achieve the target. The detailed analysis of the legislative processes also shows how SR15, together with the European Commission's modeling efforts, has been an influential resource for putting CDR on the agenda and embedding CDR in the European Green Deal. In addition to the publication in the Handbook, the chapter includes additional material and observations on the NECPs and can thus provide insights into differences across Member States.

5 Staging science: Dramaturgical politics of the IPCC's Special Report on 1.5 °C[30]

5.1 Introduction

5.1.1 Policy-relevant climate science in a post-Paris world

The Intergovernmental Panel on Climate Change (IPCC) is on the world stage: Unprecedented media coverage of the Special Report on Global Warming of 1.5 °C during its sixth assessment cycle (IPCC-52, 2020) was the latest indication that the IPCC is the focal point for climate change-related science-policy-politics interfaces. The SR15 (IPCC, 2018a) showed that the intergovernmental body's products can substantially shape debates in its primary audiences, i.e. multilateral negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) and national climate policymaking (Hermansen et al., 2021; Livingston and Rummukainen, 2020; van Beek et al., 2022). The SR15 is referred to in numerous net-zero pledges (Fankhauser et al., 2022), climate litigation strategies, and court rulings (Preston, 2021). The "Unite behind the Science" campaign was also shaped by the publication and findings of the report (Evensen, 2019; Marquardt, 2020), and the publication in early October 2018 was the main climate-related media attraction that year (Boykoff and Pearman, 2019). These observations provide evidence that the IPCC is the key "boundary organization" in the institutional setting of international climate governance (Beck and Mahony, 2018; Guston, 2001). Since its founding in 1988 and that of the UNFCCC in 1992, scholars have observed strong interlinkages between climate science and climate diplomacy (Dahan-Dalmedico, 2008; Jasanoff and Wynne, 1998). The new climate governance regime has consolidated the IPCC's position as the key intergovernmental assessment body where science-policy interface expectations culminate.

The IPCC's official mandate and its ambition to provide "policy-relevant" but not "policy-prescriptive" assessments have been extensively studied by sociologists and science and technology studies (STS) scholars[31]. The literature shows that in the course of over three decades since the IPCC has first started to produce assessments, the expectations directed at the latter have evolved, grown, and diversified – especially in the context of the new focus on solution-oriented global environmental assessments (De Pryck and Wanneau, 2017; Edenhofer and Kowarsch, 2015; Jabbour and Flachsland, 2017). To add to a better understanding of what these expectations are and how the IPCC reacts to them, this article proposes to further develop a different angle to study the IPCC, by investigating its dramaturgi-

[30] Published as: Schenuit, Felix (2023). Staging Science: Dramaturgical Politics of the IPCC's Special Report on 1.5°C. Environmental Science and Policy, 139: 166–167. https://doi.org/10.1016/j.envsci.2022.10.014

[31] for recent studies see e.g., (Beck and Mahony, 2018; De Pryck, 2021; Engels, 2019; Grundmann and Rödder, 2019; Hermansen et al., 2021; Lahn and Sundqvist, 2017; Livingston and Rummukainen, 2020; Pryck and Hulme, 2022; Sundqvist et al., 2018).

cal practices and politics (Hajer, 2012; Livingston, 2018). The article argues that efforts to trace how scientific knowledge is produced, validated, and incorporated into policy and politics (Jasanoff and Wynne, 1998) must go beyond studying what the IPCC does and also explore how, where, and in front of what audiences it performs and is put on stage. This paper aims to explore how a dramaturgical analysis can contribute to exploring the IPCC's science-policy-politics interfaces and, through a case study of a particular report, identify key challenges and recommendations to the IPCC in the ongoing debates about possible reforms of the intergovernmental body. SR15, as the most prominent report in the sixth assessment cycle, qualifies as a key case study for exploring dramaturgical politics at science-policy-politics interfaces in the new climate regime. This in-depth dramaturgical analysis shows that in addition to self-staging practices, the IPCC is also being staged by a variety of different actors. Drawing on this observation, the article argues that in addition to studying co-production, practices and patterns of co-performance of IPCC's products should receive more attention, particularly to the politics inscribed in strategic staging efforts.

5.1.2 A new context for the IPCC: Climate governance post-Paris

The Paris Agreement establishes a hybrid architecture of international climate governance. It contains both top-down elements consisting of international rules to promote ambition and accountability and new bottom-up elements to promote flexibility and participation (Rajamani and Bodansky, 2019). Thinking in terms of polycentric governance (Jordan et al., 2018) and facilitative governance (Hale, 2016) is a prominent way of making sense of emerging structures in UNFCCC governance. It contributes to better understanding the increasingly opaque set of actors involved. At the same time, however, scholars also highlight that this perspective entails the risk of failing to address the "black box of power" (Morrison et al., 2019). A second strand of literature on UNFCCC climate governance particularly focuses on the importance of discursive and symbolic power structures in emerging mechanisms of soft coordination (Aykut et al., 2022, 2017; Lövbrand et al., 2017). By pointing to these dimensions, climate governance scholars build upon research on the performative dimensions of global environmental summits and governance (Campbell et al., 2014; Death, 2011; Little, 1995). Investigating how and by whom discursive "momentum" and "signals" are generated is particularly instructive as the post-Paris governance architecture deliberately relies on encouraging increasing numbers of actors to facilitate ambitious climate policies by generating and maintaining momentum (Aykut et al., 2021; Ourbak, 2017). In this context, the notions of "performance" or "staging" describe social practices that together constitute a central element of climate governance (Aykut et al., 2022). This argument follows the common observation in political sociology that the production of public policy processes, collectively binding decisions, and governance structures is inextricably linked to their performance (Luhmann, 2000). There is a long tradition in sociology of focusing on the performance and dramaturgy

of social interactions (Benford and Hunt, 1992; Burke, 1969; Goffman, 1959). Scholars from political science and anthropology have also developed and applied perspectives that focus on the performance and dramaturgical dimensions of politics (Edelman, 1985), governance (Hajer, 2009), and social movements (e.g., (Chaffee, 1993; Miles, 1989). However, empirical studies that systematically explore dramaturgical politics and move beyond using theatre-related terminology as a metaphor are scarce. This article explores further the analytical tools to study dramaturgical politics in climate governance by proposing and applying a novel analytical framework for an in-depth case study of the SR15.

5.2 Studying dramaturgical politics at science-policy interfaces

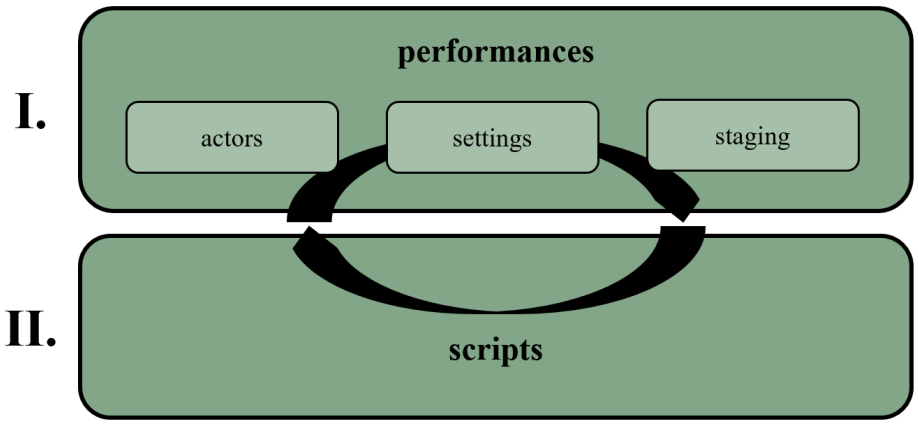
In the STS literature on science-policy interfaces, the notion of coproduction has been influential (Jasanoff, 2004). Both conceptual and empirical research on co-production practices within climate science and the IPCC has demonstrated that neither the IPCC's neutrality nor the universality of its assessments can be taken for granted (Beck, 2011; De Pryck, 2021; Mahony, 2014; Miller, 2004; Turnhout et al., 2019). In-depth studies on IPCC assessment production processes illustrate the importance of social practices within assessment processes (Cointe et al., 2019; Lahn, 2020; Mahony and Hulme, 2012), adding to the evidence gathered in a long tradition of research from a constructivist perspective highlighting the importance of social practices in science (Bourdieu, 2008; Kuhn, 1962; Latour and Woolgar, 1979). The social practices of the performance of policy-relevant climate science and IPCC assessments, however, have thus far received less attention. This is despite the fact that performances were an important element of the early STS literature (e.g., Latour, 1987). Hilgartner (2000) also emphasized how science is "performed" and scientific advice is put "on stage." Applying Erving Goffman's sociological definition of "performance," Hilgartner proposes a view of scientific advice as "public drama" (p. 5), explaining that science advisors "use a variety of dramatic techniques to create - or better, to enact - the basis of their authority as experts" (p. 8). Hajer (2009) and (Livingston, 2018) showed that the "science on stage" perspective can be fruitfully applied to the IPCC. Drawing on this body of work, the next section presents an analytical framework that aims to provide an analytical tool for studying dramaturgical politics at science-policy-politics interfaces.

5.2.1 An analytical framework for dramaturgical analysis

Hajer's work on "authoritative governance" (2009) provides a starting point for widening the perspectives on science-policy-politics interfaces. Hajer proposes to study governance from a dramaturgical perspective, focusing on practices such as scripting, staging, performance, as well as settings to combine discourse analysis with a dramaturgical perspective: "Whereas discourse analysis analyses the political dynamics of what people say, the dramaturgy of

politics analyses how they say it, where they say it, and to whom they say it" (p. 65). Attempting to overcome the "rationalist bias" (p. 75) in policy studies, it conceptualizes politics as "a sequence of staged events in which actors interact over the meaning of events and over how to move on" (p. 66). In order to apply these notions to a systematic empirical case study of the IPCC's SR15, I use a two-layered analytical framework (Figure 5.1) and three main sources of empirical material. In the first step, performances and staging practices by different actors in different settings are identified. Following Hajer (2009) and Aykut et al. (2022), performances are understood as public interactions that produce social realities and refer to a specific script. This observable 'play' disseminates, shapes, and manifests problem definitions, knowledge, decisions, new power relationships, roles for specific actors and rhetorical devices that provide a specific meaning to the overall dramaturgical process. Staging practices are efforts to organize specific interactions and performances. They entail selecting and applying a script, interpreting it through links to existing or new symbols and characters, and providing material, symbolic, or reputational incentives for actors to engage in performances. These performances and stagings are enacted by actors with varying degrees of agency[32] who strategically pursue or challenge a certain narrative arc in their dramaturgical practices. This occurs in various settings, the physical stage(s) where performances (are intended to) take place.

Figure 5.1: Overview analytical framework for dramaturgical governance analysis



[32] Depending on their position and role in different settings of the broader climate governance regime. Following Stammer et al. (2021), agency is understood as: "The capability of individual and collective actors to formulate future aims and realize them in the present, even if only partially and with unforeseen outcomes (following Emirbayer and Mische, 1998) in the form of everyday social practices and individual decisions (Giddens, 1984; Tilly, 1984)."

Beginning with the report's publication on October 8th, 2018, empirical material was gathered and key SR15-related performances, actors, settings and staging practices were identified (Appendix II). The guiding question was how and by whom the IPCC was intentionally put on what kinds of stages (by external actors or upon own initiative). The empirical material gathered consists of three main sources that were collected between October 2018 and November 2021. To observe how staging, setting and performances related to SR15 unfolded on the ground, ethnographic observations were conducted. I attended COP24 2018 in Katowice, Poland and COP25 2019 in Madrid, Spain in person under an accredited observer status as part of a "collaborative event ethnography" research project (for details on the approach see Aykut et al., 2017; Campbell et al., 2014; and for intermediate results of the collective approach, see Aykut et al., 2020). These two COPs were essential for SR15: the report was published shortly before COP24, and during COP25 the report's findings were expected to help prepare UNFCCC signatories to demonstrate new ambition. I observed in person more than 30 IPCC and SR15-related events, among them official negotiations, plenary sessions, official side events, and pavilion events; additional events were observed through online streams (see Appendix I.I.a/b for an overview). Studying performances, actors, staging practices, and various settings from this perspective allows for a bottom-up perspective on the SR15-related science-policy-politics interfaces at COPs. The relevance of these conferences and their stages was highlighted by (Craggs and Mahony, 2014), who, following on from (Death, 2011) and (Shimazu, 2014), understand "a conference as a visible stage" that "calls the attention to the actions of individuals at conferences as performers and audiences" (p. 415). Collecting observations at COPs allows for the study of what (Mahony, 2013b) calls "boundary spaces [...] in and through which the work of organising and negotiating the boundary between science and politics is conducted" (p.31).

A second source of empirical material consists of eight semi structured expert interviews, twenty responses to a short questionnaire, and background conversations. The respondents and interviewees included IPCC authors, climate journalists, public officials, and policymakers (Appendix I.II). In an exploratory and iterative research design, the transcriptions of interviews, survey responses, notes from background conversations and participatory observations were of great importance in tailoring the analytical perspective on the dramaturgical element of science-policy-politics interfaces. However, since most interviewees and survey participants responded under the condition of anonymity and to make referencing as transparent and accessible as possible, the observations and analyses are referenced with publicly available UNFCCC or IPCC documents (Appendix II), which I drew on as a third major source for empirical material (Appendix I.III).

In the second step of the analytical framework, key patterns in these performances and practices were identified, primarily focusing on commonalities and differences in narrative arcs

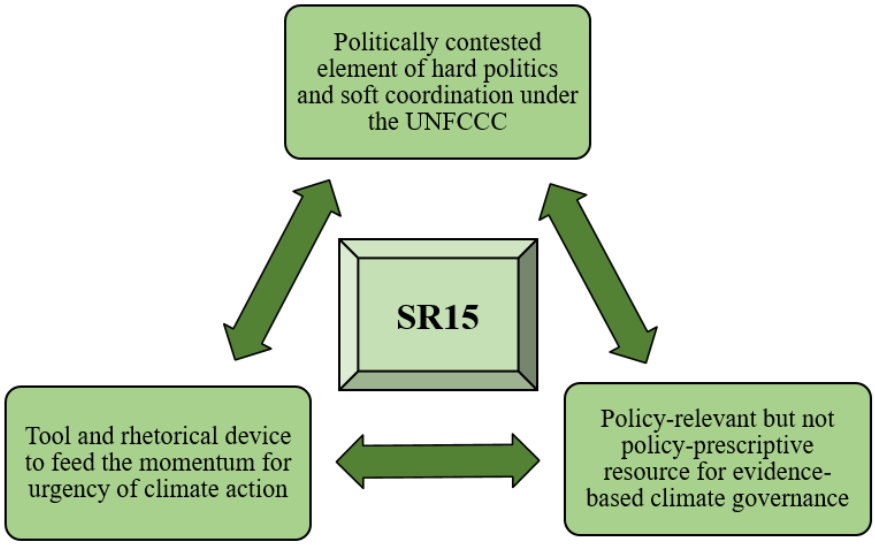
they contain and the expectations they direct at the IPCC. The objective of this step was to identify key scripts and develop conceptual and analytical distinctions between them. In dramaturgical terms, scripts are defined as a bundle of expectations and norms forming the general character of a political dramaturgy that consists of a sequence of performances. Enacted and referred to on stage, they articulate a general narrative arc across a specific sequence of performances that provides cues for appropriate behaviour (Aykut et al., 2022). Scripts are not orchestrated plans but the result of multiple performances and struggles about the narrative arc in different boundary spaces. In addition to this dramaturgical lens, the analytical framework used here also links it to scholarship applying the perspective of a 'new institutionalism', where the term 'script' refers to sets of expectations that organizations and all kinds of actors face in modern globalizing societies (Drori et al., 2006). Associated scholarship on international organizations highlights the use of scripts as strategic devices (Halliday et al., 2010) and points out that multiple scripts can circulate at the same time, as the codification of norms is contested (Kentikelenis and Seabrooke, 2017). Incorporating the multiplicity of possible scripts as both narrative archs and expectations organizations face into the analytical framework allows for an assessment of the different expectations directed to the IPCC in post-Paris climate policy and its (lack of) strategies to deal with their incompatibility.

5.3 Analysis: the dramaturgical politics of SR15

The exploratory and iterative research process resulted in the conceptual distinction of the following three scripts (Figure 5.2). The first presents SR15 as an independent, policy-relevant but not policy-prescriptive assessment of the state of climate science on keeping global warming within 1.5 °C, which feeds into evidence-based climate governance. The second describes SR15 as an element, subject, and tool of the hard multilateral politics and soft modes of coordination inscribed in the Paris Agreement and its contested implementation processes. Finally, the third script presents SR15 as a tool and rhetorical device to feed momentum for more ambitious climate action in the climate regime through claims of urgency and emergency. These three scripts should be considered as an analytical distinction that emerged from the systematic review of the empirical material on SR15 used for this study. In other contexts, at a different time, additional scripts may be observable. While these scripts provide detailed insights into the IPCC's SR15 dramaturgical politics, further generalization would require additional case studies (see also Section 5). Furthermore, it is important to stress that although the scripts are distinguished conceptually, they do overlap. In fact, an observable performance might refer to more than one of the identified scripts, and references to specific elements of a given script can be contested on stage. Furthermore, scripts should not be understood as set in stone but as subject to change. Despite being blurrier in the real

world, the analytical distinction helps to explore key sets of expectations enacted in the political environments of the IPCC. The subsequent sections will synthesise the performances, actors, stagings, and settings observed in the empirical material and describe the scripts in more detail (Appendix II).

Figure 5.2: Conceptual overview of three scripts for SR15.



5.3.1 SR15 as independent, policy-relevant but not policy-prescriptive resource for evidence-based climate governance

The first script identified in the empirical material follows the official mandate of the IPCC as an objective, comprehensive, policy-relevant but policy-neutral assessment of the state of climate science on limiting global warming to 1.5 °C that feeds into evidence-based climate governance. Not surprisingly, it is the most visible of the scripts. It has its roots in the late 1980s when the intergovernmental body was founded, under the aegis of its parent organizations UNEP and WMO, as a preface to the institutionalization of multilateral climate governance under the UNFCCC (Vardy et al., 2017). This script was most visible in official negotiation settings during COPs in the wake of the publication (esp. COP24, COP25) as well as official side-events (co-)-organised by the IPCC Secretariat. Another setting in which this script played a relevant role was the production process of the report. As the script most aligned with the official mandate, key actors were the IPCC leadership, as well as UNFCCC and Subsidiary Body for Scientific and Technological Advice (SBSTA) officials (for more de-

tails see also Appendix II). In the following, four main patterns of performances, actors, settings and staging practices will be described in more detail. The first pattern consists of new self-staging efforts by the IPCC. In 2018, for the first time, the IPCC was offered the opportunity to set up its own pavilion to showcase SR15 and other IPCC work in the COP24 exhibition area (see Appendix I.I.a/b for the full programs). While the pavilion was set up in a rather ad hoc and spartan manner at COP24, at the very end of the venue, it was much more professionally designed and very prominently placed at COP25. The pavilion quickly turned into a contact and meeting point for IPCC authors, observers covering climate science issues, and media representatives. As a setting where the IPCC decides on its own self-staging, it is no surprise that the script that is closest to the formal mandate, shaped all of its performances. More generally, at COP24 and COP25, the impact of the newly adopted communications strategy (IPCC, 2018b) could be observed, including the results of collaboration with professional communications experts (Corner et al., 2018) and efforts to increase audiences on social media platforms (IPCC, 2019a). Together with the principles, considerations on IPCC spokespeople, and procedural innovations in the communication strategy, these observations point to efforts of professionalizing the IPCC's communication through deliberate self-staging (see also reflections by former IPCC communication manager (Lynn and Peeva, 2021).

The second pattern in IPCC's numerous appearances in official negotiations settings at COP24 and COP25 is that the performances always included a reference to its formal mandate, as well as to the fact that the UNFCCC invited the IPCC to write SR15. A notable addition to the formal mandate was that IPCC Chair H. Lee, who took office in 2015 with a promise to put more emphasis on solutions (Tollefson, 2015), and explicitly spoke of solutions in every statement he made on SR15. The statements show very clearly how careful he was to avoid being perceived as politically prescriptive (Appendix I.I.a). Instructive examples of this pattern of performances are the special SBSTA-IPCC events on the SR15 during COP24 (SBSTA-49, 2019) and the so-called "structured expert dialogue on the second periodic review of the longterm global goal" (SBSTA, 2021), which illustrate the institutionalized and ritualized enactment of the IPCC as the key resource for evidence based climate governance under UNFCCC. This embedding in the UNFCCC process reflects the high level of trust that is usually placed in the IPCC (Beck, 2012; Rayner, 2010).

However, these rituals and the level of trust have been questioned through a third pattern of performances – especially at COP24. The widely shared perception of the IPCC as a provider of universal knowledge was challenged in front of the large public attending and following the UNFCCC climate negotiations. A small alliance led by Saudi Arabia provoked political turbulence by rejecting an initiative to "welcome" the report on grounds that it was "incomplete" (Hickmann, 2018). In an unprecedented interview on SR15 in the hallways of COP24,

a senior member of the Saudi Arabian IPCC and UNFCCC delegation accused other UNFCCC delegations and the IPCC of seeking to reverse the IPCC's mandate with SR15, so that "instead of science telling governments what to do, now we are governments telling science what to do" (Hickmann, 2018). As a result, national delegations failed to reach a compromise on the issue at COP24 in Warsaw, and the conflict continued until SBSTA 50 in Bonn in 2019 (ENB, 2018a, 2019a; Farand, 2019; SBSTA-50, 2019). This incident points to a sequence of performances that aimed at challenging the prevalent script. In fact, the IPCC's fidelity to its formal mandate had been challenged throughout the production and dissemination of SR15: Saudi Arabia, as its most outspoken opponent, criticized the decision to invite the IPCC to produce SR15 from the very beginning at COP21, and extensively challenged the draft reports as "policy-prescriptive," usually in the context of statements on the required transformations (comment 9978, SODCHP1), governance (comment 9976, SODCHP1), fossil fuels (comment 9866, SODCHP1), and the decoupling of economic growth and GHG emissions (comment 9900, SODCHP1). In the SR15 approval session, Saudi Arabia and the USA eventually documented their dissatisfaction in statements attached to the report of IPCC's 48th Session. While Saudi Arabia explicitly referred to IPCC's mandate and highlighted that mentioning nationally determined contributions (NDCs) in its products contradicts it (ENB, 2018b, p. 14; IPCC-48, 2018, p. 14), the US distanced themselves from the report's Summary for Policymakers (SPM) and criticized limitations in the processes behind the production of the report (ENB, 2018b, p. 16).

These efforts to counter the prevalent script of a neutral IPCC were not only prominent because of Saudi Arabia's public escalation, but also because its criticisms pointed to a weak spot. The lack of and gaps in the 1.5 °C-relevant scientific literature, the close link between the topic of the report and the political goal agreed upon under the UNFCCC, as well as the very short timeline allowed for the production of SR15 led to concerns and discussions about research priorities and the role of the IPCC and scientific advice (e.g., Geden, 2016a; Hulme, 2016; Peters, 2016; Rogelj and Knutti, 2016; Schleussner et al., 2016). The issues of the missing literature, new research priorities, as well as the role of the IPCC in a new climate regime have also been discussed in official IPCC settings (IPCC-43, 2016).[33] These debates show that the decision to produce the report was taken under the assumption that the IPCC's incentive and engagement structures would lead to more research on 1.5 °C. During the post-approval press conference in Incheon, IPCC Chair Lee emphasized that the invitation "catalyzed" scientific research on the 1.5 °C target to fill the existing gap (IPCC, 2018c), a dynamic that was supported by SR15-specific research funding lines by national governments (e.g., Federal Ministry of Education and Research (BMBF), 2016; The Research

[33] Especially documents IPCC-XLIII/INF. 8, p.43 & p .49 f and IPCC-XLIII/INF. 9, Comments from the Co-chairs on Special Report proposals.

Council of Norway, 2021). Thus, before SR15 turned into a resource for evidence-based policymaking, the mobilization of the IPCC through the UNFCCC decision had a significant impact on research agendas in climate science. Although this fact in itself says nothing about the scientific integrity of the assessment, it can – as shown above – be used politically to challenge how the IPCC interprets and enacts its formal mandate in organizational practice.

Apart from substantial political conflicts in the official negotiation settings, a fourth pattern was observable during side events. At COP24 and COP25, UNFCCC representatives, delegation members, the IPCC's parent organizations (UNEP/WMO), and IPCC representatives often referred to the IPCC as a source of universal knowledge. However, they also started to put the IPCC in perspective, pointing to a broader range of sources for climate expertise relevant for climate policymaking. An example for this dynamic played out during a side event at COP24 on science-policy interfaces co-hosted by UNEP, WMO, and the IPCC (Appendix I.I.a). Speaking at event "Climate Science for Policy," Abdalah Mokssit, the IPCC Secretary, said in his concluding remarks that the IPCC's reports should be perceived as being one part of a "bouquet" of sources for climate expertise, accompanied by products such as the UNEP Emissions Gap Report and annual WMO publications, among others. This practice of performing the mandate while situating IPCC products within the broader "bouquet" of climate expertise appeared to be an effort to keep the IPCC from being singled out in ongoing controversies. It points to an ongoing functional diversification of climate expertise on a continuum between policy relevance and policy neutrality. Furthermore, in light of the strong accusations made in some places at the COP24, WMO and UNEP could be observed proactively performing their role as parent organizations to support the IPCC and defend its policy-neutrality (Appendix II).

5.3.2 SR15 as politically contested element of hard politics and soft coordination under the UNFCC

The second script presents the IPCC and its products as elements of hard multilateral climate politics and soft modes of coordination under the UNFCCC. Although leading IPCC authors have previously reported on the political battles surrounding the production of assessments (Edenhofer and Minx, 2014), and the fact that relationship between the IPCC and the UNFCCC has always been both close and contested (Schneider, 2009), the UNFCCC's first request for the IPCC to produce a special report on a genuinely political target led to a new degree of embeddedness of the IPCC in the politics of multilateral climate negotiations. This script began to play a role at COP21, where the SR15 was presented as part of the 1.5 °C compromise. During the production and after the publication, it occurred at IPCC meetings as well as at COPs. The main actors were the national delegations, as well as the COP Presidency and the UNFCCC leadership. Three key patterns of performances, actors, settings and staging practices are described next in more detail (see also Appendix II).

A key pattern of performances related to this script emerges from the report's origins and the political conflicts around it. The idea of inviting the IPCC to produce a report on 1.5 °C began to circulate in diplomatic circles at COP21. In particular, the Alliance of Small Island States (AOSIS) and the Small Island Developing States (SIDS) had pushed for the inclusion of the 1.5 °C target in the agreement (Ourbak and Magnan, 2018), while others vehemently opposed it (ENB, 2015). Eventually, inviting the IPCC to provide a special report in 2018 on the impacts of global warming of 1.5 °C in Decision 1/CP.21 II.21 helped to find a consensus on the temperature target (Dimitrov, 2016). There was no real doubt that the IPCC would accept the invitation, especially because the IPCC plenary itself – the body that ultimately decides on the special reports – consists of government delegations that agreed to the invitation in Paris, and IPCC and COP delegations tend to overlap or have close ties. In this regard, one IPCC-43 delegate said, "They are us" (ENB, 2016, p. 12).[34] However, the political compromise on both the 1.5 °C target and the invitation to write the special report was quite fragile. Ongoing efforts by some countries to counter the prevalent script on the report's role led to a situation where the IPCC's SR15 assessment processes were used as a site to display the instability of the consensus achieved in Paris and then, after publication, the SR15- related UNFCCC decisions were used as opportunities to showcase the fragility of the new Paris Agreement architecture (see above, and Hermansen et al., 2021; Livingston and Rummukainen, 2020).

A second pattern concerns the operationalization of the Paris Agreement's temperature target. The report turned into the key reference for defining the mitigation requirements to achieve the 1.5 °C target, and has also been used as the key rhetorical resource to shift the focus from the 2 °C threshold to 1.5 °C (Livingston and Rummukainen, 2020; van Beek et al., 2022). After the political conflicts regarding the report settled in 2020, the UK's COP26 Presidency managed to include an operationalization of the 1.5 °C target in a UNFCCC document for the first time (Forster et al., 2022). The Glasgow Climate Pact both includes a reference to the substantially lower impacts of climate change in a

1.5 °C compared to a 2 °C warmer world (COP26, 2021) and states that "rapid, deep and sustained reductions in global greenhouse gas emissions, including reducing global carbon dioxide emissions by 45 per cent by 2030 relative to the 2010 level and to net-zero around mid-century, as well as deep reductions in other greenhouse gases" (COP26, 2021, IV.17) would be needed. This diplomatic effort by the UK Presidency was embedded in a sequence of performances related to one of COP26′s key objectives: "keeping 1.5 °C alive" (UK Gov-

[34] IPCC-43 agreed to accept the invitation, but as a compromise between country delegations added "[…] in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty" to the title and thus facilitated both the widening of the scope of the Special Report and greater embeddedness in the UNFCCC political processes through the use of the language of Art. 2.1 of the Paris Agreement.

ernment, 2021). From the outset at COP24, many SR15-related performances emphasized that 1.5 °C is still within reach. However, the strong emphasis on keeping the 1.5 °C target within reach does not represent only a call for more ambitious climate action. It also has a dimension of multilateral distributive politics: if the 1.5 °C target is not upheld politically, it would call into question the cohesion of the signatories to the Paris Agreement and increase the importance of negotiating issues that are uncomfortable for so-called "developed countries," in particular Loss and Damages (Farand and Galey, 2022; Osaka, 2022; Tschakert, 2015). Thus, the SR15 was once again being put on stage as an element and tool of the politics inscribed in UNFCCC processes. A third pattern relates to the scheduling of SR15 in line with the UNFCCC process of conducting an initial stocktake, the Talanoa Dialogue. As the Paris Agreement enabled the transformation of multilateral climate governance from a top-down approach to a hybrid architecture based on national climate pledges, the period between the success of negotiations in Paris and actual implementation was fraught with institutional uncertainty for the UNFCCC. The procedural alignment was an attempt to reduce this uncertainty by maintaining the momentum of climate governance and thereby demonstrating that the new architecture of the Paris Agreement worked (Ourbak, 2017, p. 12; Ourbak and Tubiana, 2017, p. 821). Performances of mobilizing the IPCC to reduce institutional insecurity were especially visible in diplomatic efforts at COP24 (Espinosa, 2018) as well as the "Time for Action" COP25 in Madrid (Guterres, 2019). They made visible how actors have used the report as an element of soft coordination towards more ambitious climate pledges (Aykut et al., 2022; Hermansen et al., 2021). Its role as a tool for soft coordination was most visible in the context of the "wave of net zero emissions targets" (Höhne et al., 2021). The report played an important role in announcements, pledges, and indications of net-zero targets by many governments (Patt et al., 2022)

5.3.3 SR15 as a tool and rhetorical device to feed the momentum for urgency of climate action

The third script consists of a narrative arc aimed at creating and fostering a new sense of urgency in the broader public climate debate. In performances following this script, the IPCC is put on stage as a provider of universal science, as in Script 1, but here it is linked with emotional rhetoric and dramatic images of the impacts of climate change to emphasize the urgency of the climate crisis and increase political pressure. In a variety of performances, including campaigns by youth activists and climate-related media coverage, but also public officials and government representatives, SR15 has been used as a tool to create new symbolic and discursive momentum for climate action. The settings in which this script was most visible were the COP24 side events, youth protests inside and outside COP24, and media coverage of the report. Key actors were, in addition to the UNFCCC and COP Presidency speeches during side events, young activists, organized civil society, and journalists. Two

major patterns of performances, actors, settings and staging practices stand out in the empirical material (for details see also Appendix II.) First, SR15 is often referred to as a report that reveals that the world is in a climate emergency. The emergency framing can be identified as a rhetorical element for emotional wake-up calls in many speeches in the context of the COP, used, among others, by youth activists (Thunberg, 2019), country representatives (Ribera, 2019), and UNFCCC officials (Espinosa, 2019). In the aftermath of its publication, there were numerous official declarations of climate emergency, including 2089 jurisdictions in 39 countries[35] – often with direct reference to SR15. Closely linked to this emergency framing are omnipresent climate deadlines defined based on SR15 findings (Asayama et al., 2019). In the aftermath of the report, dwindling carbon budgets and the theme of climate clocks were ubiquitous at COP, including the logo of COP24 (Aykut et al., 2020), and in the wider climate debate (Hulme, 2019). The unprecedented media attention had a strong focus on short term-action until 2030 and a deadline of 12 remaining years (Boykoff and Pearman, 2019). Numerous climate activists, policymakers and journalists continuously referred to this number (Kohl and Stenhouse, 2021). In climate science, however, this caused a debate about the actual findings of SR15 and the role of deadline-ism in its uptake in the public debate (Asayama et al., 2019; Marvel, 2018). Several senior SR15 authors, (e.g., Coordination Lead Author Myles Allen, 2019), WGIII Co- Chair Jim Skea and lead author Kristie Ebi (Woodward et al., 2019), made their discomfort public, arguing that this deadline cannot be derived from the report. However, this was not the first time that IPCC authors were confronted with attempts to derive a year-based deadline from the report. According to Earth Negotiations Bulletin reporting, during the SPM approval session India and Germany suggested adding language to section C1 “noting that the 1.5 °C carbon budget would be exhausted within 10–15 years at current emissions rates” (ENB, 2018b, p. 9). While this language did not make it into the final SPM, the media reporting and extensive use of the emergency and deadline rhetoric inseparably linked this message to the report (Boykoff and Pearman, 2019). For the IPCC, this demonstrates its limited control over how its reports are used and staged, and what rhetorical devices and symbols are derived from them. It also reveals that apart from individual public statements by senior authors, the IPCC does not yet see the need, or does not have a mechanism, to respond to such viral misrepresentations.

The second major pattern consists in efforts by civil society and youth activists to bring the report out onto the stages of their campaigns, where “Unite behind the Science” was one of the key slogans in 2019 (Evensen, 2019; Marquardt, 2020). Many performances of this slogan and practices of staging the IPCC and its authors can be identified (Appendix II). One illustrative example of practices of putting the IPCC on stage is the side event with the presumably largest audience and the most media representatives at COP25. On 10 December

[35] See https://climateemergencydeclaration.org/, data retrieved: 23 November 2022.

2019, close to the scheduled end of the thus far rather unsuccessful COP25, Fridays for Future activists Greta Thunberg and Luisa Neubauer initiated an event in the so-called Climate Action Hub. Under the headline "Unite behind the science," they invited five scientists – two of them IPCC WG Co-Chairs, two of them leading authors in previous assessment cycles. Reflecting on the large platform and media hype surrounding her and the activists, Thunberg explained that they aimed to share this media attention with scientists. The two IPCC co-chairs brought onto the stage officially represented the IPCC and used the stage to explain its role, present key findings of recent reports and advertise its outreach activities. They praised the activists' efforts and thanked them for being "effective ambassadors for science." Put in the spotlight by the activists, they walked the fine line of calling for urgency while avoiding policy-prescriptive language. Their statements are best summarized by the shorthand that shaped many other IPCC outreach efforts: "Every bit of warming matters, every year matters, and every choice matters."[36] The other two panellists who were previously involved in the IPCC but did not officially represent the organization spoke much more vocally about climate (in)justice and climate emergency. In addition to the youth activists' staging strategy, this observation points to an ambiguity in IPCC speaker roles as an important feature of the IPCC as an organization that can be observed on many different occasions. In an organization characterized by the fluid membership of scientists in different authoring roles in different reports, working groups, and assessment cycles, this ambiguity in speaker roles is an effective strategy to manage otherwise incompatible expectations (Brunsson, 2017; Grothe-Hammer, 2019).

5.4 Discussion: main tensions deriving from multiplicity of expectations

A common feature of the observed performances and the three identified scripts is that SR15 and the trust associated with the IPCC is mobilized to lend (il)legitimacy to governance structures or certain political positions and demands. More specifically, the above patterns indicate that the IPCC is used as a resource for the following three political purposes: The first is to perform evidence-based policymaking in order to legitimize existing and emerging governance structures and promote multilateral climate action under the UNFCCC. The second is for political management and bargaining processes, including both hard multilateral politics and soft modes of coordination within and beyond the UNFCCC. And the third is for emotional and admonishing emergency claims articulated to increase political pressure for more ambitious climate action. As described in the more detailed script analysis in Section 4, scripts and mobilizing efforts are enacted in different settings, or "boundary spaces" (Ma-

[36] According to personal communication with an IPCC Secretariat official, it was developed by two co-chairs, "discussed among the Bureau, authors and communications team after the approval ahead of the press conference" and perceived as "informal communication tools which are not part of the official approved text."

hony, 2013b). While the first script is most visible in official SBSTA/UNFCCC negotiations and in the IPCC's self-staging efforts by official representatives of these organizations, the third script, by contrast, is most clearly seen in official side events with large audiences that are not part of the official negotiations, in youth protests, and in media coverage. The second script about hard politics and soft coordination is visible in very different contexts, from high-level negotiations to side events designed to facilitate soft coordination.

Before turning to the specific implications and challenges that the IPCC faces in this context, two conceptual considerations should be made about dramaturgical analyses: The analysis has shown that the relative importance of scripts varies in different settings and depends on the actors and alliances involved in performing and shaping them. Scripts should therefore not be understood as completely planned, but as the result of contested dramaturgical practices by a variety of actors in different settings. They are results of struggles over the resource SR15 for different political purposes and should therefore neither be seen as set in stone nor strictly separate. Scripts are in motion, can overlap and interact (e.g., soft coordination in Script 2 and maintaining momentum in Script 3). Struggles occur not only between the different scripts but also within the different scripts (e.g., the discussion about the mandate in Script 1). Secondly, it is important to emphasize that this dramaturgical analysis is only a snapshot at a particular point in time, focusing on the UNFCCC and IPCC processes. It is likely that scripts with different characteristics would be identified if the study had taken place at a different time or focused on different locations. In addition, it is expected that a more fine-grained analysis, e.g. on specific issues covered by the report, will identify different scripts for different specific issues (e.g., with respect to emissions reductions vs. carbon dioxide removal, CDR). Comparative case studies of CDR policy, for example, have shown that the report has played very different roles in different countries (Schenuit et al., 2021a). Despite these limitations, the dramaturgical analysis conducted here provides insights that are relevant to the IPCC and to science-policy-politics interfaces more generally. Table 5.1 summarizes the key findings and challenges for the IPCC, and the next sections discuss what recommendations this research holds for the IPCC.

Section 4 provided some illustrative examples of observations that point to the organizational challenges facing the IPCC due to the incompatibility of expectations. In a condensed way, they consist of: first, efforts to strategically question the IPCC’s successful fulfilment of and fidelity to its official mandate; second, the political embeddedness of the Paris Agreement and the spillover of political bargaining into IPCC assessment production processes; third, misrepresentations of its findings either by cherry-picking specific parts of its reports or by translating them into easy-to-communicate rhetorical symbols. Each of these challenges poses a major risk for the IPCC’s credibility and trust as boundary organization at science-policy-politics interfaces.

The dramaturgical analysis found that, already prior to the publication of SR15, the IPCC had started to proactively address some of these challenges. Among the organization's responses is a new communication strategy, which strengthens efforts of self-staging and is expected to help to communicate its fidelity to its mandate. In particular, new settings, such as the pavilion or extended social media platforms, provide the IPCC with opportunities for self-staging to provide consistent performances on its products, mandate and procedures. In addition, efforts to embed the IPCC in the broader context of climate expertise, particularly efforts by WMO and UNEP officials, are helping to bolster the IPCC in politically turbulent situations. Finally, the IPCC has the advantage of being an organization with a fairly small secretariat but a large and rather fluid set of authors and contributors. This leads to a situation in which IPCC authors who also have other professional roles at universities or research institutes can apply a strategic ambiguity in their roles as speakers. This grey zone, where scientists use their IPCC credentials but do not officially speak for the IPCC, are an effective strategy for living up to otherwise incompatible expectations.

Table 5.1: Overview of patterns and political purposes

	I. Policy-relevant, but not policy-prescriptive	II. Hard politics, soft coordination	III. Feed the emergency momentum
Patterns of performances and staging practices	▪ IPCC's self-staging and new outreach efforts ▪ Institutionalized cooperation between SBSTA and IPCC to perform evidence-based climate governance ▪ Debates about the formal mandate and capacity to provide a report on 1.5 °C; incl. IPCC as part of a "bouquet" of expertise	▪ IPCC processes as venue for performing fragility of 1.5 °C target compromise and emerging governance structures ▪ SR15 as an element of political bargaining about 1.5 °C goal ▪ SR15 as a tool to "keep 1.5 °C alive" politically ▪ SR15 as an element of soft modes of coordination for NDCs and net-zero pledges	▪ SR15 as main reference for declarations of climate emergency ▪ Derive and spread new deadline framings from the report ▪ Increase visibility of IPCC and science more generally to substantiate demands for climate action ▪ Ambiguity of IPCC speaker roles
Settings	COP24-26: IPCC pavilion, side events; SBSTA 49-50; IPCC SR15 assessment production (review, approval)	High level negotiations at COP21, COP24-26, IPCC assessment production (review, approval)	COP24 side events with large audiences; media reporting; youth protests
Actors	IPCC leadership and authors; UNFCCC/SBSTA representatives; country delegations; UN representatives	Country delegations, esp. Saudi-Arabia + small alliance; COP presidencies; most vulnerable countries, AOSIS	UNFCCC secretariat; COP presidencies; youth activist; ENGOs; media; most vulnerable countries, AOSIS
Resource for...	evidence-based policymaking to legitimize existing and emerging governance structures and to foster multilateral consensus	political management and bargaining processes under the UNFCCC including hard multilateral political bargaining and soft modes of coordination	emotional emergency claims articulated to increase political pressure for more ambitious climate action
Main challenges facing the IPCC	➢ efforts to question the IPCC's successful fulfillment of and fidelity to its official mandate ➢ spillover of political bargaining into IPCC assessment production processes leading to an obstruction of report production ➢ misrepresentation of its findings either by cherry-picking or by translating them into easy-to-communicate rhetorical symbols		

At the same time, the dramaturgical analysis identified weak spots in the IPCC indicating that these adopted communication and self-staging strategies as well as ambiguous speaker roles for its authors will not suffice to deal with the challenges posed by the incompatible expectations identified above. The controversy about the 12-year deadline highlights the growing importance of the IPCC's political responsibility for how its products are taken up, and shaping the wider climate debate (Asayama et al., 2019). Aside from individual authors speaking up in different ways, part of this responsibility could be addressed by establishing a transparent and clear mechanism within the IPCC Secretariat for dealing with misrepresentations of IPCC products that have a significant impact on public debates.

Moreover, to deal with disputes about the IPCC's mandate and SR15′s impact on research agendas, the IPCC would also need to revise its description of its role in the climate science community. The IPCC's structuring effects have been well documented (Cointe et al., 2019; Corbera et al., 2015; Hughes and Paterson, 2017; Oppenheimer et al., 2019; van Beek et al., 2022; Vasileiadou et al., 2011) indicating that its self-perception following a linear model of only assessing existing literature is insufficient. Transparency about its assessment procedures should include reflection on its role in climate science – including material and symbolic incentive structures in climate science, biases in the choice of disciplines and forms of knowledge to include in reports (Petzold et al., 2020; Victor, 2015), as well as existing knowledge gaps due to "undone science" (Hess, 2016). In the light of presumably more contested political environments in the future, the IPCC should address this mismatch between its formal mandate and its real world practices proactively in future assessment cycles. To ensure its credibility as a key boundary organization mobilized for incompatible political purposes, boundary work is needed to help ensure that its interface practices – just as with its efforts to avoid policy-prescriptiveness – are perceived as science-relevant, but not science-prescriptive.

The most challenging task, however, will be to prevent the spillover of political bargaining into IPCC processes. Dwindling carbon budgets, pressure from vested interests in the fossil fuel industry, as well as political struggles around specific solutions are expected to lead to even more polarized political environments for the IPCC. SR15-related conflicts within the IPCC and UNFCCC indicated that in the context of fundamental political conflicts, the functionality of the existing assessment practices cannot be taken for granted. If more parties were to join an obstructionist camp in future assessment processes, reaching consensus in, for example, scoping and SPM negotiations could become harder, or even impossible. This fundamental problem, however, cannot be solved within the IPCC alone. The future embedding of the IPCC in UNFCCC governance structures, and the expectations that policymakers within and beyond the UNFCCC, journalists, and civil society impose on the intergovernmental body will also play an important role.

5.5 Conclusion

The IPCC is brought out onto the world stage for different political purposes. The dramaturgical analysis of SR15 presented here has shown that now more than ever, the IPCC is embedded in the politics of multilateral climate governance and is considered a key and strategically mobilized resource for (de)legitimizing governance structures and policy positions and demands in the post-Paris climate regime. Following on strands of existing research that highlight the symbolic and discursive elements of post-Paris climate governance, this article further developed the analytical tools to study the dramaturgical politics at science- policy-politics interfaces in global climate governance. Applied to the case of the IPCC's SR15, combining diverse sources of empirical material, this analytical framework allowed to study the IPCC's interface practices from a bottom-up perspective and identified recommendations for upcoming political challenges and reform debates. The key finding is that the IPCC is brought on stage in a variety of different contexts by a multiple and diversifying set of actors, with limited control over what it is mobilized for. While the dramaturgical perspective is not the only research design capable of identifying struggles in different boundary spaces, this article showed that placing performances of IPCC's strategic mobilization at the center of research can complement existing research that focuses on the conditions of assessment production.

Although the IPCC's new proactive stance on dissemination and communication strategies can be seen as a first step in addressing the challenges identified, more strategies would need to follow. In particular, if the Paris Agreement were eventually evolve from the current "claim and shine" to a "name and shame" regime (Aykut et al., 2022), the IPCC's assessments are likely to become more politically contentious and the long identified need for reform would become more pressing (see e.g., Beck et al., 2022; Carraro et al., 2015; Edenhofer and Kowarsch, 2015; Geden, 2018; Hulme et al., 2010; Pryck and Hulme, 2022). In addition to a fundamental debate on the IPCC's mandate and its self-perception (Beck, 2011; Grundmann and Rödder, 2019), two practical reforms could help address these challenges. First, a clear misrepresentation response mechanism that establishes transparent and practicable criteria and procedures for the IPCC to react as an organization in case of misleading claims. Secondly, and much more difficult to implement in practice, the IPCC requires new safeguards to prevent IPCC assessment processes from becoming simply another option in political venue shopping for escalating conflicts in international climate politics.

Taking a step back, the results of the analysis also show that, just as with policymaking, the production and performance of global environmental assessments are inextricably linked. In the future, exploration of the interfaces between science, policy and politics should focus not

only on co-production, which usually leads researchers to turn to the IPCC's internal processes i, but also on the co-performance of assessments.

For future research, three areas would be of particular interest. First, in-depth case studies on dramaturgical practices, focusing on other AR6 or AR7 products and other settings such as national climate policymaking and non-state climate action. In addition, examining expectations of the IPCC within the scientific community in more detail and gaining a better understanding of its material and immaterial structuring effects would be relevant next steps. Finally, the dramaturgical perspective could be extended to other areas of global governance in order to explore the politics of the production and performance of different legitimacy resources in hybrid governance regimes.

6 It's a Performance, Not an Orchestra! Rethinking Soft Coordination in Global Climate Governance[37]

6.1 Introduction

The opening ceremony on December 2, 2019, set the tone for the United Nations (UN) twenty-fifth Conference of the Parties (COP25) in Madrid. While the conference's official aim was to finalize the Paris Agreement's governance framework, it also represented an occasion to build momentum ahead of the scheduled resubmission of nationally determined contributions (NDCs) in 2020. Politicians and celebrities, among them the presidents of Chile and Spain, musician Alejandro Sanz, and UN secretary-general António Guterres, addressed the audience of delegates and observers with emotional speeches expressing indignation and moral outrage but also outlining reasons for hope and signs of progress.

To international relations scholars trained in the analysis of formal institutions and the sober play of state interests, such public happenings might appear anecdotal and ultimately irrelevant for serious analysis. After all, a common understanding in the field holds that international regimes coordinate collective action through common "principles, norms, rules, and decision-making procedures" (Krasner, 2004, p. 2)—not through drama and performance. However, global governance has undergone major changes over the last decades. In many areas, hard regulation through legal rules gave way to soft governance modes (Abbott and Snidal, 2000), which operate through global goals (Biermann et al., 2017), transparency mechanisms (Gupta et al., 2020), the provision of incentives (Abbott, 2018) and expert knowledge (Mitchell et al., 2006), and the emission of signals and discourses for global audiences (Death, 2011). Rather than directly prescribing a certain conduct, these new forms of authority target addressees' beliefs and expectations (Krisch, 2017).

In the international climate change regime, the Paris Agreement adopted in 2015 marks such a transition (Aykut et al., 2021). Climate governance moved from a "regulatory" approach with binding reduction commitments for states to a "catalytic and facilitative model" (Hale, 2016) that combines two strategies of soft coordination: first, an ambition mechanism aimed at aligning national climate policies through a system of common objectives, NDCs, and public review and resubmission cycles, and second, measures to orchestrate" private and subnational climate action, for instance, through the Marrakech Partnership for Global Climate Action and the Global Climate Action Portal (NAZCA). This shift from hard to soft modes of coordination has sparked debates about its effects and conditions of effectiveness. These usually address soft coordination from legal or institutionalist perspectives, for instance, by

[37] Aykut, Stefan C., Felix Schenuit, Jan Klenke, and Emilie d'Amico. 2022. "It's a Performance, Not an Orchestra! Rethinking Soft Coordination in Global Climate Governance." Global Environmental Politics, September, 1–24. https://doi.org/10.1162/glep_a_00675.

examining relations of delegation between central and subordinate governance bodies (Abbott, 2018) or by defining ideal-typical governance functions (Oberthür et al., 2021). However, this disconnects analyses of soft coordination from the social agents that populate global climate governance and give life to its mechanisms. As a result, statements on the effectiveness of the Paris framework often rely more on theoretical assumptions than on empirical observation. This applies to the capacity of the agreement's ambition mechanism to build trust and exert pressure (Gupta and van Asselt, 2019). It also applies to the question "whether and for how long the United Nations Framework Convention on Climate Change (UNFCCC)—the Conference of the Parties (COP) or the Secretariat — has been an orchestrator" and, if so, "through precisely what causal mechanisms" they have exerted influence (van Asselt and Zelli, 2018, p. 36)

This article proposes a change in perspective. Instead of formal relations of authority or governance functions, we place the focus on social interactions at UN climate conferences to examine soft coordination *in practice*. Who initiates coordination attempts and where? How, through which practices and mechanisms, does soft coordination unfold? Importantly, interactions at climate conferences take place in a highly mediatized environment and entail public performances of transparency, disclosure, and review (Kinchy and Schaffer, 2018). To capture these symbolic dimensions, we use "dramaturgical policy analysis"—an approach that examines how discursive and dramaturgical interventions shape public performances of authority (Edelman, 1985; Hajer, 2009). Contrarily to studies that operate a clear distinction between "performative" and "substantive" politics (e.g., Ding, 2020), such a perspective assumes that performances are neither secondary nor a distraction but core governance features.

Empirically, the article analyzes COP25 in Madrid in December 2019. It combines ethnographic observation, background interviews, document analysis, and systematic coding of standardized observation notes to identify patterns of influence and agency in soft coordination. The qualitative research design sheds light on both direct and indirect, noncodified sources of influence, which rest on the day-to-day work of implementing governance mechanisms, circulating communicative frames, and shaping global norms.

6.2 A dramaturgical approach to soft coordination

One of the most pressing questions in climate governance scholarship is whether and how a governance architecture based on self-determined pledges and transparent reporting of state and nonstate agents can achieve climate goals. Orchestration is often seen as an analytic lens to answer this question (Abbott, 2018; Hale and Roger, 2014). It refers to an "indirect mode of governance that relies on soft inducements," such as the provision of incentives, as

well as on the creation of intermediaries (Abbott, 2018, p. 189). The metaphor also points to a central conductor or principal, who coordinates other agents' behavior. But is this the right metaphor? In other regulatory fields, orchestration usually refers to direct, hierarchical modes of intervention. However, direct control is rare in global governance. Moreover, there frequently is not one but several potential conductors. Reflecting on the Sustainable Development Goals, Biermann and colleagues (2017, p. 29) therefore suggest that "a better description for governance through goals might even be conductorless jazz." Of course, even conductorless jazz follows rules imposed by harmonies and progressions, standards that provide structure, roles attached to instruments, and expectations of different audiences. But the plea for a metaphor and analytical lens that pay more attention to practice, performance, and distributed forms of agency is spot-on. With this in mind, the section reviews the existing climate governance literature on soft coordination along three guiding questions: Who coordinates (*agents*)? Where does coordination take place (*sites*)? and How does it unfold (*mechanisms*)?

6.2.1 Who? Widening the focus to treaty secretariats and nonstate agents

Formally, the supreme governing body in the international climate regime is the COP. Two other main bodies treat issues related to the Kyoto Protocol (Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol, CMP) and the Paris Agreement (Conference of the Parties serving as the meeting of the Parties to the Paris Agreement, CMA), while more specific questions are delegated to subsidiary bodies (Subsidiary Body for Scientific and Technological Advice, SBSTA, Subsidiary Body for Implementation SBI, and ad -hoc bodies). In all of these, state delegates decide by consensus. This state-centric and hierarchical organization contrasts with the polycentric nature (Jordan et al., 2018) and multiagent network structure (Saerbeck et al., 2020) of contemporary climate governance. Of course, this is not entirely new. There is a long history of nongovernmental organizations (NGOs) shaping global environmental governance by providing technical expertise, raising public attention, and building transnational networks (Betsill and Corell, 2007). But the Paris regime takes this one step further by encouraging private and subnational entities to contribute directly to reducing emissions (Hale, 2016) and NGOs and think tanks to support the process by scrutinizing country submissions, tracking implementation, and exerting pressure on laggards (van Asselt, 2016).

Another type of governance agent that has attracted scholarly attention recently comprises international bureaucracies, which are found to exert different forms of influence in different phases of the policy process (Biermann et al., 2009). Treaty secretariats in particular organize state relations, frame issues, and manage institutional overlaps, especially when state preferences have not yet solidified (Jinnah, 2014). The UNFCCC Secretariat (hereinafter the

Secretariat) is a good example. Despite a "prohibitively strict mandate as a technocratic facilitator," it adopted a proactive "entrepreneurial" role in Copenhagen in 2009, and then again a decade later, after US president Trump's announcement to withdraw from the Paris Agreement, when it acted as a "knowledge broker" and "communication hub" for stakeholders to ensure the continued centrality of the UN process (Well et al., 2020). This and other studies show that only a practice-based perspective interested in "what international bureaucracies [and other governance agents] 'do,' rather than what they 'are'" (Littoz-Monnet, 2020) allows for full capture of the new complexity of a polycentric climate governance regime, in which a variety of agents participate in implementing governance goals but also in shaping the new regime. This means widening the focus from the formal authority of the COP and relations of delegation to distributed forms of agency and practices of (soft) coordination.

6.2.2 Where? Global climate conferences as sites of coordination

Over the last decade, climate governance scholars have grown an interest in "the ability of the UNFCCC to bring together different actors across time and space" and in global summitry as a "facilitative practice that holds the polycentric regime complex together" (Lövbrand et al., 2017, p. 580). This builds on critical governance literature traditions, which have analyzed the symbolic and performative dimensions of UN conferences as transnational mega-events (Aykut et al., 2017, p. 20; Campbell et al., 2014; Little, 1995, p. 195). Paul Little's (1995) account of the 1992 Rio conference, for instance, identifies the endless litany of speeches by heads of state and government during the opening ceremony as a series of performances directed at their respective home audiences. Carl Death (Death, 2011, pp. 9–10) identifies the 2002 Johannesburg and 2009 Copenhagen conferences as attempts "to inspire and conduct the self-optimization of the watching global audience" and as a "distinct technology of government" in which symbolic aspects are not sideshows but core governance instruments.

For these authors, global mega-conferences transcend formal negotiations; they are also important loci for the production of meaning, new discourses, and policy frames. This perspective allows for analysis of recently growing expectations for climate conferences to support the "momentum" of public and private climate action by staging success stories and positive narratives (Chan and Pauw, 2014) and by signaling commitment to policy makers and investors (Biniaz, 2020). COPs are thereby understood as transnational mega-events combining different social spaces that spread out concentrically across the host city (Dahan et al., 2009). These include a negotiation space with access limited to negotiators and some observers; a trade fair of ideas and climate solutions within the so-called Blue Zone, which is open to a larger public of accredited global experts, NGOs, media, and businesses; and a popular happening, with self-organized meetings, cultural events, and demonstrations in public spaces.

6.2.3 How? Global governance as drama and performance

Soft governance works by aligning expectations, creating trust, and altering preferences (Bang et al., 2016). However, as discussed earlier, legal and institutionalist analyses often lack the analytical tools to examine these elements. Network analyses provide a useful complement in highlighting informal relations and information flows (Saerbeck et al., 2020). But they, too, are less helpful for understanding the role of symbols, discourses, affects, or sentiments in international communication. Governance bodies frequently use "visual, verbal, and gestural symbols to foster an impression of good governance" (Ding, 2020) or resort to emotional messaging, alternating "positive" self-praise with "negative" messaging focused on threats and dangers (Patz et al., 2022, p. 202). To capture these communicative and affective dimensions, we draw on Marteen Hajer's (2009) dramaturgical perspective on politics. This places the focus not only "on *what* people say" but also on "how they say it, where they say it, and to whom they say it" (Hajer, 2009, p. 65). Hajer introduces four basic analytical categories: staging, scripting, setting, and performance. In table 6.1, we adapt his definitions to foster an analytical tool kit for the observation of global climate governance.

Table 6.1 Dramaturgical Practices at UN Climate Conferences

Practice	*Definition*
Scripting	The *script* defines the general character of a UN conference: its purpose, sequence of events, and narrative arc. It also comprises implicit rules of behavior along with more specific instructions laid out in treaties, decisions, and rules of procedure. *Scripting* denotes attempts to operationalize existing rules or introduce new ones or to shape the overall narrative of a conference. This includes shaping expectations for appropriate behavior and determining the set of *roles* that are available to participants in a given setting (*role provision*). *Counterscripting* challenges prevalent scripts by questioning existing rules or recasting roles.
Setting	*Setting* denotes the provision and design of stage(s) where performances take place, their spatial distribution across a conference space, and the equipment of performances with accessories, artifacts, and symbols that interpret the script.
Staging	*Staging* refers to the overall organization of interactions and performances in a multilateral setting. It entails selecting and applying a script; interpreting it by establishing links to existing and/or new symbols and characters; and providing material, symbolic, or reputational incentives for agents to engage in dramaturgical practices. Staging establishes a distinction between actors and audience(s). By extension, it therefore also includes interventions aimed at bringing other agents virtually "onstage" by referring to them, quoting them, highlighting their achievements, or voicing their concerns.
Performing	*Performances* are public interactions during a conference that enact a script and produce social realities. Actors thereby engage in technical debates or emotional statements within given settings, embody preset roles (*role taking*) or reshape them (*role making*), and creatively interpret and improvise on scripts.

Adapted from Hajer (2009).

The dramaturgical perspective builds on a sociological understanding of human interactions as a series of staged "scenes" in which individuals act (or *perform*) in a specific social context (*setting*), according to implicit and explicit rules of behavior (*scripts*) and bundles of expectations (*roles*) (Goffman, 1959). Agents onstage—*actors*[38]—follow scripted roles and instructions but also creatively interpret and reshape these. Shifting analytical attention from formal rules and functions to staged performances permits examining soft coordination through the design of material settings, the scripting or sequencing of events, and the provision of roles for conference participants. Seen through this lens, global climate governance appears as an always temporary, more or less stable convergence of expectations about scripts and roles, shaped not only by treaties and legal documents but also by dramaturgical interventions of different agents and creative performances before varying audiences.

6.3 A bottom-up perspective on a bottom-up regime

Our collective research included a series of preparatory and follow-up meetings and a two-week "collaborative event ethnography" (Aykut et al., 2017; Campbell et al., 2014) at COP25. We used standardized observation templates, data-sharing routines, and regular exchanges of experiences to produce 110 observation notes (see Annex 2 for a sample). These cover negotiation sessions accessible to observers, plenary sessions of COP bodies, high-level and Presidency events, and side events. Although these formats have different purposes, all of them take place before an audience and hence include a performative dimension. In this section, we examine first the overall *script* of COP25 and then its spatial, material, and organizational *setting.* Performances are analyzed in the next section.

6.3.1 The script: A transition from negotiations to implementation

On paper, COP25 was only intended to be a "transition COP" to finalize the post-Paris architecture. This included operationalizing the carbon markets mentioned in Article 6 of the agreement and finalizing the reporting and assessment framework of its "ambition mechanism." The latter combines a continuous assessment process—the "enhanced transparency framework"—that progressively supersedes existing assessments under the Convention and a collective review or "global stocktake" every five years. In Madrid, negotiations on transparency covered topics like "structured summaries" for biennial transparency reports, "common reporting tables" for greenhouse gas inventories, and "common tabular formats" for reporting progress on implementation. Success in these negotiations was considered vital to start the upcoming review cycle in time, as a first round of assessments under the new

[38] We speak of *actors* in this article when individual agents perform a role or embody a character onstage.

framework was scheduled for 2022, followed by the global stocktake a year later and new NDC submissions in 2025.

But communication by the Chilean Presidency also framed the conference as an occasion to build momentum for new country pledges and increased participation of nonstate agents. This corresponds to a shift in focus from the COP as a negotiation body to the larger conference space as an arena to facilitate global climate action (Kinley, 2017). As transnational mega-events, UN climate conferences provide a forum and site of convergence for diverse agents and a focal point for climate-related communication. In this facilitative practice, the rotating COP Presidency and Secretariat are key. Together, they determine the spatial and visual organization of the venue and the sequence of side events accompanying the negotiations. The Secretariat controls the formalities of access and accreditation of organizations, provides information, and assists the negotiations (Saerbeck et al., 2020). The Presidency has a more explicit agenda-setting function, branding an overall theme—for COP25, *Blue COP*—and organizing Presidency events (UNFCCC Secretariat, 2020).

6.3.2 The setting: a mega-event designed as a signal for global audiences

COP25 took place under the shadow of an increasingly polarized global political situation and intensifying conflicts over climate and energy. The year 2019 had seen an unprecedented global youth mobilization for climate action but also a wave of protests against social and economic inequalities, which put the theme of a "just transition" at the heart of debates. Political turmoil also ushered the relocation of COP25 from Brazil to Santiago de Chile (after Jair Bolsonaro retracted Brazil's commitment), and then to Madrid (when social unrest erupted in Chile). This broader context shaped performances within the conference space in terms of participants, themes, and frames, as well as outside, for instance, at the climate march organized midway through the conference.

Despite the very short planning time due to the last-minute move from Chile to Spain, the design of the venue reflected both this broader context and the new expectations placed on the UNFCCC process. The Chilean Presidency framed COP25 as a critical moment to address the climate emergency. Its communication strategy used illustrative symbols like a dissolving clock and a strong urgency frame, underpinned by references to scientific facts. In the corridors leading from the Feria de Madrid metro station to the conference building, large billboards referenced projected warming impacts, such as an estimate of 143 million climate-related migrants by 2050. In the conference's corridors, halls, and pavilions, calls for "climate action" or to "act now" were ubiquitous, echoing the official COP slogan #tiempodeactuar (time for action). While emergency frames have a long history in climate debates, this official urgency branding appears as a specific feature of COP25.

Another striking element of the venue was the so-called Climate Action Hub. The central location of this space, situated right after the entry and credential check, its name, and its design—a half-open space reminiscent of an ancient amphitheater—stood symbolically for the will to reach beyond governments and directly address wider (global) society. To reach the negotiation rooms situated on the other end of the vast conference complex, delegates had to pass through long hallways with civil society booths and national pavilions. They could thus get a sense of a global society in action. Some of these arrangements may reflect material limitations imposed by the venue. But a similar spatial organization at COP26 in Glasgow a year later, including an immense Climate Action Zone in the form of a sports arena, suggests that the design was not coincidental. Both the script and the setting at COP25 hence prepared the stage for performances centered on creating transparency, conveying a sense of urgency and activating the potential of global climate action.

6.4 Time for action! Decoding the COP climate theater

Speeches and public performances at COP25 crystallized around recurring patterns of interaction that can be schematized into a set of social roles. To illustrate these, consider the following quotes from UN secretary-general António Guterres' speech at the Global Climate Action event on December 11, before a packed and cheerful audience:

> *The scientific evidence presented in recent weeks has only heightened the urgency. The world is getting hotter and more dangerous faster than we ever thought possible. Irreversible tipping points are within sight and hurtling towards us. As the logo for COP25 suggests, it is five minutes to midnight in the global climate emergency.*

Guterres then recalled the UN Climate Action Summit in September 2019:

> *Today, I'm pleased to release my report from the summit. It is already available in the UN website and the UNFCCC website. It captures what the summit delivered. . . . We're still a long way from our objective of a carbon neutral world by 2050.*

He closed his remarks on a positive note:

> *I'm delighted to see that momentum continues to grow as we are seeing it today here. Led by Chile, the Climate Ambition Alliance was launched at the Climate Action Summit in New York. Seventy countries signed up along with 100 major cities, they were joined by businesses worth combined $2.3 trillion and the investors managing over $2 trillion .... In short, the summit provided the global stage to show who is stepping up.*

The quotes exhibit a typical narrative arc for speeches at COP25. The first paints an alarming picture of the climate emergency. The second highlights efforts to gather and assess data on climate policy. The third depicts growing momentum for climate action in society. From a dramaturgical perspective, the quotes point to distinct social roles that Guterres embodied during his talk. These three roles also structured other public performances at the conference.

6.4.1 A tale of accountants, admonishers, and animators

We first identified these roles in the course of an exploratory, inductive screening and discussion of our observation notes. Further analysis then helped to describe them in more detail and track their occurrence across different settings.[39] *Accountants* scrutinized country submissions in official assessment formats, discussed reporting requirements and review methods in the negotiations, and presented new data-generation methods in side events. This role was mostly enacted by state delegates and representatives from NGOs and think tanks. The two additional roles used a more emotional register to disseminate contrasting images of possible futures. *Admonishers* warned of the consequences of runaway warming and stressed the urgency to act by referring to scientific assessments or climate-related catastrophes. This role was embodied by scientists and activists, the COP Presidency, public figures, and senior government representatives. *Animators*, by contrast, engaged in positive storytelling and motivational speeches, highlighting success stories and best practices. They conveyed the impression that the low-carbon transformation is already unfolding. This role was frequently enacted by representatives from firms, cities, and consultancies but also senior UN personnel. As in the preceding example, actors would often switch from one role to another during a speech, adding to the dramatic intensity of their performances.

To understand how these roles shaped the conference's dramaturgy, we analyzed quantitatively where and in what circumstances they appeared. We constituted a subcorpus of fifty-two observation reports covering the negotiations (seventeen, including six plenary sessions), high-level and Presidency events (fourteen), and side events (twenty-one).[40] Plenary negotiation sessions serve to take stock of progress made in smaller informal meetings and to adopt decisions. High-level and Presidency events do not take decisions. Typically less formal, they target a larger audience. Side events provide a platform for observer organizations highlighting diverse issues. Using MAXQDA software, we applied five codes to this subcorpus. We coded the appearance of the three roles before examining where they coin-

[39] We examine the three roles in more detail in Aykut et al. (2020).

[40] This sample was selected with a focus on mitigation-related issues and Blue Zone events. Following the official program, six Marrakesh Partnership events organized in the Action Hub were grouped as side events. Two others, organized respectively as high-level and Presidency events, fall into these categories. Annex 1 provides a full list.

cided with practices of *scripting* and *staging*.[41] Although the quantified data must be interpreted with some care, they provide instructive insights into patterns of performances at COP25 that complement the qualitative analysis.

Table 6.2 shows which roles were prevalent in which event types. We find that negotiations mainly provided a stage for accountants. By contrast, side events staged all three roles, with many instances of animating talk, but also accounting and admonishing performances involving NGOs and think tanks. High-level and Presidency events frequently featured prominent figures embodying admonisher and animator roles. This points to a greater dramatic intensity, or *theatricality*, of these stages.

Table 6.2: Distribution of Roles Across Event Types

Stage	*No. Coded Segments*		
	Admonisher	*Accountant*	*Animator*
Side events[a]	63	81	**152**
High-level and Presidency events[b]	**199**	96	**167**
Negotiations and plenary events[c]	24	**135**	27

Values in boldface indicate the prevalent role(s) in an event type.

[a]*n* = 21. [b]*n* = 17. [c]*n* = 14.

Table 3 shows where practices of *scripting* and *staging* coincided with one of the roles (additional information in Annex 3). Negotiations were key sites for *scripting* the accountant role, reflecting the official aim at COP25 to complete the Paris rulebook. Delegates often expressed diverging views on the format of public reporting and the practical organization of assessment exercises. During the first week of informal negotiations on common tabular formats for country reports for example,[42] the European Union, US, and Swiss delegates wanted to discuss common reporting tables, while the Chinese delegate argued that the structured summary "can have different formats, including tables, narratives, graphs." This seemingly technical question will shape the practice of future assessment exercises by determining how accounting performances will be *equipped*. The final COP decision, the so-called Chile Madrid Time for Action, provides another example for scripting. It "requests" the Secretariat to prepare a synthesis report on NDCs for COP26, hence assigning it an accountant role.[43] By contrast, table 6.3 also shows that side events, high-level events, and

[41] Annex 3 contains details on codes, keywords, and the coding process.
[42] SBSTA informals on CTF tracking progress, December 5, 2019.
[43] See Decision 1/CMA.2, para. 10, which builds on Paris decision 1/CP.21, para. 25 (2015).

Presidency events were key venues for *staging*, in which animators and admonishers voiced the concerns and presented the achievements of a wider variety of agents.

Table 6.3: Co-occurrence of Practices and Roles Across Event Types

Role/Practice	*Scripting*			*Staging*		
	Account-ant	*Anima-tor*	*Admon-isher*	*Account-ant*	*Anima-tor*	*Admon-isher*
Negotiations and plenary	92	7	7	10	14	7
High-level and Presidency events	44	39	34	23	101	78
Side events	42	57	13	21	84	27

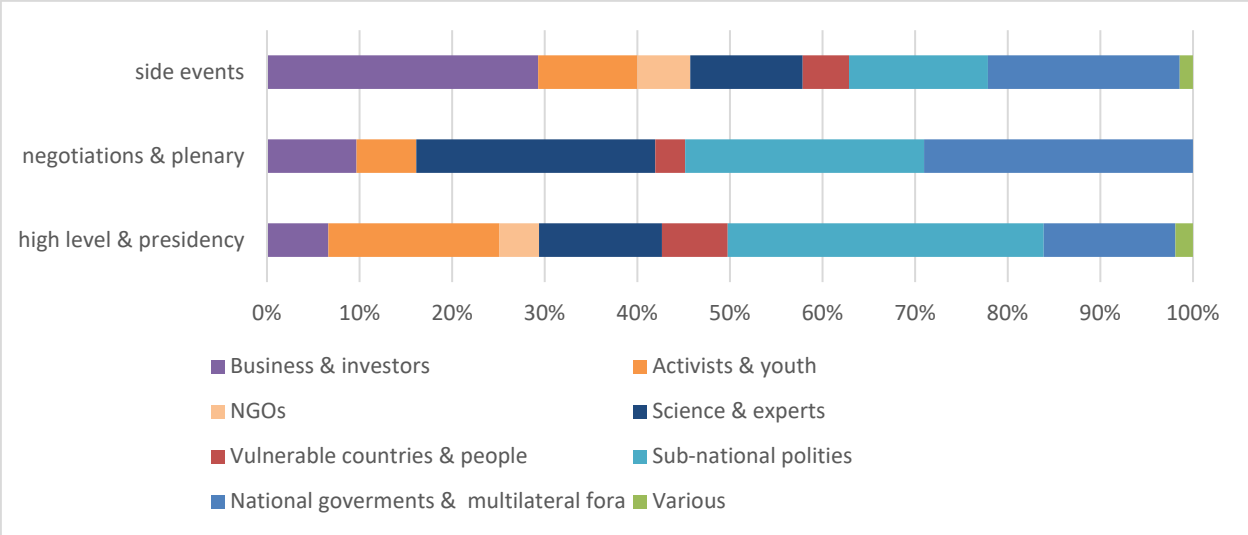
Dark shaded cells indicate prevalent combinations of practices and roles in an event type.

We thus identify different spaces and logics underlying the construction and enactment of social roles at COPs. While the accountant role was explicitly scripted in negotiations among state delegates, the animator and admonisher roles were shaped largely in public performances staged in the wider COP arena.

6.4.2 Polycentricity as performance

A dramaturgical perspective also sheds new light on polycentricity in global climate governance. In a context where UN climate conferences have come to constitute performative events for global audiences (Aykut et al., 2021), staging polycentricity becomes a key governance technique. Through their flesh-and-blood presence onstage or as reference points in public speeches, nonstate actors embody important elements of the new regime. Activists, experts, and scientists personify public scrutiny and social pressure. Businesses and subnational authorities represent momentum for climate action. In the post-Paris regime, COPs also gain legitimacy as *the* political space and moment where all these voices are heard, and global agendas seemingly align on their demands. To understand how this played out during COP25, we examined which types of agents were *staged*, that is, referred to in speeches at different events (Figure 6.1).

Figure 6.1: Agents "Staged" Across Event Types



While negotiations only displayed sporadic instances of staging, mostly of scientists and subnational entities, a greater diversity of agents populated interventions in high-level, Presidency, and side events. There, admonishing interventions frequently cited vulnerable communities, scientists, and youth activists, whereas animating speeches often referred to bold climate action by businesses and investors, cities, and states. Overall, side events and high-level events involved the greatest diversity in terms of both speakers and agents mentioned in interventions. They also displayed the highest level of *theatricality* by combining high degrees of dramatic intensity, emotionality, and publicity. As an example, take this excerpt from a speech by entrepreneur and high-level champion for climate action Gonzalo Muñoz during the Energy Action Event:

> *We are suffering a crisis of empathy. We, people in this room, are not the ones that are suffering most of the real problems, daily basis. . . . The ones that have less possibility of adapting, the ones that are suffering on a daily basis, they are probably not very connected to the documents that have to be signed. . . . We have to be much more empathetic, and, as I said yesterday, it's not only about people; it's about many other species. And the message is that we have to love all children of all species for all times.*[44]

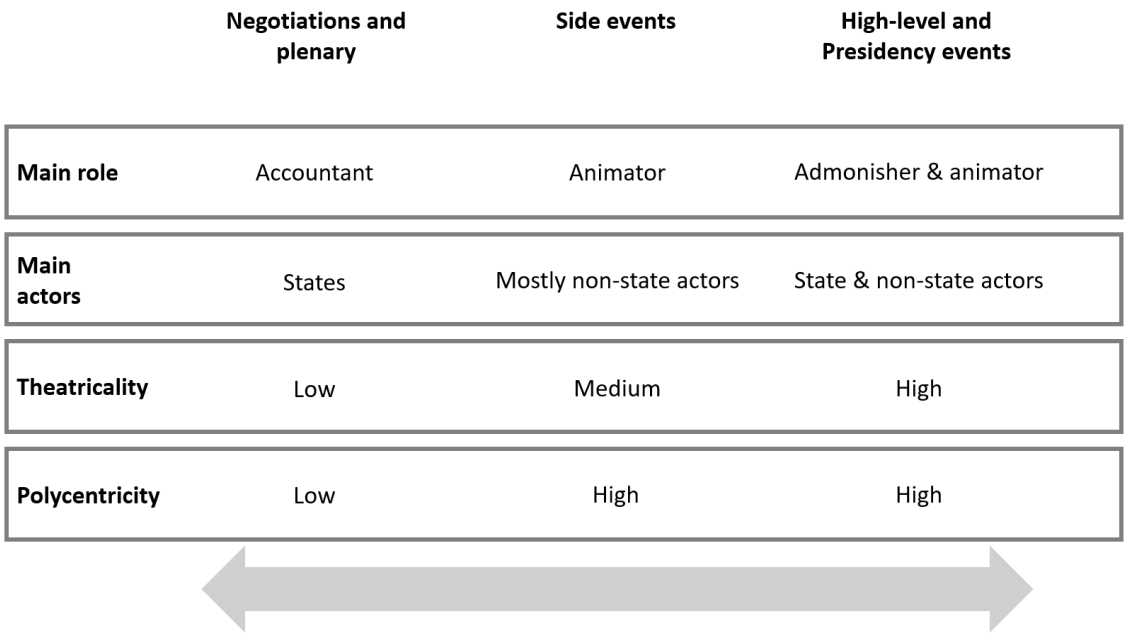
High-level and Presidency events hosted dramatic performances depicting the risks of runaway warming or summoning delegates to act. Interventions in these arenas, often by senior officials and public figures, fundamentally differed from interventions by state delegates in negotiations. The former seized the stage provided by the COP to perform before a global

[44] COP25, "Climate-Proofing Global Energy Systems," Global Climate Action event, December 7, 2019.

public, using emotional language and dramatic pictures to narrate encouraging success stories or invoke the struggle of vulnerable communities and demands of youth activists. The latter performed in technical accounting formats, used less emotional language, and frequently engaged in discussions over the script of future assessment exercises and appropriate behavior in these settings.

Figure 6.2 provides a synoptic presentation of our findings concerning the character of different settings at COP25. Our analysis indicates that different spaces and event formats at the Madrid conference appeared to afford specific types of acts, roles, and audiences. But in practice, performances were not only shaped by their setting; they also depended on actors' performing skills, on their interpretation of roles and scripts, and on the outcome of efforts to rescript aspects of a play. Accordingly, performances always combined elements of top-down guidance and bottom-up agency.

Figure 6.2: Characterizations of Different Settings at COP25



6.5 Dramaturgical interventions as mechanisms of soft coordination

While important elements of the current governance transition are scripted in the Paris Agreement and subsequent COP decisions, the texts leave room for interpretation. Agents at COP25 used this room to creatively shape the new regime. Earlier, we showed that this involved interpreting scripts and roles in public performances. Here we take a step back and

identify three types of dramaturgical interventions that were frequent at COP25 and represented distinct strategies of soft coordination: *rehearsals* aimed at preparing state-led accounting exercises through training and equipment, *role provision* was used to shape expectations of appropriate behavior in public performances within the wider conference space, and *counterscripting* consisted of challenging aspects of the current governance approach throughout all event types and outside the conference halls.

6.5.1 Rehearsals: preparing the grand accounting theater

The Paris ambition mechanism combines a continuous assessment process, regular moments of collective review, and the resubmission of country pledges. These upcoming reviews and assessments partly build on existing formats. Even where they do not explicitly do so, the path dependency of UN diplomacy means that they can be expected to largely emulate existing assessment practice. The Talanoa Dialogue organized between 2018 and 2019, for instance, was widely considered a test run for the first global stocktake. The "stocktake on pre-2020 implementation and ambition," an additional format mandated at COP23 on the demand of developing countries, provided another illustration for current assessment practice. At COP25, it consisted of a "technical" and a "high-level" session.[45] The latter took the form of a panel discussion, with representatives from Rwanda, India, St. Lucia, Finland, and France presenting their climate policies, implementation progress, and expected financial support. Even though a recurring mantra in speeches at COP25 was that "the world is watching," the session only attracted limited public attention. It was conducted in a technocratic accounting style, with varying degrees of detail and types of information presented. Delegates frequently criticized unspecified ambition gaps whithout blaming individual countries. Rather than offering moments of critical scrutiny and peer control, the exercise thus constituted an occasion for self-staging and displays of punctual successes.

The Talanoa Dialogue and pre-2020 stocktake stand as *rehearsals* for upcoming review and assessment exercises, such as the regular "multilateral consideration of progress" (Article 13) or the grand accounting theater of the global stocktake (Article 14). However, current assessment practice enacts an inverted version of the principle of "name and shame" by providing a stage for participants to "claim and shine." This partly corresponds to the Paris Agreement's script, which insists on the "non-intrusive," purely "facilitative" nature of accounting exercises (Article 13). But it also stems from the way in which delegates enacted this script at successive COPs, where they refrained from direct criticism of their counterparts. This seemingly apolitical design (Weikmans et al., 2020) of existing assessments reflects substantial underlying political tensions. It is therefore hard to change directly. Despite this, a

[45] The following quotes are from COP25, "COP 25 Stocktake on Pre-2020 Implementation and Ambition," observation notes, December 4 and 11, 2019.

series of agents at COP25, including representatives from think tanks and NGOs, engaged in efforts to improve current assessment exercises. The Secretariat took an active part in such efforts. It intervened in events to signal the need to reinforce countries' reporting capacities. It also produced technical inputs on guidelines for national communications, concept notes to clarify the mandate of international experts, and proposals for partnerships with climate data providers. This strategy of including nonstate agents in transparency performances within the UNFCCC culminated in the workshop "Pressing 'Record' on Climate Action" on December 9 in one of the larger meeting venues.[46] There Luis Alfonso de Alba, UN special envoy for the 2019 Climate Action Summit, sketched an extended role for the UNFCCC in compiling and examining private climate action, including by proactively engaging discussions with climate data experts on new formats and indicators to support the global stocktake. In the words of a representative of the incoming COP26 Presidency, this would add a new voice to the "common song" of global climate action, alongside country submissions. By proactively supporting existing assessments, and by using side events to mobilize actors and equipment for upcoming ones, the Secretariat positioned itself as a key body in post-Paris climate governance.

6.5.2 Role provision: creating momentum for climate action

Another type of dramaturgical intervention shaped events in the wider conference space. Mandates and scripts for such events are usually less defined than they are for multilateral processes. This gives considerable leeway to organizers, especially the Secretariat and the Presidency. By selecting, scheduling, and sequencing events, they provide visibility to specific issues, frames, and agents (UNFCCC Secretariat, 2020). The Chilean Presidency used these prerogatives to imprint an urgency framing on COP25 by branding the slogan Time for Action and through a series of events that provided a stage for admonishers. A high-level event Climate Emergency was organized during the second week on the conference's plenary stage.[47] Environmental scientist Johan Rockström opened the event by presenting research on climate tipping points. This set the scene for other panelists, who evoked the "powerful voice of science" (Spanish minister for the ecological transition Teresa Ribera) or its "guiding light" (executive director of Greenpeace Jennifer Morgan) and claimed, "We no longer have time to leave out the science" (activist Greta Thunberg).

But Time for Action not only stresses emergency; it also evokes the new focus on implementation. This shift was embodied in the centrally located Climate Action Hub, which was designed by the Secretariat as a theater of achievements and climate solutions. This new space—first introduced at COP24 in Katowice—displayed nonstate climate action in several new formats. Among them, the Global Climate Action awards ceremony was announced as a

[46] COP25, "Pressing 'Record' on Climate Action," CAMDA Workshop on tracking progress 2020–2023, Global Climate Action event, December 5, 2019.
[47] COP25, high-level event on "Climate Emergency," December 11, 2019.

"moment of celebration . . . with inspiring speakers, videos, photography, and a musical performance."[48] It placed the spotlight on fifteen carefully selected examples of technological and social innovations by individuals, city governments, and business leaders. These were presented as evidence of a global groundswell of climate action. The Secretariat facilitated these and other activities by providing specific Global Climate Action badges for representatives of civil society, start-ups, businesses, and cities; establishing the agenda of events; and setting up a dedicated organizing team in the Climate Action Unit.

New actors are thus encouraged to populate climate governance arenas, exhibit their ideas and solutions on public stages, and attend informal meetings. This is noteworthy, as "the Paris Agreement itself says remarkably little about non-state and subnational action" (van Asselt et al., 2018, pp. 30–31). While COP decisions specify elements like the mandating of IPCC special reports or the appointment of high-level champions, Presidencies and the Secretariat also intervene creatively by organizing public events and structuring interactions at COPs. In Madrid, they significantly shaped available roles in public performances. While the Climate Emergency event exemplifies the strong emphasis on the natural sciences and risk language that pervaded admonishing performances, the Global Climate Action award ceremony represents the focus on businesses and individuals in the quest for climate solutions. In both cases, role provision and casting aimed to attract media attention, while positioning the UN process as a necessary part of a solution. While some of these events did provide a space and public stage for (sometimes harsh) critique, they also tended to confirm dominant framings in climate debates by dissociating systemic critique in admonishing events from discussions on solutions and decontextualized best practices in the celebratory climate action events.

6.5.3 Counterscripting: strategic delay and uninvited participation

COP25 was also characterized by tensions, and in some spaces, performances did involve direct contestation of dominant governance scripts. Difficult negotiations on several agenda items concerning reporting and transparency showed that accounting rules for countries were still highly contested. On some occasions, delegates also tried to *counterscript* and actively contest the implementation of the Paris Agreement, for example, through strategically delaying negotiations. This was visible, for example, in efforts by some developing countries led by China to adjourn decisions on common tabular formats and other elements of the common accounting infrastructure (ENB, 2019b). No conclusion was reached at COP25, and discussions were postponed until the next COP. This was interpreted by some as a strategy to improve developing countries' negotiation position on issues of finance and adaptation.

[48] COP25, Global Climate Action Award Ceremony, December 10, 2019. The event belongs to the UN's Momentum for Change initiative, which is supported by major philanthropic organizations.

Similarly, Brazil's general unwillingness to compromise—most notably on Article 6—appeared as a tactic to buy time and return to the issue at a later, more favorable moment.[49]

Counterscripting also occurred outside official negotiations. Climate and social justice activists repeatedly made use of their access to the venue to disrupt procedures with protests and to challenge prevalent narratives. In their eyes, this would also ensure that their participation in the conference exceeded the invited and carefully staged admonishment that also provides legitimacy to the UNFCCC process. On December 11, close to the scheduled end of the COP, rumors of an impending flash mob were circulating, and activists eventually disrupted an event in one of the plenary rooms. UN security shut off parts of the venue and dissolved the flash mob of around 200 activists by pushing them through a nearby gate. The Secretariat called this "an unfortunate security incident" and temporarily took away their access rights to the venue. This reveals the limits of creating symbolic inclusiveness by providing access and visibility to activists. It also suggests that performances can only be controlled to a certain extent. Actors interpret or circumvent scripts, improvise on established roles, and use the attention provided by climate conferences to advance their own agendas.

6.6 Conclusions

UN climate conferences are global political events that attract worldwide media attention and representatives from virtually every country of the world, but also from companies, municipalities, NGOs, and social movements. This article shows that they are also key sites of soft coordination in global climate governance. Using dramaturgical policy analysis as a conceptual lens and collaborative event ethnography as a method, we examined how core dispositions of the Paris governance framework—its ambition mechanism and strategy to facilitate nonstate climate action—were operationalized, enacted, (re)interpreted, and challenged during COP25 in Madrid in 2019.

Seen through the lens of dramaturgical policy analysis, the conference implemented a specific script, which stipulates a transition from negotiations to implementation and from a logic of top-down regulation to one of bottom-up pledges and social control through peer pressure and public assessments of progress. The material setting, organization, and agenda of COP25 reflected this new script. The conference appeared less as mainly diplomatic space and more as a transnational mega-event composed of a series of different stages, on which participants performed three social roles—accountant, admonisher, and animator. While the accountant role is clearly part of the Paris Agreement's script, the latter two are less directly traceable to formal provisions in legal documents. Both used a more emotional register and were particularly present in high-level and Presidency events. These roles and event for-

[49] Background interview with a senior delegate.

mats, which attracted the largest audiences and staged the most dramatic performances and the greatest diversity of agents, appear as core elements of the ongoing governance shift.

Our analysis also indicates that the governance transition is not fully scripted and that its outcome remains uncertain. This provides room for actors to creatively interpret roles, alter the intended course of performances, and participate in scripting elements of the new regime. At COP25, the Secretariat and COP Presidency in particular intervened through a series of dramaturgical practices. These included background interventions, such as designing the venue and equipping its stages, setting up events, and casting participants, and delimiting available roles in public performances. The Presidency also shaped the overall narrative arc of the conference by circulating urgency frames and organizing a sequence of thematic events. Less visible but just as active, the Secretariat supported private climate action performances, intervened to equip state-led assessments with data, attracted nonstate agents to provide expertise and increase publicity, and supported fora for transparency outside the negotiations. These activities involved the strategic mobilization of organizational capacities and prerogatives. Together, they constitute what we might call a *dramaturgical repertoire* of soft coordination, through which the Secretariat exerts considerable influence beyond its formal mandate. Despite these efforts, however, state-led reporting formats, such as multilateral assessments, were poorly structured and attracted limited public attention. In practice, instead of naming and shaming laggards through rigorous peer monitoring, they provided occasions for “claiming and shining” through selective and punctual reporting.

Overall, the article makes three key contributions to research on soft coordination in global (climate) governance. Conceptually, it proposes a novel understanding of soft coordination as performative practice, instead of a formal relation of delegation based on (chains of) orchestration. This foregrounds symbolic and communicative governance dimensions that usually fall under the radar of legal, functionalist, or institutionalist perspectives. Methodologically, it provides an approach to examining soft coordination that combines ethnographic observations at UN climate conferences with an analytical focus on a limited set of dramaturgical practices. Finally, it empirically identifies actors, sites, and mechanisms of soft coordination in climate governance, showing that the current regime shift manifests in a set of typical event formats, social roles, and dramaturgical strategies, which enact performances of disclosure and review but also mobilize emotional communication frames to stress urgency and create momentum. A quick look at COP26 in Glasgow a year later, with its considerably enlarged Climate Action Zone, carefully casted celebrities, and flurry of announcements and declarations, appears to corroborate our analysis (Aykut et al., 2022).

Of course, the analytical perspective sketched in this article also has its limitations. Observable performances represent only one among many types of activities that take place at UN climate conferences, let alone in the wider climate governance landscape. To provide a more

complete picture, a dramaturgical lens must be complemented with perspectives that examine soft coordination through other means, such as the diffusion of global norms or the building of transnational networks. Research should also study the relations between soft and hard mechanisms of coordination. Under what conditions does soft coordination effectively supplement enforceable legal norms? When does it, on the contrary, constitute a substitute for, or a distraction from, binding regulations? Moreover, future research could take a more systematic look at changes in symbolic and communicative strategies over time to trace the evolution of dramaturgical practices and repertoires in climate governance and other governance fields. Our article hence opens new avenues of research that show that a focus on performances and dramaturgical practices represents, beyond the climate arena, an important and promising analytical entry point to grasp contemporary transformations of world politics.

7 Markets for Public Attention at the Interface of Climate Science and Policy Making[50]

In so-called post-truth politics, the interface between climate science and policy making is becoming increasingly prominent (Beck and Mahony, 2018). Academics have highlighted how knowledge is generated through a combination of science and politics (Jasanoff, 1995), but scientific knowledge is still frequently regarded as "speaking truth to power". Global Marches for Science have attracted great interest and active participation (Guglielmi et al., 2018), and the Trump administration has been severely criticized by the media for their attacks on climate science (New York Times, 2019). These examples indicate the importance attributed to science as a source of objective, unbiased information. Science can guide society towards decisions that advance the interests of the whole population, rather than just a narrow range of vested interests. However, as we discuss in this article, scientists need to reflect upon the biases and incentives for the production and use of knowledge. Only an honest assessment of uncertainties and value judgements inherent in scientific practice can counter the recent development that markets for public attention at science-policy interfaces are turning into markets for lemons for scientific studies that provide a biased picture of scientific knowledge.

Studies have identified the strategies used by special interest groups to cast doubts on the credibility of scientific findings, aiming to undermine the position of science as a central pillar of a liberal society (Oreskes and Conway, 2010). While trying to safeguard this role of science, however, scientists who engage with the public need to avoid the trap of adopting a position of radical positivism. The danger is that they claim to possess the "true facts" that can be objectively verified and thus unambiguously prescribe the ideal policies for society to pursue. That is, instead of exclusively focusing on the critique of interference of political interests in scientific practices, which is undoubtedly justified, scientists need to acknowledge the existing biases and problematic incentive structures in the production of scientific knowledge, and its use in a market for public attention. These are key to understanding the links between climate science and policy making. In order to better understand these biases, we discuss the science-policy interface from a principal-agent perspective, highlighting how adverse selection may transform the market for public attention into Akerlof's (1970) market for lemons, and showing how moral hazard can influence the production of scientific knowledge. We explain this perspective based on recent debates in climate science, which provide good examples of a politically contested field of research.

[50] Published as Schenuit, Felix, Larissa Koch, and Michael Jakob. 2020. "Markets for Public Attention at the Interface of Climate Science and Policy Making." Environmental Communication 14: 1–5. https://doi.org/10.1080/17524032.2019.1688370.

Cook et al. (2013) identified that 97% of published scientific articles expressing a position on the changing climate, endorse the view that humans are causing global warming. Yet, the approach of "counting consensus" only focuses on the smallest common denominator and is an inadequate basis for questions that have underlying future assumptions and value judgements at their core (Pearce et al., 2017). The observation that more knowledge on climate change may result in higher, rather than lower, polarization between ideological positions (Kahan, 2015) illustrates how worldviews impact on an individual's interpretation of scientific "facts". Confirmation bias causes different ideological camps to base their argument on a few selectively chosen, supportive research findings, while disregarding evidence contrary to their point of view. Instead of downplaying uncertainties and conflicting views, science needs to deal with the pluralism connected with different worldviews and scientific practices. This is not to say that all claims to truth have the same legitimacy. For instance, those skeptical of climate science face a substantial challenge to demonstrate the validity of their argument, given a well-established scientific body providing ample evidence of anthropogenic global warming. Arguably, the distinction between facts and values gets more blurred the more relevant certain research is for policy decisions. Hence, the closer the scientists and their research subject are to the political decision-making process, the greater their responsibility of acknowledging that the scientific "facts" incorporate some degree of value judgement. Examples of such judgements might include the methodological approaches regarded as producing reliable knowledge, and the types of policy conclusions which can be drawn from scientific findings. In practice, the influence of worldviews and ideological positions on the interpretation of scientific knowledge could, for instance, be examined by studying varying preferences for different greenhouse gas emission reduction policies (Cherry et al., 2017).

Now that literature on climate change is exploding (Minx et al., 2017a), the use of knowledge in the public debate is increasingly shaped by the incentive problem of adverse selection. Journalists and media outlets will usually pick out those studies that provide clear, unequivocal answers rather than those that convey uncertainties and the role of different value judgments. This is a natural result of the journalistic norms of novelty and dramatization (Boykoff and Boykoff, 2007). There is an excessive focus on extreme cases, together with too little appreciation of the distribution of results and their robustness. Consequently, reporting of extreme values also undermines trust in the scientific results on climate change amongst the public and policy makers. A recent publication by Millar et al. (2017), who employed a novel assumption regarding the response of the climate system to rising concentrations of greenhouse gases in the atmosphere to model pathways consistent with the 1.5 °C temperature target, is a salient example of over-proportionate media attention on a single study. The study's key result, even though it was subsequently explained in more detail by the authors, was interpreted as clearly indicating that remaining below the 1.5 °C target was achievable

with substantially higher cumulative amount of emissions than previously expected. Several newspapers used this piece of evidence to justify lurid headlines such as “Climate models are ‘wrong'” (see Johnston (2017) for an overview of reporting on this paper). Explanatory statements and other comments by the authors as well as other studies on this issue were ignored in large parts of the media. Given the operating incentive of adverse selection on the market for public attention, it may be increasingly difficult to attract attention and policy relevance to well-balanced scientific assessments. Hence, just as decent used cars are driven out of the market by “lemons” that carry some hidden defect in Akerlof’s famous example, studies that arrive at a straightforward result and generate comparatively high media attention, such as a particularly high or low number for the carbon budget, crowd out well-balanced scientific assessments.

Scientists face a complex set of expectations, and the “medialization of science” gives increasing importance to the “ambivalence of visible scientists” (Rödder, 2012). This set of expectations gives scientists incentives to produce results that receive more attention from their peers, the media, and policymakers. Consequently, on top of an adverse selection of available scientific evidence, the selective use of knowledge by the media also introduces a moral hazard bias in the production of scientific knowledge. The case of the carbon budget for the 1.5 °C target provides a useful illustration of this argument. Different competing definitions of the “carbon budget” are available in the literature (Rogelj et al., 2016). The use of, as yet unproven, carbon dioxide removal technologies, would allow the carbon budget to be temporarily exceeded on the understanding that “negative emissions” would be achieved at a later date (Fuss et al., 2014). However, the different underlying assumptions regarding the use of such technologies can result in very different conclusions on the ability to stay within a given carbon budget. By failing to clearly specify the assumptions behind a certain carbon budget, for example, that generating the global temperature increase target, different studies appear to arrive at contradictory results. Some find that the 1.5 °C target is still a realistic option, and others that it is already practically out of reach (Geden and Löschel, 2017). Scientists are incentivized to use the leeway for subjective choice in order to justify a particularly high or low number to satisfy proponents of either position.

Researchers increasingly face the temptation to provide unequivocal answers to complex societal problems demanded by policy makers, the media, and the public, without clearly communicating the full range of results that could be obtained under different, but equally valid, assumptions. Even if most scientists stick to their scientific ethos and resist this temptation, those who do not will be rewarded by citations, headlines, and increased funding possibilities. In times of steadily increasing pressures on scientists to demonstrate the usefulness of their research, such attention can be critical for a successful scientific career. Funding is closely tied to metrics such as citations and media appearances and being forced to

choose between their self-interest and scientific integrity, scientists frequently face a serious dilemma. This has the potential to either negatively affect the quality of their research, or – for those scientist critical of media coverage (Besley and Nisbet, 2013) – lead to a situation in which scientific findings and perspectives might remain unnoticed while being important for the public debate.

Adverse selection and moral hazard incentivize scientists and the media to produce and report results that can be considered extreme, while disregarding findings that confirm other results. This has the effect of skewing the distribution of scientific results to suggest more uncertainty than actually exists, which can easily be exploited by populist actors aiming to discredit climate science. This development will make it easier for "stealth issue advocates" (Pielke, 2007) to exploit the integrity of climate science in political debates and make it harder for "honest brokers" (Pielke, 2007) to explore and assess different policy alternatives. As we discuss in the following, however, focusing on different actors producing and using scientific knowledge, can provide some ideas for improvement.

First, researchers and journals should be encouraged to adopt the logic of assessment-making (Edenhofer and Kowarsch, 2015), employed to some extent in global environmental assessments such as the reports of the Intergovernmental Panel on Climate Change. In this way, scientific papers could be made "assessment-ready" by demonstrating a range of results, such as a range of scenarios, under varying assumptions (Trutnevyte et al., 2016) and editors and reviewers of scientific journals would need to take this into account when evaluating submitted manuscripts. Academic journals could establish guidelines on the transparent communication of underlying assumptions and how they affect the results, in a similar way to the current examination of uncertainties and robustness checks for statistical results.

Second, given the rapid increase of scientific literature, it will probably become increasingly hard for specialists to maintain an appropriate overview of the literature (Minx et al., 2017a). An increased use of meta-studies, which is common practice in health research, but so far still rather an exception for other branches of science, could help to manage the ever-increasing volume of new literature. An increasing reliance on meta-studies, especially in the social sciences would increase the transparency of the criteria for inclusion or exclusion of a study in an assessment of the literature. In order to provide incentives for scientists to engage in such meta-analyses, universities and research institutes would need to amend their hiring and funding practices. For instance, contributions to large-scale environmental assessments could be included in performance metrics (such as the H-index) and be considered as being of equal importance to publications in peer-reviewed journals when awarding tenure.

Third, the science-policy interface probably needs new ways to communicate scientific uncertainties between scientists and policy makers and reconcile the supply-side (science) with the demand-side (policy) (Sarewitz and Pielke, 2007). Arguably, some trade-offs between comprehensive communication of uncertainties and clear communication of key results are inherent. But these trade-offs can be minimized, for instance by encouraging scientists to follow specific pre-defined protocols that summarize the uncertainties of their results in terms that are accessible to the public (Fischhoff and Davis, 2014). In order to increase adherence to these protocols, research institutes could provide best-practice guidelines and ongoing training for their employees. Further, the treatment and communication of scientific uncertainty could be strengthened in scientific training and made an integral element of university curricula. Finally, ongoing face-to-face dialogue forums to enhance collective learning about coherent long-term solutions could be a way for researchers to communicate scientific uncertainty to policy makers, journalists and civil society in a transparent way that reduces problematic incentive structures on both sides.

We hope that the above recommendations will spark a lively debate on how to prevent the markets for public attention from turning into a market for lemons for scientific studies.

7.1 Additional Material: Illustrative case study on “The Global Tree Restoration Potential” (2019)

This section provides a short case study as additional material to the peer-reviewed article which illustrates the identified biased incentives at science-policy-politics interfaces. It deals with the Paper “The Global Tree Restoration Potential” by Bastin et al. (2019b).

In the summer of 2019, at the height of climate protests (Marquardt, 2020), a publication in the prestigious journal Science caused wide-reaching attention in media reporting and science and policy circles. Bastin et al. (2019b) published the paper "The Global Tree Restoration Potential," claiming that with their new methodological approach, they can revise the potential for tree restoration upwards. In the initial version of the published article, they claimed that it is "our most effective climate change solution to date". The publication was accompanied by extensive public relations efforts facilitated by a communication agency called Greenhouse Agency. The agency counted 700 pieces of media coverage spanning more than 100 countries, highlighted references to the paper by Alexandria Ocasio-Cortez and Greta Thunberg, and described the launch as "momentous" (Greenhouse Agency). The incentives for the research group behind the paper, the so-called "Crowther Lab," to hire a PR firm are well summarized in the following statement Tom Elliot, the Managing Director of the research group, provided for the agency’s website:

"Communicating science in a way that is relatable and inspires action is not easy, but Greenhouse [the communication agency] were instrumental in getting this vital message to a truly global audience. Whilst their knowledge in relation to the media landscape is outstanding, they've also demonstrated a fantastic ability to grow our network and deliver much needed attention towards restoration organisations all around the world. Thank you!"[51]

Professionally produced videos and a dedicated websites[52] further underline the goals of the authors to generate the broadest possible audience. This is also observed during the ethnographic observation conducted at COPs. At the side event "Nature based solutions for negative emissions, global tree potential and landscape restoration," organized by three research institutes, one of the co-authors of the Science publication entertainingly promoted the paper and joked about the media hype it generated and defended the methodological approach.

In fact, flaws in the methodology and results have been at the heart of the five responses - an unusually high number - published in science point (Friedlingstein et al., 2019; Grainger et

[51] See their website: https://www.greenhouse.agency/case-study/tree-potential/.

[52] For the video, see https://www.youtube.com/watch?v=v30tP-lrI-w; for the website, see https://crowtherlab.pageflow.io/trees-against-climate-change-the-global-restoration-and-carbon-storage-potential#215060. On their website, the Crowther Lab suggest that their paper led to World Economic Forum’s initiative “With all the attention – which even led to the launch of the World Economic Forum’s Trillion Trees initiative (1T.org) – came questions about how trees can help mitigate climate change. We’ll answer some of them here.”

al., 2019; Lewis et al., 2019; Skidmore et al., 2019; Veldman et al., 2019) (Lewis et al. 2019; Veldman et al. 2019; Grainger et al. 2019; Friedlingstein et al. 2019; Skidmore et al. 2019). Key criticisms of these responses were: (1) flaws in methodology, esp. with regard to assumptions about carbon initially stored in existing soil and biomass, the albedo of reforested areas, as well as changing environment (2) missing acknowledgment of existing research on the issues touched in the contribution; (3) challenging the framing of tree restoration as the most effective solution based on the results and contextualizing actual implementation of large-scale reforestation. Most of the criticism was formulated in a rather harsh tone.

Skidmore et al. 2019 concluded in their response:

"[..] the emerging global political myth of massive tree planting and restoration as a panacea for global warming requires an unrealistically large area. Although tree planting should be welcomed, curbing emissions appears to be the key, albeit politically challenging, action." (Skidmore et al. 2019 p. 1-2)

This statement points to the political context of the tree restoration potential, which explains the enormous attention (and the strong pushback). The paper was published during a momentum for what has been called "nature-based solutions," a framing criticized by scholars (see, e.g., Osaka et al., 2021), that shifted attention to carbon sequestration potentials of afforestation and other approach (see e.g., Seddon, 2022). This momentum has not only been driven by green NGOs or actors pushing for ambitious climate action. More recently, it has also been co-opted by vested interests of the fossil fuel industry and other large emitters that use these strategies to shift attention away from their continuous fossil fuel production (see, e.g., Melanidis and Hagerman, 2022). This pattern can also be observed in international climate politics: At 2020's World Economic Forum, the One Trillion Trees initiative was announced, and the Trump administration, which withdrew from the Paris Agreement earlier, joined the initiative and later signed a related Executive Order (The White House, 2020). These initiatives have been criticized for pretending action, talking down the problem of climate change, and the required transformation towards a low-carbon society (see, e.g., Melanidis and Hagerman, 2022). This is why not only the methodology but also the framing of the "most effective solution to climate change" caused substantial criticism (see esp. the response by Veldman et al., 2019).

Bastin and his colleagues replied with a technical response in 2019, defending against the comments they received (Bastin et al., 2019a). In 2020, they published an erratum to the earlier publication, which, while keeping the main numbers, changed the framing from "most effective climate change solution to date" to "restoration of trees remains among the most effective strategies for climate change mitigation" (Science, 2020). The erratum reads:

"First, in the original version of the Report, the authors stated in the abstract and in the main text that tree restoration is the most effective solution to climate change to date. This was incorrect. They meant that they know of no other current carbon drawdown solution that is quantitatively as large in terms of carbon capture. They did not mean that tree restoration is more important than reducing greenhouse gas emissions or should replace it, nor did they mean that restoring woodlands and forests is more important than conserving the natural ecosystems that currently exist".

In addition to this change, the erratum includes a reference to the airborne fraction of carbon (see Friedlingstein et al. 2019 for the critique on this) and adding a large uncertainty range of 133.2 to 276.2 GtC for the key result of 205GtC the initial paper claimed as potential canopy cover restoration (Science 2020). Both corrections, however, have of course not been widely discussed in the media or policy circles[53].

Providing unequivocal answers such as forest restoration as "most effective solution to climate change to date" omits many of the problems that have been identified in the context of large-scale reforestation. Bastin et al.'s (2019) way of exploring the potentials of tree restoration does not consider threats for people living in or depending these land areas, risk for biodiversity, as well as lack of permance are not considered (Fleischman et al., 2020). The example thus is a key example for the risk for what Veldman et al. 2019 described as "carbon-focused tree planting". The excessive optimism linked to tree planting as nature-based solution is often based on under complex assumptions about actual implemention of large-scale afforestation project. The case study showed that this optimism does not come from political initiatives but is also shaped entrepreneurial science like the paper discussed here.

This brief reconstruction of a science controversy shows why this case is a prime example of the risk described in the article "Market for public attention at the science-policy interface." Biased incentives in policy-relevant climate science and related media and policy interfaces can lead to a "market for lemons" in the sense of Akerlof (1970). As described in the paper earlier, he argued that in markets for used cars, "decent used cars are driven out of the market by "lemons" that carry some hidden defect." Publishing a straightforward results based on questionable assumptions and controversial methodology, which fits well into the current political environment, allows entrepreneurial scientists to generate attention for their research. Combined with professional public relations, as in this case, metrics such as media appearances and citations open up new possibilities for funding opportunities, etc.

Based on the insights from the chapter and the case study is becoming clear that both studying and designing the interfaces science is involved in, policy, politics, and also media, should consider the market for public attention as a risk for scientific integrity.

[53] For a journalistic reconstruction of the Billion Trees campaign (in German), see Knuth and Fischer, 2020).

8 Carbon Dioxide Removal Policy in the Making: Assessing Developments in 9 OECD Cases[54]

8.1 Introduction

Since the adoption of the Paris Agreement and the publication of the IPCC's Special Report on Global Warming of 1.5 °C (SR1.5), numerous political actors have agreed on net-zero emissions targets. This type of long-term target—usually, but not always, defined as a balance of greenhouse gas (GHG) emissions and removals—is emerging as a new organizing principle of climate policy at almost all political levels. Attempts to operationalize net-zero targets have been accompanied by increasing attention on the need for anthropogenic carbon dioxide removal[55] (CDR) to achieve these targets (Fuss et al., 2020; Geden, 2016a). The importance of CDR would increase further if pathways involving net-negative emissions are pursued in order to recover carbon budgets consistent with temperature goals after they are exceeded (IPCC, 2018a).

The scarce but growing academic literature on the governance of CDR has shown that the configuration and design of CDR policies, as well as their interactions with other climate policies, have important implications for the role of CDR in the transition toward net-zero emissions societies (Bellamy et al., 2019; Geden and Schenuit, 2020; McLaren et al., 2019). Based on a comparison of nine case studies, this article attempts to track the extent to which CDR policies are already part of domestic climate policy regimes and how the integration of CDR is evolving. While the transition of international climate governance toward a bottom-up, polycentric, and performative climate governance unfolds (Aykut et al., 2020), analyzing the facts on the ground of transformations toward deep decarbonization becomes even more important (Victor et al., 2019).

In the process of case selection, we followed four key criteria: (1) We limit our cases to members of the Organization for Economic Co-operation and Development (OECD). Countries with high income and high historical emissions are generally expected to be responsible for a greater quantity of CDR deployment if distributional equity is taken into account (Fyson et al., 2020; Pozo et al., 2020). This reflects the expectations institutionalized in the international climate negotiations under the United Nations Framework Convention on Climate

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[55] See definition by the IPCC, SR1.5: "Anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage, but excludes natural CO_2 uptake not directly caused by human activities" (IPCC, 2018a).

Change (UNFCCC). Although the Paris Agreement does not officially maintain the dichotomy of Annex 1 and non-Annex 1 countries and has introduced a less rigid distinction between developed and developing countries as well as other subtle differentiations (Pauw et al., 2019), aggregate expectations for high-income countries with historically high emissions to lead on climate change mitigation continue to shape the negotiations. At the same time, these countries are expected to have rather high shares of mid-century residual emissions in hard-to-abate sectors (Bataille, 2020; Davis et al., 2018; Luderer et al., 2018); challenges to and high costs of achieving their net-zero targets will shift increasing attention toward CDR. This is not to argue that developments in other countries with different socio-economic structures, land resources, and climate policy priorities would be less relevant; an assessment of those countries is already planned in future research projects.

In addition to this first criterion, we limit this study to countries: (2) that have already integrated CDR in their existing policy mix; (3) in which the adoption of net-zero targets has spurred a debate about the integration of CDR policies in the climate policy regime, or; (4) in which developments in niches, e.g., geochemical-based CDR, begin to put pressure on the existing regime. We therefore have an intentional bias toward countries that already deal with CDR and exclude those without CDR policies or emerging debates about it.

Based on these criteria, we identified the following set of case studies: the European Union (EU)[56] (and three of its Member States: Ireland, Germany, and Sweden), Norway, the United Kingdom (UK), New Zealand, and the United States (US)[57]. Drawing on the case studies, provided by authors from each country and updated as of January 2021, we attempt to explore the varieties of CDR integration into climate policy regimes and propose an analytical typology to distinguish between different ways of approaching CDR politically.

8.2 Analytical framework

To provide a systematic overview of recent developments in CDR policy across the cases, we developed an analytical framework consisting of five key dimensions and a template of questions. The framework is based on the multi-level perspective (MLP) heuristic of socio-technical transitions and integrates key findings of academic literature on CDR policy and governance. The following sections summarize key elements of the MLP and the CDR governance literature. Subsequently, we provide a brief overview of how these perspectives are being applied in this exploratory study to systematically track and assess CDR-related developments across the nine cases.

[56] The EU as a supranational organization is not a full member of the OECD, but the European Commission takes part in its daily work.

[57] Throughout the initial process of case selection, experts from several other OECD countries were contacted (among them Japan and Canada) to decide whether these countries would fit into this set.

8.2.1 Applying the Multi-Level Perspective (MLP) to CDR policies

Research on sustainability transitions has increased rapidly in the past 10 years (Köhler et al., 2019). The MLP on socio-technical transitions is one of the most prominent strands of transition studies. It provides a "middle range theory that conceptualizes overall dynamic patterns in socio-technical transitions" (Geels, 2011, p. 26)[58]. While it provides a straightforward heuristic for exploring transition processes, it should not be misunderstood as being capable of predicting future trajectories.

We do not attempt to provide a full MLP analysis of all nine case studies here. Rather, we apply the MLP heuristic to structure our effort to track and compare transitions toward integrating CDR policy. The advantage of the MLP perspective is its "relatively straightforward way of ordering and simplifying the analysis of complex, large-scale structural transformations" (Smith et al., 2010, p. 441) while still taking into account macro-political developments and developments in small niches. This makes the MLP our preferred choice over other more fine-grained theories[59], concepts and heuristics in the—to our knowledge—first attempt to compare CDR policy development across countries.

The MLP sees transitions as non-linear processes resulting from interactions between developments at three different levels: First, the socio-technical regimes "represent the institutional structuring of existing systems leading to path dependence and incremental change" (Köhler et al., 2019, p. 4). Second, the exogenous socio-technical landscape, which consists of broader political, economic or demographic "contextual developments that influence the socio-technical regime and over which regime actors have little or no influence" (Geels et al., 2017, p. 465). And third, niche innovations, a level that describes "protected spaces and the locus for radical innovations" (Köhler et al., 2019, p. 4) which differ substantially from the currently dominant system and can put pressure on the existing regime (Geels et al., 2017). In addition, MLP adds a temporal dimension and distinguishes between the three phases of emergence, diffusion and reconfiguration (2019)

Key strengths of heuristics such as the MLP are their capacity to identify path-dependencies, lock-in incentives and power distributions within a current system, as well as in emerging and diffusing innovation dynamics (Geels et al., 2017)—aspects that most integrated assessment models hardly address in their pathways (van Sluisveld et al., 2020). The strong focus on innovation in MLP should, however, not lead to an overly optimistic innovation bias; questions of possible "unanticipated consequences" (Merton, 1936, p. 894) and "intended but

[58] For a discussion of middle range theory approaches, see Geels (2007).

[59] Future research would gain from integrating insights from other strands of the sustainable transition literature, as well as other concepts developed in political science such as public policy paradigms Carson et al. (2010) and policy innovation Jordan and Huitema (Jordan and Huitema, 2014).

unrealized effects" (Hirschman, 1977, p. 131) should therefore always be part of analyzing transition processes.

8.2.2 Key insights from the CDR policy governance Literature

The literature on scientific and technical aspects of CDR is growing rapidly (Minx et al., 2017b) and, since the adoption of the Paris Agreement, literature on CDR governance and policy-making has also started to gain traction. Key issues addressed by scholars are the risk of mitigation obstruction (McLaren et al., 2019; Minx et al., 2018; Morrow, 2014), and the importance of policy and target design to address this risk, e.g., through prioritizing conventional mitigation and separate targets for emission reductions and removals (Geden and Schenuit, 2020; McLaren et al., 2019).

Other important strands of the debate touch on the patterns of emerging societal debates and their possible polarization (Colvin et al., 2020) as well as the public perception (Cox et al., 2020), socio-political prioritization (Fridahl, 2017; Rodriguez et al., 2020)(, innovation dynamics (Nemet et al., 2018), incentive structures for research and deployment (Bellamy et al., 2021; Cox and Edwards, 2019; Fajardy et al., 2019; Fridahl et al., 2020b; Lomax et al., 2015; Torvanger, 2019) and framings of different CDR methods (Bellamy and Osaka, 2020; Waller et al., 2020; Woroniecki et al., 2020). Furthermore, the literature highlights the role of CDR in integrated assessment modeling and possible implications for climate policy (Beck and Mahony, 2018; Geden, 2016b; Haikola et al., 2019; Workman et al., 2020), negative implications of deploying large-scale CDR for sustainability and biodiversity (Buck, 2016; Dooley et al., 2021; Honegger et al., 2020; Smith et al., 2019), and justice and equity considerations (Anderson and Peters, 2016; Fyson et al., 2020; Morrow et al., 2020; Peters and Geden, 2017; Pozo et al., 2020; Shue, 2018).

Especially in political debates, CDR methods are often separated with the rather ambiguous differentiation of "natural" and "technological" approaches. As framings of certain CDR methods have considerable political implications, in particular the terminology of "natural" or "nature-based" (Bellamy and Osaka, 2020; Waller et al., 2020; Woroniecki et al., 2020), we use the analytical and intended to be value-neutral distinction between ecosystem-based and geochemical-based approaches6.

8.2.3 Five dimensions for observing CDR policy

The following five dimensions represent an attempt to apply and bridge the conceptual work of the MLP on socio-technical transitions with existing research on CDR policy and governance to provide an analytical framework that allows systematic exploration of different case studies in a comparable way (see Table 8.1).

Table 8.1: Dimensions of observations

(1) Institutional setting, actors, and coalitions	• Overall institutional and political setting in domestic climate policy (incumbent regime) • Macro-political developments that influence CDR debate [e.g., Paris Agreement, Sustainable Development Goals (SDGs), …] • Actors and coalitions in CDR-related climate policy making but also in broader societal debate [business/industry, environmental non-governmental organizations (ENGOs), …]
(2) CDR accounting and methods	• Accounting practices of CDR toward domestic climate targets and its relation to gross emission reductions • Methods addressed and differences in accounting • Groupings/separation and framings of different methods (e.g., "technological"/vs. "natural" CDR) • Socio-political prioritization of different methods
(3) Policy instruments	• Policy approach • Timing and broader political circumstances • Political struggles in public policy processes (main critique vs. justification patterns) • Relation to other climate, environmental and sustainability policy instruments and targets (discursively, politically, legally)
(4) Expert bodies and science	• Role for expert bodies and science more generally in societal CDR debate as well as in public policy processes • Role of IPCC reports (esp. 5th Assessment Report, SR1.5 and Special Report on Climate Change and Land (SRCCL) and domestic modeling or technology development
(5) Developments in CDR niches	• Developments with regard to CDR methods in "protective spaces" that shield, nurture, empower (Smith and Raven, 2012) • Emerging business cases • New actors that demand change in incumbent climate policy regimes to integrate CDR

While the dimensions (1) institutional setting, actors, and coalitions, (3) policy instruments and (4) expert bodies and science attempt to explore key aspects of the MLP-levels socio-technical regimes and exogenous socio-technical landscape, dimension (5) particularly focuses on observing niche innovations. Dimension (2) CDR accounting and methods covers important aspects on definition, accounting and framings raised by the emerging academic CDR governance literature.

Limiting the comparison to these five dimensions means that neither all dimensions of MLP can be covered, nor can all aspects of CDR literature be fully represented. But this rather narrow and straightforward analytical framework enabled the systematic collection and comparison of facts on the ground in nine cases in this study. Analyses based on this material, however, must consider its limitations.

8.3 Case studies

The case studies presented in this section were conducted by experts from each country and followed the analytical framework presented above (see Table 1). In addition to the dimensions for observation, a template of guiding questions for each dimension was provided to the case study author teams to ensure comparable findings across cases. The five dimensions also structure the presentation of the highly condensed results in the following sections.

8.3.1 European Union

Institutional Setting, Actors, and Coalitions

The European Union (EU) is regarded as a key frontrunner in international climate policy and was a driving force behind the Paris Agreement. Among its Member States and between EU institutions, however, the appropriate level of ambition is contested (Rayner and Jordan, 2016). The EU's climate policies are separated into three regulatory pillars: the EU Emissions Trading System (EU ETS), the Effort Sharing Regulation (ESR), and the land use, land-use change and forestry (LULUCF) Regulation (Kulovesi and Oberthür, 2020). While the EU ETS covers emissions from power stations, energy-intensive industries and intra-European aviation, ESR sets national targets for emissions reductions in the transport, buildings, and agriculture sectors.

Since the adoption of the Paris Agreement and the IPCC SR1.5, the EU's executive arm, the European Commission, has started to address the issue of CDR proactively (European Commission, 2018a). Recent policy initiatives are directly linked to the new 2050 target of net-zero GHG emissions. The European Parliament and Member State governments in the Council of the EU—the co-legislators in EU policymaking—are still negotiating, but it is already apparent that the EU Member States differ considerably in how they approach CDR politically (see the case studies on Germany, Ireland, and Sweden). The shared competence between the EU and its Member States on the environment and therefore climate policy, combined with path-dependencies, deep-rooted conflict lines (Szulecki et al., 2016), and new distributional issues will shape the upcoming decisions (Geden and Schenuit, 2020). ENGOs are likely to play a vocal role in this process. Although ENGOs increasingly acknowledge the need for CDR to achieve the net-zero target, their positions are often critical, especially with regard to what some call large-scale “artificial negative emissions technologies” (Climate Action Network, 2018, p. 3). Other advocacy groups have started to call for integrating CDR into EU climate policy (e.g., Bellona). Furthermore, governmental and industry representatives of the Northern Lights project (see the case study on Norway) turned to the EU to pro-

mote cooperation on carbon capture and storage (CCS), including bioenergy with CCS (BECCS).

CDR Accounting and Methods

The Commission regards CDR as key to achieving net-zero GHG emissions by 2050. Its modeling shows that net-zero pathways require ecosystem- (LULUCF) and geochemical-based direct air capture and CCS (DACCS) CDR, as well as BECCS as a hybrid form. At present, the EU does not fully account for LULUCF removals toward its economy-wide mitigation targets of −40% by 2030 compared to 1990 levels. In the context of revising the target (−55%) and its new Nationally Determined Contribution (NDC) submitted in December 2020, the Commission and the Member States, however, modified the accounting toward a full consideration of the LULUCF sink. It is likely that the rather unspecific differentiation between "natural" and "technological" CDR will become a controversial issue. ENGOs have invested substantial political capital in this differentiation, and the Member States have different socio-political CDR prioritizations (Geden and Schenuit, 2020).

Policy Instruments

The current 2030 Climate and Energy Framework established in 2018 includes no distinct CDR policy. However, given the new 2030 target, this will change by 2022. The current LULUCF Regulation contains a "no-debit rule" meaning that countries are obliged to balance any emissions with removals in the LULUCF sector. To a very limited extent, LULUCF credits can be counted toward mitigation targets in the ESR sector (Ø 1% of 2005 ESR emissions). This flexibility, however, was not explicitly framed as CDR policy, i.e., intentionally incentivizing removal capacities to achieve an economy-wide mitigation target, but rather as acknowledging the hard-to-abate emissions in the politically influential agricultural sector (Böttcher et al., 2019; Matthews, 2019). For now, explicit CDR policies are only under preparation by the Commission. Gradually, however, they are being taken up by the Council and the Parliament. These initiatives focus mostly on ecosystem-based methods: In its Circular Economy Action Plan, the Commission announced a regulatory framework for the certification of CDR by 2023. In its Farm to Fork Strategy, the Commission proposed to use money from the Common Agriculture Policy to reward farmers and foresters who sequester carbon. Apart from that, most existing initiatives are linked to research and innovation funding. The EU's Horizon 2020 program funds large CDR research projects and the EU ETS Innovation Fund (€10 billion) is open for applications from CDR and CCS pilot and demonstration plants. Furthermore, the Commission supports new geological storage projects such as Porthos in Rotterdam and Northern Lights politically and financially (see the case study on Norway). Almost all climate legislation is up for re-negotiation in 2021 and 2022 in the context of upgrading the

2030 target. CDR will likely be addressed in these revisions, maybe even in the EU ETS (Rickels et al., 2020).

Expert Bodies and Science

The Commission refers to the IPCC SR1.5 and in-house modeling efforts to justify CDR (European Commission, 2018a). This justification is in line with a paradigm in EU climate policy that attaches great importance to evidence-based target setting and policy design (Geden et al., 2019). Concurrently, the EU plays a key role in funding the production and mobilization of climate science, in particular, it played a decisive role in the financing of the integrated assessment modeling community (Cointe et al., 2019; Lövbrand, 2011)—one of the key gateways for the diffusion of the CDR issue on the political agenda (Low and Schäfer, 2020). Although the EU's long-term strategy models net negative CO_2 in the second half of the century (European Commission, 2018a) and legislation includes language on the need for it, actual target-setting and other policy initiatives do not address the issue so far; it is almost exclusively addressed by climate scientists.

Developments in CDR Niches

With regard to CDR niches, the involvement of the Commission in CCS projects in the Netherlands and Norway and the funding opportunities for researching and demonstrating CDR under the EU ETS Innovation Fund are the most important developments. In November 2020, three EU Member States (Netherlands, Denmark, and Sweden) together with Norway published a “Non-paper on Carbon Capture and Storage” in which they stress the importance of CCS as well as CO_2 removals to achieve the EU's goal of climate neutrality (Klima- Energi- og Forsyningsudvalget Danmark, 2020). Other niche developments can be best observed at the Member State level (see the case studies on Germany, Ireland, and Sweden).

8.3.2 Germany

Institutional Setting, Actors, and Coalitions

Germany is often perceived as a frontrunner in crafting mitigation policies. Since the late 1990, German policymakers have promoted the “Energiewende” (energy transition) and its main purpose of supporting the expansion of renewable energy sources to reduce CO_2 emissions. At the same time, its climate policy is deeply interwoven with EU policy making (see EU case), occasionally creating tensions between the largest EU Member State and the EU level (Jänicke, 2017). Although German climate policy explicitly refers to the net-zero GHG target stemming from Art. 4 of the legally-binding Paris Agreement (German Government, 2016), the issue of CDR to balance residual emissions is not explicitly addressed. This holds also true for the Climate Law adopted in 2019. Neither the balancing of residual emissions

nor net-negative emissions beyond 2050 are addressed in the law (Bundesgesetzblatt, 2019).

After the German government decided to follow the EU Commission's proposal to set a net-zero GHG emissions target in 2019, the fact that achieving net-zero target requires removals, both ecosystem-based and geochemical-based got increasing attention in German climate policy (Prognos, Öko-Institut, Wuppertal-Institut, 2020). In general, however, the issue of CDR is approached with restraint. The Free Democratic Party is the only party in the German parliament calling for a proactive approach to CDR. The political reluctance is linked to the strong political path-dependencies created by the energy transition and the low level of public acceptance of CCS (Dütschke et al., 2016). However, the acknowledgment that residual emissions must be balanced to achieve net-zero GHG emissions in 2050 is likely to lead to an intensified CDR debate and incremental modifications of existing climate policy. ENGOs increasingly acknowledge the fact that some carbon removal will be needed, and support for enhancing “natural” sinks is being expressed (Deutscher Naturschutzring, 2020). Their position toward integrating geochemical-based CDR remains very skeptical. Their main arguments against the integration are concerns about mitigation obstruction as well as strong rejection of CCS. The German industry has so far not been openly calling for the integration of CDR in future climate policy.

CDR Accounting and Methods

CDR is not yet accounted for in national mitigation targets, neither natural (e.g., enhanced LULUCF sink) nor geochemical-based methods (except for limited flexibilities, see EU case). However, EU Member States including the German government and the EU Commission now support a proposal of changing the accounting methods for climate targets at EU level, incl. the 2030 target, toward a “net” emissions logic. Such a reform would then likely also be implemented in the German climate law.

Policy Instruments

The emerging CDR debate in Germany is shaped by the differentiation between “natural” and “technological” methods. Options linked to CCS in particular are quite contested. In the years before the incremental acknowledgment of the need for CDR to neutralize residual emissions in the context of net-zero targets, deliberate CDR was not discussed by political actors but only by climate scientists and usually dismissed as a form of climate engineering. At the national level, no CDR-related policy instruments exist yet. The developments at EU level, however, will shape German climate policy substantially. Not only because of EU competencies in climate and energy policy, but also because it is easier for German policymakers to elevate a rather controversial issue to Brussels. As the German LULUCF sink is projected to decrease and turn into a source of emissions and the existing EU legislation already

requires to adhere to the “no-debit rule” (see EU case), the development of policies that aim for enhancing LULUCF removals are to be expected.

Expert Bodies and Science

In the National Energy and Climate Plan 2030, submitted to the EU in 2020, the German government addresses both “natural” CDR (“plant growth”) and “technological” CDR (“direct air capture”). It is being noted that research will be stepped up (Bundesministerium für Wirtschaft und Energie, 2020, p. 61). A research initiative is also announced with regard to the enhancement of the sink function of soils and forests (Bundesministerium für Wirtschaft und Energie, 2020, p. 119). The integration of controversial topics into the political debate through formalized expert bodies and research funding is a common approach in Germany (Jasanoff, 2005). For 2021, the Federal Ministry for Education and Research announced two large research funding lines (Bundesministerium für Bildung und Forschung, 2020a, 2020b).

The debate on CDR entered the policy debate only after the IPCC's SR1.5 in 2018. Policy-makers in parliament and public officials in the relevant ministries, however, are still reluctant. Since the adoption of the net-zero target, the debate is incrementally shifting and a discussion about funding for researching and developing CDR emerges. So far, CDR measures were almost absent from domestic modeling efforts (Hahn et al., 2020). However, first studies on achieving net-zero GHG emissions indicate the need for large-scale geochemical-based CDR (5% of 1990 emissions) (Prognos, Öko-Institut, Wuppertal-Institut, 2020). The issue of net-negative emissions in the second half of the century, however, is only addressed by climate scientists so far.

Developments in CDR Niches

Due to the aforementioned strong path dependencies in German climate policy, the support for CDR niches is rather limited. The new funding lines indicate emerging support for research and development but not for deployment of geochemical-based CDR. An increasing amount of German companies are cooperating with internationally emerging CDR businesses in order to explore possible ways to achieve voluntary climate targets, e.g., Audi/Volkswagen with ClimeWorks in Iceland (VW, 2020). The decreasing LULUCF sink and existing regulatory obligations might put pressure on German climate policy regime and could accelerate the support for niches.

8.3.3 Ireland

Institutional Setting, Actors, and Coalitions

Ireland expresses consistent aspirational support for effective climate policies, but following the financial crisis of 2008 it generally prioritized economic recovery. Within the EU's multi-level processes Ireland has played a generally constructive role but resisting high ambition, and maximizing so-called “flexibilities.” The role of GHG sinks, and specifically forestry-based sinks, has been part of Irish policy since the adoption of the Kyoto protocol. Ireland's compliance with its (relatively modest) obligations under the first commitment period of the protocol relied on including accounting for forestry sinks. However, the overall Irish LULUCF sector continues to be a net GHG source rather than sink. The government that took office in 2020 tabled a draft for new national climate action legislation, including a statutory net-zero objective for 2050, explicitly defined as a balance between GHG emissions and removals (Irish Government, 2020).

Since 2016, after IPCC's AR5 and the adoption of the Paris Agreement, there is active discussion of net removals among a small number of scientific experts, agencies, and relevant government departments but not apparently extending to senior ministerial level. Among these, views are very preliminary, but there is some rough consensus on the need for strengthening national policy capacity and understanding. To date, geochemical-based CDR has played virtually no role in public discourse. Among NGO actors, CDR is largely viewed with suspicion and assumed to be a device for mitigation obstruction. There is active consideration by industry actors in the agriculture and forestry sectors, focused on potential “credits” (financial or otherwise) to be gained by accounting of gross removals. The influential Irish agri-food sector strongly promotes the potential role of land use removals.

CDR Accounting and Methods

Current national policy ring-fences any removals attributable to forestry as implicitly contributing to a 2050 approach to GHG neutrality within the agriculture, forestry, and other land use (AFOLU) sector, separate from all other sectors. The new legislation would, if enacted, supersede this by establishing an integrated economy-wide GHG neutral by 2050 target. Afforestation is incentivised, but Ireland is characterized by low existing forest cover and afforestation rates have consistently fallen short of targets. Relatively maximal flexibility for LULUCF removals was also sought under the EU Effort Sharing Regulation (ESR) for 2021–2030 (see EU case). There is a separation between discussion of forestry and soil carbon sequestration as against geochemical-based approaches, partly due to relative familiarity and deployment maturity, and because the agriculture sector views the former as tacitly balancing N2O and CH4 under the EU ESR. Bioenergy policy should cut across this: but current bioenergy development is still assessed in terms of unabated use in direct fossil fuel substitu-

tion, rather than potential combination with CCS for CDR (BECCS). There is some ongoing exploration of CCS deployment for fossil fuel emissions abatement, but not CDR.

Policy Instruments

So far, no explicit CDR policy exists, except for incentivising private forestry development. But this policy is generally perceived as primarily about promoting forestry as an economic sector rather than climate mitigation. The proposed climate bill refers to a need for policy flexibility "to take advantage of opportunities … to accelerate the removal of greenhouse gases" (Irish Government, 2020, p. 9). It also proposes the adoption of a rolling programme of 5-year cumulative GHG budgets, though the draft is equivocal as to whether these would be net, or separated into gross emission and removal components. Perhaps more significantly, it makes provision for potential allocation of funding for "projects that seek to increase the removal of greenhouse gas, particularly nature based solutions that enhance biodiversity" (emphasis added, Irish Government, 2020, p. 51).

Expert Bodies and Science

In light of AR5 and the Paris Agreement, the Irish Environmental Protection Agency sponsored a research project to provide a preliminary assessment of the overall potential for negative emissions technologies in Ireland (McMullin et al., 2020). From 2017 onwards, reports of the national Climate Change Advisory Council (CCAC) have started arguing more clearly and explicitly for enhancement of forestry specifically as mitigation. The most recent CCAC annual report (Climate Change Advisory Council, 2020) contained, for the first time, a full section introducing and reviewing the potential role of CDR in Irish climate action. IPCC's SR1.5 has contributed to the expert discussion. Especially to the most recent documents and reports from the Irish Climate Change Advisory Council. Since then, net-zero by 2050 has acquired a sort of totemic usage. Domestic academic analysis is starting to incorporate the finite cumulative GHG budget framing, including downscaling to the national level (based on explicit interpretations of prudence and equity) and this in turn is strengthening consideration of CDR (Glynn et al., 2019; McMullin et al., 2020; McMullin and Price, 2020). The fact that IPCC scenarios assume large scale global net-negative emissions (post 2050) has so far received only marginal political attention. A CCAC communication to Government on the subject of setting national carbon budgets noted that any overshoot or exceedance "will have to be recovered with negative emissions" (Climate Change Advisory Council, 2019, p. 2). It is unclear if this message is yet seriously percolating into national policy thinking, and is not an aspect of wider public discourse. But local NGOs are beginning to raise the issue, particularly in the context of global and intergenerational climate justice.

Developments in CDR Niches

In general, a perception of Ireland as a technology taker rather than innovator in heavy industry sectors prevails in Irish climate policy. From a general industry point of view, interest will remain very limited unless there are plausibly profitably CDR business models. The governmental support for developing or deploying niche CDR methods is therefore rather limited. The new climate bill, however, might change this perspective.

8.3.4 Sweden

Institutional Setting, Actors, and Coalitions

Sweden has pioneered climate policy development since the 1980s. Around the mid-1980s, it adopted several policies targeting energy efficiency and, by the early 1990s, became one of the first countries to instigate a carbon tax. Today, Swedish climate policy is highly interwoven with EU policies and Sweden is traditionally one of the EU Member States with the highest climate ambitions. Although the Swedish political debate on CDR is old and tied to forestry, it intensified after the adoption of the Paris Agreement and following a broad Parliamentary approval of the Swedish climate law in 2017 (GoS, 2017). The climate law was preceded by intense debate among researchers, NGOs, and politicians on the appropriateness of planning for BECCS to contribute to long-term climate targets. While the Swedish BECCS potential is high, planning for BECCS, it was argued, could lead to near-term mitigation obstruction followed by inability to meet the long-term target if BECCS did not deliver. Policymakers agreed on a compromise, with separate targets for emission reductions and so-called supplementary measures.

CDR Accounting and Methods

The separated target structure established by the Swedish climate law distinguishes between emissions reductions (at least −85% compared to 1990 levels) and supplementary measures (maximum 15%), i.e., CDR through targeting additional enhancement of LULUCF sinks and BECCS (GoS, 2016) as well as international offsetting. Supplementary measures have mostly been justified as a means to provide flexibility to the milestone targets and to balance hard-to-mitigate residual emissions in 2045. While all Swedish climate policy is anchored in the climate law and framework, CDR-related policies are largely done separately.

Policy Instruments

In 2020, a government committee proposed a strategy to realize the supplementary measures (GoS, 2020). Although international offsetting was forwarded as one alternative, the committee suggested to minimizing offsetting and to instead focus on BECCS and enhanced LULUCF. The over 50 actions proposed by the strategy include state-led reverse auctions for BECCS, improved coordination, increased funding to afforestation, agroforestry,

rewetting of drained peatlands, and to push for an EU-wide BECCS policy and improved monitoring and reporting rules. The proposed strategy has received substantial backing by Swedish industry and civil society. Some politicians have indicated resistance to subsidized BECCS, including representatives of the Green Party, while others have largely reacted with silence. In January 2021, the Swedish Government tasked the Swedish Energy Agency to design a support scheme for BECCS to be implemented in 2022 either as a reverse auction or as a flat subsidy (GoS, 2021). Forest and energy companies are requesting policy-induced economic incentives to deploy BECCS and are also generally of the opinion that biomass may contribute to decarbonization and negative emissions in many other ways (Rodriguez et al., 2020). Several NGOs have criticized the strategy for not capitalizing fully on the potential of enhanced “natural” carbon sinks.

While forest-based CDR has long been discussed, LULUCF sinks are not foreseen as the main CDR method; LULUCF sources and sinks are reported but unaccounted toward the climate targets. Taking the LULUCF sink into full account would enable net-zero emissions soon after the mid-2020s, provided that fossil emissions continue to decline. The proposal is to only account for additional LULUCF removals that are a direct effect of new supplementary measures policy and that are not necessary to meet the no-debit target in the EU LULUCF Regulation (GoS, 2016, 2016). In addition to initiatives in the context of the climate law, policy measures for LULUCF sinks exist, a few existing policy measures also target BECCS and biochar. These instruments include the Industrial Leap Scheme Industriklivet, an investment fund with a specific appropriation for BECCS RDD&D, and the Climate Leap Program Klimatklivet and the Rural Development Programme that supports biochar market introduction. Regulatory clarity on CO_2 transport and storage is also in force, in response to EU regulation (GoS, 2014).

Expert Bodies and Science

When the debate on fossil CCS intensified in the late 1990s, Swedish researchers started exploring BECCS as a source of negative emissions (Möllersten, 2002; Obersteiner et al., 2001) and to expand the technology portfolios of integrated assessment models (Azar et al., 2001). At the time of the approval of SR1.5, the Swedish climate law had already been passed in Parliament. By then, the Swedish debate had matured to take note of the high uncertainties related to BECCS but also to distinguish between the large trade-offs associated with the widespread BECCS deployment assumed in many global scenarios and the more limited but less problem-struck domestic potential for BECCS. In the process of designing the separated targets, domestic modeling played an important role. It was used both to arrive at the total target quantity for supplementary measures in 2045, and to argue for bringing the target forward from 2050 to 2045. The Swedish potential for net-negative emissions in the

second half of the century is also discussed in expert circles and established as a climate objective yet in unspecified qualitative terms (to achieve net-negative emissions after 2045).

Developments in CDR Niches

Due to strong governmental support for research, development, and deployment, BECCS is developing quite fast. Most prominently, Stockholm Exergi, an energy utility, pledges to become “climate positive” (i.e., net-negative) by 2025, relying on its own production of biochar and BECCS deployment to deliver on its pledge. About 10 other companies are also planning to implement BECCS between 2025 and 2030.

8.3.5 Norway

Institutional Setting, Actors, and Coalitions

Norway's climate target is to reduce GHG emissions by 50–55% by 2030 compared to 1990 but does not have a specific net-zero target. By 2050 the ambition is to reduce GHG emissions by 90–95%. The industry and energy sectors are fully integrated in the EU ETS, whereas other policy instruments are directed at the transportation, agriculture, buildings, and waste sectors. According to the EU's LULUCF regulation, which Norway is associated with, the no-debit rule applies to LULUCF by 2030 (see EU case). The CDR story in Norway is short, and there is not much public debate about CDR. However, the CCS story is longer—stretching back to the 80s in terms of research and mid-90 in terms of the first industrial application. CCS is not a CDR approach on its own but needed for BECCS and DACCS. CCS entered the public debate in the early 1990s, and gained traction from 1996 onwards after CO_2 was separated from natural gas at the Sleipner platform to make the gas commercial and geologically stored. The subsequent debate on CCS in Norway was associated with power production from natural gas. CCS became a compromise between industrial development based on natural gas and climate policy. Full-chain CDR operations, foremost biomass use combined with CO_2 capture in industry and biochar, have only been on the debate agenda for the last decade, catalyzed by IPCC's SR1.5 from 2018.

The interest in industry-based CCS has picked up in the last years, foremost in some energy-intensive industries, to capture fossil- and process-related CO_2 emissions, or to produce hydrogen from natural gas combined with CCS. These industries also have plans to replace some of the fossil inputs with biogenic materials, which would establish a CDR chain. One example is the planned carbon capture operation at the waste incineration plant of Fortum Oslo Varme AS. However, so far little attention has been given to specialized BECCS. The agricultural sector has taken some interest in biochar and established a network (Norsk Biokullnettverk, 2020). Technology focused environmental NGOs accept geochemical-based CDR, whereas the nature conservation focused NGOs favor ecosystem-based CDR. Indus-

try groupings and agriculture see themselves as stakeholders in CDR, but still expect significant public facilitation in terms of public funding and an improved policy framework.

CDR Accounting and Methods

Norway has had a net CO_2 sink through forest growth for decades but has been cautious to include this in the national GHG accounting, with a view to the country's position on sinks in international climate policy negotiations. In the case of BECCS, waste incineration, and biogenic inputs for industry with CCS, removals can be accounted for if these can be subtracted from emissions of CO_2 and other GHG. There is a challenge with CDR in industry due to the EU ETS, however, since biomass is included in the baseline (i.e., assumed to be CO2-neutral) and biomass-based entities are excluded from the trading system.

Policy Instruments

Explicit CDR policies are currently almost absent from Norwegian climate regulation. So far government financial support for R&D has been the major policy instrument for CCS and CDR development. Since Norway is fully linked to the EU ETS, CDR-related funding from the EU's Innovation fund (see EU case) will also provide some CDR incentives in Norway. As part of a broader debate, one proposal is to establish a specific fund to catalyze CCS and CDR deployment in industries. Regarding forestry, in 2016 a scheme for enhanced carbon fixation in forests was introduced, with economic support for forest fertilization, denser tree planting, and development of improved tree species. Aside from managing the net CO_2 sink of forests, there will not be much development on other CDR methods.

The Northern Lights project, a CCS project to transport and sequester CO_2 from Norway and other countries, is a key initiative. This project is part of emerging international full-CDR chains and potentially a component of future CDR business cases in Norway and beyond.

Expert Bodies and Science

The first actors to push both CCS and CDR into the policy debate were scientific experts and some NGOs. Aside from an earlier start in the scientific community, the public attention and debate first picked up after recent IPCC reports. In Norway, this awakening has merged with the longer-term understanding of the need and potential for CCS to reduce GHG emissions, and Norway being in a promising position to facilitate the required technology development, not the least regarding storage of CO2.

Developments in CDR Niches

In Norway, several CDR-related CCS projects are emerging, financed by the government as well as possibly by the EU's Innovation Fund. In September 2020, the government launched the project Langskip, announcing that a full-scale CCS facility at Norcem Heidelberg Cement, Brevik, will receive close to full government funding. Furthermore, a full-scale CCS facility at

the Fortum Oslo Varme AS waste incineration plant will receive almost 50% government funding, contingent on remaining funding from own and other sources. Parts of these processes can be regarded as CDR. The Northern Lights initiative is the third component, in which an infrastructure for transportation and storage of CO2 under the North Sea seabed is developed, supported by Equinor, Shell, Total, and the Norwegian government. Companies from other European countries are invited to join. So far, companies from Norway, the UK, the US, Ireland, Sweden, Belgium, France, and Germany, have expressed an interest. More generally, there is wide-spread industrial interest in Norway to reduce industry-related CO_2 emissions through installing CCS facilities and using biogenic resources.

8.3.6 United Kingdom

Institutional Setting, Actors, and Coalitions

Before submitting its first NDC in 2020, the UK had made its commitments under the UNFCCC as part of the EU. The UK has had comprehensive emission targets set by domestic legislation since 2008, however, and withdrawal from the EU does not appear to have changed its overall positioning as an international leader. The legislation of the 2050 target for a UK GHG reduction of at least 100% (i.e., net-zero) (UK Government, 2019) has raised the profile of the debate around CDR, in the UK often referred to as Greenhouse Gas Removal (GGR) to keep open the possibility of non-CO_2 approaches. CDR entered the national political debate with the publication of the 2016 report “UK Climate Action following the Paris Agreement” by the Committee on Climate Change (CCC) (The Committee on Climate Change, 2016). Before that, CDR was not explicitly addressed as a topic but several initiatives indicated implicit CDR policy. Reforestation was a policy topic in the UK early on after a history of heavy deforestation. The UK had integrated carbon storage as a goal of forestry by 1994 and committed to create more woodland in the context of climate targets in 2009 (Raum and Potter, 2015). Increased tree planting became a high-profile campaign issue during the 2019 election, with the environment, and carbon in particular, highlighted as a key motivation.

Recently, some businesses and industries have promoted geochemical-based CDR. Perhaps the most notable (in terms of potential scale) is Drax, the UK's largest thermal power station, which is trialing carbon capture on its biomass-fired units with the aim of becoming a BECCS facility. Other, smaller-scale CDR start-ups are also emerging. Conclusions from the UK Citizens' Assembly on Climate Change suggest a majority of the public prefers ecosystem-based approaches to geochemical approaches. There is however some support for research into “engineered” CDR. Common concerns include CO_2 leaks from storage and that CDR fails to address the root cause of the problem (Climate Assembly UK, 2020). Other UK

surveys confirm this, and suggest publics may not accept removal unless accompanied by ambitious near-term emission reductions (Cox et al., 2020). The position of UK ENGOs on CDR is rather mixed. Mitigation deterrence is a concern, although at least some consider a need for geochemical CDR alongside widespread emissions cuts (FoE, 2018).

CDR Accounting and Methods

In UK mitigation targets, emissions and removals are treated equally in accounting and LULUCF sources and sinks are included (UK Government, 2019). The legislation only mentions the LULUCF sector in reference to removals which can be accounted for in targets. This implies that any CDR reported outside the LULUCF sector (e.g., BECCS, DACCS) would not be included, however, an adjustment to the legislation would at least in principle be simple.

Policy Instruments

The most developed area of policy relating to CDR in the UK is for forestry. A framework for monitoring, reporting, and verification (MRV) of voluntary actions to increase carbon in forests has been developed as the Woodland Carbon Code. Incentives exist in the form of grants and, more recently, the Woodland Carbon Guarantee which provides long-term prices for carbon credits. Several policies are in place to reduce the wider negative impacts of these policies (UK Government, 2018).

Despite previous failed attempts to initiate CCS in the UK, the government intends to deploy CCS at scale by the mid-2020s. It has announced a CCS Infrastructure Fund of £1 billion to build four clusters by 2030 (UK Government, 2020a). Support has been given to several innovation projects, FEED studies and strategy documents, and a consultation carried out on business models to support different CCS applications, including BECCS. The government has also announced it will invest £640 million in tree planting and peatland restoration (i.e., enhanced soil carbon) in England (UK Government, 2020b), is studying policy options to incentivise a range of CDR methods (Vivid Economics, 2019) and has noted its openness to considering future inclusion in carbon pricing mechanisms. Up to £100 m support for innovation in CDR has been announced (UK Government, 2020a).

Expert Bodies and Science

The UK's approach is guided substantially by the CCC. Its advice emphasizes independent expertise and scenario building, with the overall timing and scope of domestic action guided by global pathways necessary to meet the Paris Agreement, taken primarily from the IPCC's SR1.5 (Committee on Climate Change, 2019). The CCC is now analyzing CDR as a sector alongside other more traditional sectors such as power and transport, and has offered a package of policy recommendations (Committee on Climate Change, 2020). The wider academic climate research community has also been a key player in the debate. The UK re-

search councils have already funded one programme of CDR research and are commissioning a new programme of demonstration. A report on CDR was published by the Royal Society and Royal Academy of Engineering in 2018 (Royal Society and Royal Academy of Engineering, 2018).

Developments in CDR Niches

In the UK, CDR niches are supported proactively by the government. The substantial amounts of funding for research, demonstrating, and deployments indicate that the UK intends to develop into a frontrunner and a technology-provider in the context of CDR. The government has stated “we want the UK's entrepreneurs, universities and engineering industries to be well-placed to exploit the advantages of global demand for these new technologies” (UK Government, 2017, p. 57). Companies, including established businesses and start-ups, are exploring CDR.

8.3.7 Australia

Institutional Setting, Actors, and Coalitions

Climate policy in Australia is a contested policy field, shaped by high vulnerabilities to the impacts of climate change on the one hand and politically influential fossil fuel interests on the other. Australia has a weak pledge for emissions reduction to the Paris climate agreement (den Elzen et al., 2019), with a commitment to 26–28% reduction on 2005 levels by 2030, though eschewing any formal commitment to a net-zero target. The federal-level reticence around climate targets is contrasted sharply by all Australian states and territories, which have adopted net-zero by 2050 (or sooner) targets (Climate Council, 2020). The issue of CDR has been implicitly present in Australia's climate policy for some time. After the publication of the King Review, the Australian Government released its first Statement on the Technology Investment Roadmap (Department of Industry, Science, Energy and Resource, 2020) in which CDR was acknowledged. The statement outlines prioritized technologies, notably including carbon capture and storage (CCS) (plus compression, transport, etc.) explicitly justified by the pursuit of negative emissions. The Statement also includes prioritization of soil carbon, a watching brief on direct air capture (DAC), and carbon capture and use (CCU) as an emerging technology. NGOs and private sector actors have not engaged substantively with CDR in public discourse (outside of the high-profile debates about CCS). The changes in 2020 sit atop a legacy of deeply contested climate policy in Australia (Crowley, 2017); a legacy which offers important context for CDR (Colvin et al., 2020) and highlights the implicit governance of some CDR approaches in Australia.

CDR Accounting and Methods

In the National Greenhouse Gas Inventory, emissions and removals by sector including LU-LUCF, are aggregated to provide a net-total for the country. Ecosystem-based CDR methods are already an implicit part of the policy mix in Australia and regarded as fungible with conventional mitigation. In recent years, LULUCF contributed net-removals to Australia's total emissions (Department of Industry, Science, Energy and Resource, 2020). The centrality of technical methods, particularly CCS, to the 2020 Statement further complicates how CDR has entered Australia's climate policy discourse. CCS in Australia has been a critical technology underpinning “clean coal” rhetoric, which was first advanced in the 1990s and considered a delaying tactic for meaningful emissions reduction (Marshall, 2016). Therefore, the promotion of CCS in 2020 initiative raises the potential that CDR will be perceived or used as the latest iteration of emissions reduction delay.

Policy Instruments

The Climate Solutions/Emissions Reduction Fund (ERF) is Australia's primary climate policy instrument. This economy wide abatement subsidy scheme was introduced in 2014, and uses reverse auctions to “purchase carbon abatement at the lowest per-unit cost” (Evans, 2018, p. 39). Under the ERF, CDR has arguably been enacted in Australia via ecosystem-based approaches such as soil carbon sequestration, tree planting, and improved grazing practices (Department of Industry, Science, Energy and Resource, 2020). In Australia's climate policy discourse, many consider the ERF to be a suboptimal policy option (Burke, 2016). It was part of the “Direct Action” approach, implemented following repeal of Australia's short-lived carbon price. This “implementation and reversal” period of climate policy (Chan, 2018, p. 302) was marked by negative and divisive politics and well-financed and influential fossil fuel industry campaigning (McKnight and Hobbs, 2018). The consequence is that the divisive politics, the contested Direct Action approach, and the forgone carbon price have fostered an industry-first, climate-later view of the political intent of the ERF.

The government response to the King Review noted that efforts to develop methods for including CCS & CCUS under the ERF are in development (Australian Government, 2020). Due to the fact that the ERF already includes carbon removal practices, the regulatory effort to include geochemical-based CDR would be comparatively low. Approaches under the ERF that may be considered CDR have been positioned in the context of emissions reductions (and now, climate solutions), rather than explicitly as CDR.

Expert Bodies and Science

The scientific community is increasingly engaging with the issue of CDR (Australian Academy of Science, 2018; Dunne, 2018) and an expert panel appointed by the government pro-

vided the King Review (Carbon Abatement Panel, 2020), which noted the IPCC and IEA regard negative emissions technologies as significant for the Paris Agreement goals.

Developments in CDR Niches

Australia has an established sector focused on ecosystem-based CDR ("carbon farming") that has been engaging with the ERF and voluntary markets (Evans, 2018). With regard to geochemical-based CDR there are few early movers. Notably, Mineral Carbonation International is an emerging Australian company, and the key entity of CO_2 Value Australia, a peak body representing the nascent carbon utilization sector. The decision to expand the scope for investment beyond renewable energy to include low, zero, and negative emissions technologies of the government agencies Climate Change Authority, Australian Renewable Energy Agency and the Clean Energy Finance Corporation may provide support for niche development. Cooperation by research, industry, and the government may guide the future development of CDR via the ERF and Technology Investment Roadmap toward a productive policy environment in which CDR is not in effect nor perception a 2020+ iteration of "clean coal" emissions reduction delay. CDR as a climate-industry win-win may promote repair of destructive climate politics and inadequate climate policy, and governance via the existing ERF mechanism may accelerate implementation.

8.3.8 New Zealand

Institutional Setting, Actors, and Coalitions

Climate policy in New Zealand to date has been shaped by a strong focus on a price-based, least cost approach to mitigation, combined with the significant economic role of the primary (land-use) sector with high emissions from agriculture and removals from afforestation. CDR from afforestation has been integral to New Zealand's conceptualization of climate change targets and policy from the early 1990s, recognizing that gross CO_2 emissions were projected to increase, but an increasing forest sink would partly compensate for this growth. New Zealand strongly argued for inclusion of carbon sinks in the design of the Kyoto Protocol and the formulation of gross-net emission targets. The domestic debate remained during the late 1990s and early 2000s about the most appropriate incentives for enhancing forest sinks.

Afforestation remains a significant element of New Zealand's approach to meeting its NDC and 2050 emission targets as it provides a comparatively cheap and significant carbon sink[60]. Despite initial concerns in the 1990s, the forestry industry is broadly supportive of plantation forests receiving units that can be traded in the emissions trading scheme (ETS). However,

[60] The net-zero target covers all gases other than biogenic methane (for NZ, essentially CO_2 and N_2O). For biogenic methane, the government has set a separate reduction target range of −24 to −47% reduction by 2050 based on IPCC SR1.5

different groups in NZ are increasingly expressing concern. Rural community groups are concerned about the potential loss of employment, population and associated effects on the community and services if widespread afforestation occurs at the expense of sheep and extensive beef farms (Harrison and Bruce, 2019). Some rural advocates regard the significant reliance on afforestation as evidence of a rural/urban split, i.e., urban elites evading the need to reduce their own (gross) emissions by relying on carbon sequestration occurring on the backs of rural communities. Environmental NGOs are primarily concerned that excessive reliance on CDR may lead to mitigation obstruction, along with risks to the permanence of forest sinks. Other concerns relate to the dominance of an introduced tree species (Pinus radiata) and only limited support for biodiversity goals that could be derived from slower growing native forests.

CDR Accounting and Methods

CO_2 removals are treated as fully equivalent to CO_2 abatement, not only in how they are defined and used to account for emission targets but also in terms of policy settings. It is therefore seen as a perfectly valid and fungible integrated component of the country's overall mitigation strategy. Other types of CDR are not being seriously discussed. There is growing interest in the farming sector to recognize carbon sequestration in soils, but insufficient science to support adoption of this method. There is a notable absence of serious discussion of BECCS, given the potentially suitable land, coupled with very limited biofuel policies compared to EU countries (Wreford et al., 2019). After several abandoned attempts to introduce price based policies, New Zealand introduced an emissions trading scheme in 2008. In this ETS, CO_2 emissions and removals from forestry are treated as fully equivalent to emissions or avoided emissions from gross emitters, to our knowledge the only ETS at national scale to do so. This use of afforestation CDR is consistent with a dominant least-cost principle to climate policy in New Zealand.

Policy Instruments

This primary price-based policy is complemented by a number of additional government programmes, most recently the One Billion Trees programme that seeks to accelerate forest planting for both climate and non-climate benefits such as erosion control and biodiversity through cash grants and technical support. The Billion Trees programme calls for “the right tree in the right place,” reflecting concerns regarding widespread tree monocultures creeping across extensive but productive farmland (MPI, 2020). Suggestions are also being made to limit the rate of carbon-price driven afforestation by allowing local government to control plantations using existing environmental (non-climate) legislation. A further point of concern, raised mainly by stakeholders from the agriculture sector, is that New Zealand chose relatively restrictive parameters for what land qualifies as forest and hence can be recognized for

afforestation, including a minimum area of 1 hectare and a minimum width of 30 m. Work programmes have been initiated to consider options to recognize the carbon being sequestered in smaller-scale plantings on farmland, especially if agricultural non-CO_2 emissions (which are currently excluded from climate policy) become exposed to emission prices as currently planned by 2025.

Expert Bodies and Science

The integration of CDR into the policy mix has been driven primarily by government officials with support from scientists, in what may be called a technocratic approach to policy development initially (Rimmer, 2016). Policymakers and experts followed the view that "net emissions is what the atmosphere sees." This first-principles lens readily leads to treating carbon removals as fungible with gross emissions. Subsequent scientific criticism of the consequences of this approach (e.g., Parliamentary Commissioner for the Environment New Zealand, 2019), covering the range of concerns noted above, has not been sufficient to change the overall framework. Impermanence was seen as an insufficient argument against the use of forest sinks, it only indicated the need for policies that provide accountability for subsequent emissions if and when they occurred. The IPCC SR1.5 strongly facilitated the adoption of the net-zero target for long-lived gases in New Zealand but did not fundamentally change the CDR policy debate, apart from an increasing recognition of the scale of afforestation and potential for negative side-effects if emissions and removals are priced consistent with that target (Ministry for the Environment New Zealand, 2019; Parliamentary Commissioner for the Environment New Zealand, 2019; Productivity Commission New Zealand, 2018).

Developments in CDR Niches

As afforestation has a well-established and low-cost role in the policy mix, activity in CDR niches is rather low. Industry interest in CCS exists but is strongly linked with enhanced oil recovery and not seen as industry opening up a more general option to pursue geochemical CDR at scale. Claims and interests in CDR via soil carbon are generally seen as speculative for the near and even medium term, but are the focus of increased government funding for research. This is, however, in part a preparation and insurance for future accounting requirements, not necessarily a goal of developing a new CDR option. While there has been some interest, biofuels policy is limited compared to EU countries (Wreford et al., 2019), and BECCS attracts no significant attention in the national debate.

8.3.9 USA

Institutional Setting, Actors, and Coalitions

CDR remains a nascent, yet relatively bipartisan, political issue in the US. National electoral politics in the US, expressed most recently in the 2020 Presidential election, typically focus on the validity of climate change science and modifying the climate policy tools implemented by former-President Barack Obama. Legislatively, most national Democrats (one of two major political parties in the US) are focused on the Trump administration's weakening of environmental regulations, and formation of post-2020 climate policy under a Democratic Biden administration. Early decisions and announcements indicate that CDR will continue to move up the US climate agenda over the coming years. So far, CDR has been discussed in US national politics in two forums: ENGOs, and the Congress.

The US currently has no economy wide emissions target. The new Biden-Harris administration, however, has re-joined the Paris Agreement and will therefore have to provide a new NDC. With regard to a long-term target, the Biden-Harris administration raised expectations toward the adoption of a net-zero emissions target in one of the early executive orders (The White House, 2021). The US' first NDC was an economy-wide reduction of GHG emissions by 26–28% below 2005 levels in 2025. CDR played a relatively small role in this NDC, primarily through inclusion of a robust sink of CO_2 in the LULUCF sector. Most US ENGOs, think tanks, trade groups, and philanthropy have been largely supportive of research, development, and deployment of CDR. ENGOs supporting carbon removal have tended to be relatively technology-agnostic, supporting both ecosystem-and geochemical-based methods. A small minority of US ENGOs oppose CDR, primarily “technological” forms of removal such as DACCS. Much of this opposition stems from opposition to CCS as mitigation option for fossil fuel technology. A core area of disagreement between these groups and other ENGOs is whether geochemical-based carbon removal can be a just and progressive form of climate action (Buck, 2019).

CDR Accounting and Methods

In its first NDC, the US intended to include all categories of emissions by sources and removals by sinks, to account for the LULUCF sector using a net-net approach, and to use a “production approach” to account for harvested wood products consistent with IPCC guidance. Arguments for carbon removal in the US tend to embrace the essential role of carbon removal in achieving climate change goals, technology innovation, sustainable agriculture, and job creation (Energy Futures Initiative, 2019; Friedmann, 2019). These innovation-centric framings span both ecosystem- and geochemical-based CDR methods (Larsen et al., 2019). Relatively few actors promoting CDR have adapted framings around equity and justice, despite its prominence in current US climate policy debates.

Policy Instruments

CDR has featured prominently in modest climate policy passed between 2016 and 2020. One prominent example of bipartisan legislation is the Agriculture Improvement Act, known commonly as the 2018 Farm Bill. This omnibus bill provides roughly half a trillion dollars in funding for various USDA functions over a period of 5 years through crop insurance, conservation payments, and loan support (Congressional Research Service, 2018). In a departure from historical precedent, the 2018 Farm Bill establishes a variety of new research programs, funding opportunities, and task forces to aid the development and deployment of a wide range of CDR methods. CDR provisions fall into four main titles: (1) Conservation, (2) Research, Extension, and Related Matters, (3) Forestry, and (4) Energy. Within these new provisions, the 2018 Farm Bill supports and incentivizes research on ecosystem-based (soils, forestry, and grazing management), hybrid (bioenergy and biogas/renewable natural gas), and geochemical-based (carbon utilization) CDR methods (Jacobson and Sanchez, 2019).

Not explicitly introduced as CDR policy, but relevant for geochemical-based or hybrid methods is the 45Q tax credit for sequestration of qualified carbon oxides, adopted in 2009. The tax credit is available for 12 years to projects. Several dozen US CCS projects have been announced in part because of the enhanced 45Q tax credit (CATF, 2020), and CDR projects are expected to calculate with the tax credited.

Finally, the Energy Act of 2020, a bipartisan renewable energy bill passed at the end of 2020, contains several provisions to promote CDR. These include establishment of an interagency CDR research program, a prize competition for direct air capture, and allocation of funds for carbon removal, carbon utilization, and carbon sequestration projects. The bill was adopted by bipartisan majorities in both houses of Congress.

Policy instruments to promote CDR have emerged in recent Congressional legislation. These instruments are primarily allocations and appropriations for research and development, and demonstration. Others make small modifications to existing regulations to promote CDR. Such proposals often enjoy bipartisan support in the US, particularly in the Senate. CDR proposals were also included in the platforms of numerous Democrats vying for their party's Presidential nomination in 2020. The platforms prominently emphasized ecosystem-based CDR approaches such as regenerative agriculture. The new administration is expected to follow-up on these and develop new CDR initiatives.

Expert Bodies and Science

Due to the negative view of the past administration of multilateral fora and scientific expertise on climate change, the IPCC SR1.5 did not play an important role in US climate policy. But the scientific community as well as experts from think tanks and ENGOs are increasingly engaged in CDR debates. As discussed above, most ENGOs in the US have been largely

supportive of research, development, and deployment of CDR and contribute to the CDR debate. Prominent themes emphasized include the necessity of CDR in climate action, economic opportunity, and innovation.

Developments in CDR Niches

Specific deployment opportunities for CDR in the US are still emerging. Nevertheless, deployment prospects are strong due to the US' particular strength in science and engineering, as well as suitable geography for demonstration and early deployment (Sanchez et al., 2018). State level technology and policy opportunities are beginning to materialize at the State and regional scale. Furthermore, start-ups are emerging and prominent technology companies, such as Microsoft and Apple, have made commitments to support and invest in CDR; developments that are likely to be accelerated by the more prominent role for CDR in the new administration.

8.4 Synthesis

The case studies show the multiplicity and varieties of ways CDR is beginning to be, or already is, part of existing climate policy mixes. Even in these countries—which were selected because they already address the CDR in some form—considerable differences in the pace and forms of acknowledging and governing CDR are observed. While CDR policy has already been adopted in some cases for quite some time, in others it is currently being shaped by political positioning of different actors. In order to identify differences and patterns of CDR policy making, we organize the synthesis along the five dimensions of the analytical framework presented in Table 1. Based on these findings, we develop a conceptual typology of the observed varieties and patterns. It is our intention that the contribution of a first attempt of organizing current developments into a conceptual frame will spur work on more fine-grained comparisons and prospects for CDR policy.

8.4.1 Institutional Setting, Actors, and Coalitions

In all nine case studies, climate policy is a well-institutionalized policy domain with clearly-defined actors, political positions and path-dependencies. The countries differ, however, in the ambition and design of emissions reduction targets. They also choose different policy instruments and measures to achieve their commitments. It can be observed that net-zero targets—which began to diffuse into domestic climate politics after the macro-political changes of the adoption of the Paris Agreement and the IPCC SR1.5—facilitated or gave new importance to CDR debates. Australia and the US are the only countries in this selection that

do not currently (January 2021) have a formally adopted net-zero emissions target of some kind at national level.

The existing net-zero targets differ substantially in their scope and timing. Whereas most countries address all GHG emissions, New Zealand for example, excludes biogenic methane from its net-zero ambition. Questions of target design have a significant impact on the amount of residual emissions that need to be balanced by CDR to achieve net-zero (Fridahl et al., 2020b; McLaren et al., 2019), and are therefore an important overarching dimension of CDR policies.

Between Highlighting and Kicking off CDR Policies After the Paris Agreement

The developments in Australia, the UK, and New Zealand show that domestic climate policies aiming at deliberately balancing emissions with removals to achieve mitigation targets is not only a post-Paris development. Although pre-Paris CDR policies were not directly framed as a tool to compensate for residual gross emissions, they aimed at incentivising different actors to enhance the LULUCF sink to help achieve mitigation targets at lower costs. In these countries, the Paris Agreement brought new attention to an already existing strand of climate policy. In the other cases, the emergence of CDR policies is closely connected with the macro-political change represented by the Paris Agreement. Here, CDR in the pre-Paris era was, if at all, regulated implicitly. Public policy on explicitly regulating and incentivising additional removals and accounting them toward domestic mitigation targets only kicked off in connection with or in the aftermath of adopting net-zero targets.

Business and Industry

The positioning and engagement of business and industry actors reflects the variety of current status and prospects of CDR in each country. In cases where the LULUCF sinks are already routinely counted toward mitigation targets, the forestry and to some extent agriculture sector generally supports the use of ecosystem-based CDR (i.e., New Zealand, the UK, and Australia), as well as existing or new initiatives to reward CDR. In the UK and the US, geochemical-based CDR methods are getting increasing attention by business actors. Also in Sweden and Ireland, the business sector is generally in support of the recent domestic CDR initiatives; some actors are directly involved in exploring business cases and actual deployment. Whereas businesses in Ireland are focused on ecosystem-based methods, Swedish companies are involved in a wider range of CDR approaches. In Norway, the fossil and energy-intensive industries are, supported by the government, engaged in deploying and promoting a CCS infrastructure relevant for durably storing domestic and imported CO_2 that could support a future expansion of geochemical-based CDR. In Germany, the industry is

rather reluctant with regard to CDR; early collaborations between industry and CDR companies, however, signal a potential change.

Environmental Non-Governmental Organizations

How ENGOs approach CDR policy also differs significantly and can be conceptualized as a continuum between suspicion and agnosticism. In the EU and its Member States, their position is primarily driven by suspicion that integrating CDR in the climate regime obstructs necessary changes to reduce gross emissions. Although the need for CDR is increasingly accepted and addressed by ENGOs, geochemical-based methods are a particular source of concern. In the US, ENGOs are mostly technology-agnostic, some support geochemical-based CDR proactively. In New Zealand, Norway, and the UK, the picture is rather mixed; whereas some ENGOs are skeptical especially of geochemical-based CDR or approaches that threaten biodiversity, others do acknowledge the need for CDR. In New Zealand, civil society also highlights a rural/urban conflict; rural communities are critical of the idea that they should live with the socio-economic consequences of land-use change to balance ongoing emissions caused in cities. In Australia, ENGOs have not engaged substantially nor explicitly on CDR.

8.4.2 CDR Accounting and Methods

The accounting of CDR varies between full equivalence and reluctance to aggregate emissions and removals. In Australia, New Zealand, and the UK, LULUCF removals are regarded as fungible8 with gross emissions to achieve climate targets. There is currently no cap on the amount of removals that can be used to achieve the domestic targets. This is in contrast to the EU and Norway, where policymakers have so far been rather reluctant to account for large shares of LULUCF sinks toward their mitigation targets. Recent policy initiatives, however, are inducing change. At the Member State level, Sweden has adopted a net-zero target with two components: a minimum amount of emissions reductions and maximum amount of CDR in combination with international offsets, so-called supplementary measures. In Ireland, land use sinks were tacitly used to balance emissions from ruminant agriculture, but emerging climate legislation gives new and more explicit importance to removals. Germany has not pursued efforts to integrate removals in their mitigation target, but a net target at EU-level would affect German accounting practices as well.

Differentiating CDR Methods

Different CDR methods attract varying degrees of attention in the analyzed set of countries. While specific definitions and attribution of methods to categories of “natural” and “technological” methods are contingent and in flux, the general distinction shapes the public policy pro-

cesses and societal debates in all cases. In the UK, Sweden, and Norway geochemical-based methods are proactively addressed, as in Australia and the US though to a more limited extent. In Germany, all methods that include CCS are highly contested in the societal debate. At the EU level, a need for geochemical-based CDR is acknowledged by the European Commission, but the policy initiatives announced so far focus on ecosystem-based CDR. All eight case studies have policy debates or pursue initiatives linked to ecosystem-based CDR in one way or the other, especially afforestation.

The Changing Political Status of Forestry

The comparison across the cases indicates that the role of forestry in climate policy is changing, a change facilitated by integrating CDR into climate policy. The countries differ in the degree to which forestry is accounted toward climate targets. Especially in those countries that aggregate emissions and removals and account for the forest sink in mitigation targets, forestry and its capacity to remove CO_2 is a key component of climate policy. Other countries, like the EU and its Member States, for example, just launched political initiatives for considering the full LULUCF sink in the context of their mitigation targets and thereby give new importance to forestry in climate policy making. In line with recent findings on the history of carbon removal (Carton et al., 2020) and a review of policy tools (vonHedemann et al., 2020) we find that the political status of the LULUCF sink, and forestry in particular, has changed with the emergence of CDR policies, legitimizing the use of LULUCF in some countries while raising questions about the scale and practices of afforestation in others. Future work on CDR policy should therefore analyze the political drivers and implications of these shifts.

8.4.3 Policy Instruments: Between Trading, Rewarding, and R&D

The comparison of CDR-related policy instruments reveals three key groups. The first consists of different policy approaches for mitigation instruments that fully integrate removals. Examples of this are the Australian reverse auction scheme under the Emissions Reduction Fund, or the emission trading scheme in New Zealand, that treat emissions and removals as fully equivalent. With its separate net-zero target, Sweden is a special case: its policies to incentivize and instigate deployment of geochemical-based and ecosystem-based CDR are structurally linked to the overall climate target, but are largely independent from conventional mitigation policies.

A second group of instruments is composed of rewarding schemes to incentivize CDR, which are not directly linked to or integrated with climate policy instruments targeting conventional mitigation. Examples are the Woodland Carbon Guarantee in the UK, or the US 45Q Tax

Credit. Incentive structures aiming to enhance the LULUCF sink through afforestation or re-wetting of drained peatlands outside emissions pricing policies are also established in New Zealand, Norway, Ireland, and Sweden. In Norway and the UK, the efforts to establish a CCS infrastructure by industry and political actors are increasingly framed as CDR-relevant, although questions of their actual accounting are not yet decided. In general, it can be observed that already existing non-integrated instruments targeting CDR received substantially more attention after the adoption of the Paris Agreement than before. In addition, many new initiatives and policy instruments were proposed and adopted since then.

A third group of policy instruments contains R&D funding initiatives that mostly target geochemical-based CDR approaches. However, as mentioned above, definitions of CDR are in flux—especially in the context of researching new approaches. One major difference across the cases is the degree to which the research funding targets deployment of geochemical-based CDR. In the UK, Sweden, and Australia, research funding targets a wide range of CDR approaches, including funds for demonstration and deployment of the geochemical-based methods. The EU Innovation Fund and Norway's support for CDR-related R&D in the context of CCS infrastructure are pointing in a similar direction. CDR research is also part of a large Farming Bill adopted in 2018 in the US. The US supports and incentivizes research on a broad portfolio of CDR methods. R&D as well as demonstration and deployment funding is expected to increase substantially in the coming years. Similarly, in Germany, the government decided to create two large CDR research funding lines from 2021 onwards—deployment, however, is not a specific objective here.

8.4.4 The Role of Experts and Science

In all case studies, scientific expertise is important for initiating and developing CDR policies. CDR entered the public policy decision-making processes through a rather technocratic approach. Scientific experts and specialized policymakers in the administrations have been key actors in pursuing CDR integration. The public debate is—compared to other climate policy related issues—almost non-existent except where it is linked with wider land management practices. The IPCC's SR1.5 and follow-up publications by national science advisory bodies in particular, however, elevated the issue of CDR on the agenda of think tanks, policymakers, NGOs etc.

National modeling studies increasingly address possible compositions of mid-century residual emissions and the amounts and types of CDR required to balance them. The need for at least some countries to achieve domestic net-negative GHG emissions, however—a necessary part of Paris Agreement's global long-term temperature target of well below 2 °C while pursuing 1.5 °C—is still only addressed by small groups of scientific experts and narrow poli-

cy circles. Despite the fact that OECD countries can be argued to have a particular responsibility for achieving net-negative emissions (Du Robiou Pont et al., 2017; Fyson et al., 2020; Pozo et al., 2020), the issue is only rarely and briefly addressed in emerging policy initiatives and could be argued to be actively disabled by a focus on net-zero emission targets.

8.4.5 Developments in CDR Niches

Developments in the niches range from very small start-up initiatives with low support to proactive support for large CDR initiatives by industrial actors. Across the case study countries, we observe very different actors engaged in the protective spaces of CDR development. Among them: energy sector companies in the UK and Sweden, fossil fuel, and energy-intensive industries in Norway, and start-ups in Australia, the US and the UK. The niches are protected in various ways and to different degrees: Most prominently, the UK support for innovation exemplifies how a government tries to strategically position itself as a frontrunner and technology-provider. In Norway, the government also proactively supports innovations in CDR-related initiatives, both in terms of developing, but also politically in the form of advocating the EU to support export of CO_2 to Norway. Together with Sweden, where especially innovations in and deployment of BECCS are supported by the government, this group of countries engage in “nurturing” and “empowering” (Smith and Raven, 2012) CDR development and deployment. In the other countries, niche developments are not supported in such a proactive way but are generally limited to incentives or research funding. However, in New Zealand for example, path-dependent reliance on incumbent CDR regimes can actively reduce incentives to invest in the proactive development of additional CDR approaches.

8.5 Varieties of integrating CDR into climate policy: toward a typology

The synthesis provided an overview of the varieties of CDR policymaking in the countries. While the peculiarities of individual cases became particularly clear, in a second step we are attempting to identify broader patterns of CDR policy making and develop an analytical typology. In doing so, we follow the MLP of socio-technical transitions, where identifying typologies of transitions is a common tool to conceptualize commonalities and differences across case studies (Geels et al., 2016b; Geels and Schot, 2007; Smith et al., 2005). This work is an important reminder of the fact that transitions are not “teleological or deterministic, but continuously enacted by and contested between a variety of actors” (Geels et al., 2016b, p. 900). Shifts between different types are of course possible (Geels et al., 2016b), for example, if societal power structures and political alliances change (Hess, 2014).

In a first step of conceptualizing our findings, we propose five key dimensions to aggregate varieties of CDR policymaking. Each dimension represents a continuum of manifestations

that we identified across the cases (see Table 8.2). It is important to note that these continua are drawn from the synthesis of case studies, and we do not intend for them to represent a definitive nor exhaustive coverage of all possible CDR policy making dynamics. However, we believe these are a useful representation as a first step to carve out differences and commonalities between political approaches toward CDR and therefore a useful step to develop a typology of CDR policymaking that may enable future comparative analysis of other countries and across policy domains and support analysis of change in CDR policy making dynamics over time.

Table 8.2: Five dimensions of CDR policy making and continua of observed manifestations.

Dimensions	Continua	
CDR in mitigation targets	Fungible	Strictly separated
View of CDR among actors of the incumbent regime	Proactive integration	Restrained integration
CDR methods addressed	Only ecosystem-based	Wide range of methods
Relation of CDR policy instruments to broader climate policy mix	Incremental opening	Full integration
Government support for developing CDR niches	Limited support	Nurturing and empowering

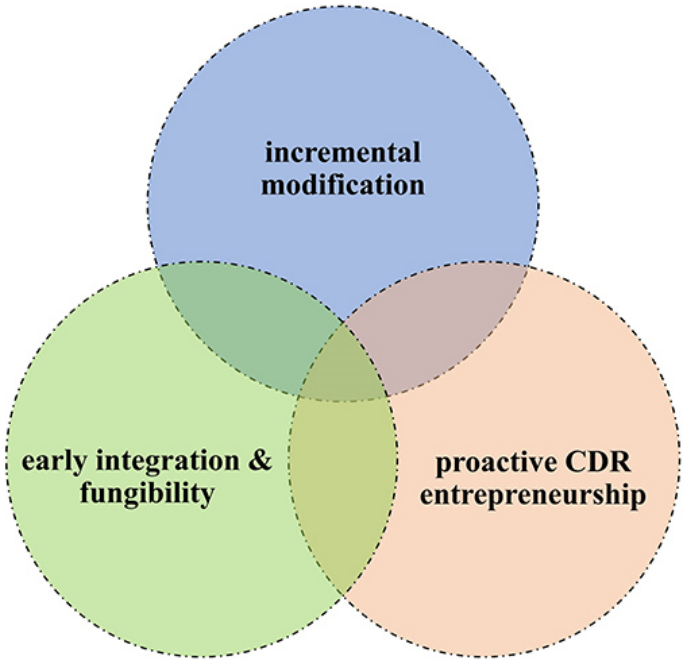
In a second step, we use the five dimensions and continua to build a three-tiered typology on how CDR is currently being addressed and integrated in climate policy regimes. The types are idealized; differences are deliberately overstated in order to support analytical clarity9. Their main utility is to illustrate divergent possible policy approaches toward CDR that we observed in the case studies. Based on the continua observed in the case studies, we attempt to identify the conceptually most distinctive types of how CDR is approached. In reality, countries might lean to one or the other type, but do not necessarily match all typical characteristics or may represent hybrids. In actual CDR policymaking, boundaries are blurry and overlaps exist. Furthermore, shifts between the different types and developing new types is possible over time; discussions about which direction to follow in CDR policymaking is expected to be politically contested. Identifying these conceptual types is, however, a way of further synthesizing the knowledge gathered through empirical case studies. It may inform future comparative work on CDR policy as well as spur a debate about possible and plausible developments in future CDR policy. These types are not formulated as a finite result. Future work, e.g., on a different set of countries might identify important amendments and additions to this typology.

Table 8.3 and Figure 8.1 provide an overview of the three conceptual types of CDR policymaking; the following sections describe the three types in more detail and give an overview of typical cases and hybrid forms of CDR policy approaches among the cases.

Table 8.3. Three types of integrating CDR into climate policy.

	I. Incremental modification	II. Early integration and 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 and empowering

Figure 8.1. Three types of integrating CDR into climate policy.



8.5.1 Incremental Modification: Limited Integration of CDR

The type of incremental modification is shaped by a restrained approach toward integrating CDR into existing climate policy instruments to address the need to balance residual emissions. These incremental steps to integrate CDR are shaped by rather strict separations between emission reductions and removals in the accounting toward mitigation targets. CDR policies and policy instruments linked to conventional mitigation are also strictly separated. Over time, the incremental opening could lead to an advancing integration of removal and reduction instruments.

Incumbent actors do not ignore the need for CDR completely; in particular, macro-political developments toward the new importance of sinks puts pressure on the climate policy regime. In this context, their incremental approach leads to a step by step integration of eco-

system-based CDR approaches. With regard to policy instruments, a cautious opening toward CDR is characteristic for this type, allowing for accounting of a limited amount of ecosystem-based CDR. Regarding geochemical-based CDR, the focus is on RD&D. Support for new CDR methods in small niches and their deployment, however, is limited; research funding is the only support for them.

8.5.2 Early Integration and Fungibility of Emission Reductions and Removals

In this type, CDR is already part of the climate policy regime. Even before macro-political developments such as the Paris Agreement and the diffusion of long-term net-zero targets, fungibility of emissions and removals was established. Established policies reflect the assumption that “net emissions is what the atmosphere sees.” Since the Paris Agreement, incumbent actors give more attention toward CDR; policymakers and other actors are now exploring options to foster and expand CDR's role in achieving long-term goals.

This type is characterized by the fact that ecosystem-based removals are fully integrated in policy instruments such as emission trading schemes or reverse auctions. Geochemical-based CDR would—from a sheer regulatory point of view—be comparatively easy to integrate, especially because the hare of CDR that can be used to achieve climate targets is not limited in this type. Because CDR approaches are already part of a stable climate policy regime and macro-political changes did not put pressure on the regime in countries of this type, developments in niches and their support is not very pronounced.

8.5.3 Proactive CDR Entrepreneurship

The political envisioning of a net-zero emissions society is directly linked to the deployment of CDR in the type of proactive CDR policy entrepreneurship10. The incumbent actors address the need to integrate and deploy CDR and pursue the reorientation and opening up of current conventional mitigation climate policies proactively. In comparison to other types, niches of radical geochemical-based CDR innovations are deliberately nurtured and empowered. In general, CDR policy is open to a wide range of CDR methods.

In contrast to the early integration type, CDR-specific policy instruments are being developed (e.g., reverse auction or financial rewarding schemes) which are not fully integrated into conventional mitigation policy instruments. This is not only because of path-dependencies created by existing policy instruments, but also because incumbent actors follow the objective of supporting the CDR development and deployment specifically. Being perceived as a frontrunner in changing macro-political contexts as well as a technology provider through developing and deploying CDR technologies and exploring business cases is one of the political objectives of the incumbent actors in this third idealized type of CDR policymaking.

8.5.4 Typical Cases and Hybrids

If we try to locate our case studies on this spectrum of varieties of CDR policy making, they can be differentiated between typical cases and hybrids. The UK can be described as a typical case for the type of proactive CDR policy entrepreneurship. None of the other countries studied have such explicit policy support for the development and deployment of various CDR measures. To a limited extent, policy entrepreneurship can also be identified in the European Union. However, the initiatives come mainly from within the European Commission; only the coming years will show how the Member States position themselves. Within the EU, Sweden is the country with the most specific and advanced CDR policy and shows policy entrepreneurship. Its regulative approach of separating reductions and removals as well as long-lasting debates on LULUCF removals, however, indicate overlaps to the types of incremental modification as well as early integration and fungibility. In Norway, we observe policy entrepreneurship with regard to CCS, a key component of several geochemical CDR approaches. Initiatives for specific CDR policies, however, are so far limited and emerging only incrementally. The new US administration is expected to establish and develop specific CDR policies in the coming years. With respect to geochemical-based CDR in particular, the US is signaling that it is striving to be perceived and act as a frontrunner.

Australia and New Zealand are typical cases for the early integration and fungibility type. Both integrated CDR into their domestic policy before the recently rising attention toward these measures. In addition, both policy-designs are shaped by fungibility of emissions and removals. Some aspects of this type are also to be found in the case study of Ireland. At the same time, however, we also observe aspects of incremental modification in Ireland. Germany is a typical case for this third type of incremental modification. Although actual integration of CDR into the climate policy mix is almost absent so far, the societal and political debate is increasingly opening toward CDR.

It is important to highlight that this assessment can only be a snapshot. How CDR is approached politically is currently contested and will be subject to political struggles in the future. Future work on comparing CDR policy approaches should therefore not only extend the list of countries but also assess how the countries initially studied for this project are developing. The cases identified as hybrids are of particular interest—an in-depth analysis of the dynamics currently taking place, including the opportunity to reveal emerging new political approaches to CDR, would be an important contribution to the emerging literature on CDR.

8.6 Conclusions

In our analysis of nine empirical case studies we analyzed the varieties of CDR policymaking and provide a snapshot of a rapidly developing policy field. Based on the analytical framework that tries to bridge insights from the multi-level perspective on socio-technical transitions and the emerging literature on CDR policy and governance, we tracked the developments across these cases. The synthesis of this rich empirical material reveals substantial differences as well as commonalities across the cases. In an attempt to conceptualize different patterns of CDR policymaking, we identified five dimensions of CDR policymaking and proposed three idealized types of CDR policy making: (1) incremental modification, (2) early integration and fungibility, and (3) proactive CDR policy entrepreneurship.

It is important to note that boundaries of these idealized types are blurry; in the real-world, specific cases do not necessarily match all characteristics of one type and hybrids exist. In addition, countries can shift between different types over time and new types might emerge. Such an evolution is expected not only because policies and approaches are expected to evolve, but also because CDR policies are contested as political actors struggle for different prospects of governing CDR. These drivers are capable of re-directing current developments in CDR policymaking toward different or entirely new types of CDR policy and governance.

The proposed conceptualization helps to synthesize the knowledge collected through the case studies and illustrates divergent possible approaches. As a conceptual typology, however, it is reductionist and does not cover all dimensions relevant to regulating CDR. Despite these limitations, this initial work on comparing CDR policymaking and conceptualizing different analytical types might spur future, more fine-grained work, including comparing different sets of countries, investigating in-depth single case studies and tracking changes in CDR policymaking over time.

9 Taking Stock of Carbon Dioxide Removal Governance in Emerging Economies: Developments in Brazil, China, and India[61]

9.1 Introduction

Achieving the climate mitigation targets agreed in the Paris Agreement requires unprecedented changes in all aspects of society (IPCC, 2022). In recent years, it has become increasingly clear in climate science and acknowledged in the climate policy debate that emissions reductions alone will not suffice to achieve the Paris Agreement target of "limiting global warming to well below 2 °C and pursuing efforts to limit it to 1.5 °C" (Fuss et al., 2020; Riahi et al., 2021; Rogelj et al., 2018). Global and national integrated assessment models (IAMs) clearly show that carbon dioxide removal (CDR) will be unavoidable to balance hard-to-abate emissions for achieving net-zero greenhouse gas (GHG) emissions and reaching net-negative emissions in some sectors and countries (Babiker et al., 2022).[62] In the Working Group 3's contribution to IPCC's sixth assessment cycle, mitigation pathways that limit warming to 1.5 °C (>50%) require substantial amounts of CDR: The pathways include net-negative emissions from the Agriculture, Forestry and Other Land Use (AFOLU) sector between 20-400GtCO2 and gross removals through Bioenergy with Caron Capture and Storage (BECCS) (30-780 GtCO2) and Direct Air Capture and Carbon Storage DACCS (0-310 GtCO2) (IPCC, 2022, p. 29). Conceptually, the IPCC AR6 WGIII report identifies three functions for CDR in mitigation pathways: 1) accelerate near-term mitigation 2) counter-balancing residual emissions for net-zero', and 3) achieving net-negative emissions. Whether and how these functions inscribed in the pathways are already materializing in practice, and whether the large amounts of CDR are plausible and feasible, will be a key question for future research on CDR.

In this paper we aim at exploring CDR methods inscribed the pathways with a particular focus on the regional differentiation. Moreover, we combine these insights with a bottom-up analysis of the state of CDR governance and policymaking in Brazil, China and India. These three countries are in regions that in IAMs are expected to contribute large shares of CDR. The state of CDR governance and policymaking, however, has not yet been studied in scientific literature. We aim to produce the first comparative case studies of CDR governance and policymaking in the key emerging economies. Furthermore, the approach of combining quantified model results with non-quantifying social science can contribute to the debate of strate-

[61] Manuscript prepared for submission, co-authored with Brutschin, E., Guo, F., Mohan, A., Oliveira Fiorini, A.C., Saluja, S., Schaeffer, R., Geden, O., Riahi, K.

[62] Examples for CDR requirements in national modelling are in China (He et al., 2020); EU (European Commission, 2018a); USA (National Academies of Sciences, Engineering, and Medicine, 2021); or Brazil (Köberle et al., 2020).

gies to bridge these different approaches (Geels et al., 2016a; Peng et al., 2021a; Pianta and Brutschin, 2022; Trutnevyte et al., 2019; Turnheim et al., 2015) and sketch out ways for future interdisciplinary work. Eventually, the interdisciplinary work might help to identify constraining and enabling conditions for socio-political and institutional feasibility of large-scale CDR deployment and to improve political robustness of gobal mitigation pathways.

We apply hybrid and mixed methods research design. In the following section 2 we review the role for CDR in in integrated assessment modeling and introduce the research strategy of an iterative strategy between IAMs and social science. Based on scenarios from the IPCC AR6 scenarios database and the ENGAGE intermodal comparison project (Riahi et al. 2021), we show in section 3 that large emerging economies and major emitters like Brazil, China, and India require more attention. In section 4 we conduct comparative case studies of these countries and synthesize the findings in section 5. We conclude the paper by further developing different types of CDR governance and policymaking – conceptual work that could inform CDR deployment narratives in future research.

9.2 A short history of CDR in IAMs

IAMs are complex models connecting representations of the global economy, energy, and land-use systems based on a wide range of assumptions. They are perceived to be instructive tools to identify “solution spaces” (Keppo et al., 2021) to achieve stringent climate targets and powerful in instigating and shaping scientific and policy debates (Cointe et al., 2019; Pedersen et al., 2021; van Beek et al., 2022). The discussion about CDR in models and policymaking is a key example of these dynamics (Beck and Mahony, 2018; Geden, 2018).

The debate on the large-scale use of CDR as an element of mitigation strategies modeled in IAMs date back to the late 1990s (Obersteiner et al., 2001; Williams, 1998). More recently, with the IPCC’s AR5 and the large amount of CDR required in the assessed scenarios to stay below the 2 °C level (IPCC, 2014b), a more technical debate has expanded from a small community of scientists to commentaries in leading science journals (Anderson and Peters, 2016; Fuss et al., 2014; Geden, 2015). While policymakers initially were reluctant to pick up the issue (Geden et al., 2019), the number of scientific studies on CDR accelerated rapidly (Minx et al., 2017b). In particular, in the run-up to IPCC’s Special Reports on 1.5 °C Global Warming (IPCC, 2018a) and Climate Change and Land (IPCC, 2019b), the research communities worked on refining the knowledge about the geophysical and techno-economic availability of CDR, including its limits if sustainability goals are taken into account (e.g., Holz et al., 2018; Roe et al., 2021; Smith et al., 2019; van Vuuren et al., 2018).

The growing importance of CDR in IAMs has been criticized in recent years (Hasegawa et al., 2021; Pedersen et al., 2021). Two main criticisms have been raised in the ongoing de-

bate: first, the sustainability trade-offs of certain CDR methods, particularly BECCS and afforestation (Anderson, 2015; Creutzig et al., 2021), where the main concerns include food security due to the amount of land and water resources required (see also IPCC, 2021b, 2019b). Second, scientists have identified a moral hazard associated with CDR, raising the problem that the deployment of large-scale CDR could lead to emissions reduction efforts being deterred or obstructed (McLaren et al., 2019; Morrow, 2014). Studies based on IAMs reacted to the critique of large amounts of CDR and especially of BECCS in two ways: First, by efforts to model a broader portfolio of CDR methods such as DACCS and Enhanced Weathering (EW) to reduce the reliance on land-intensive BECCS (e.g., Bistline and Blanford, 2021; Fuhrman et al., 2021; Hanna et al., 2021; Strefler et al., 2021). Secondly, modeling teams aimed at deliberately reducing the reliance on CDR. The intermodel comparison (Riahi et al., 2021), for example, presented peak net-zero scenarios that do not allow global net-negative CO_2 emissions. Nevertheless, the modelled pathways still require substantial amounts of CDR to counter-balance residual emissions in some world regions.

This article argues that these efforts should be accompanied by integrating findings on CDR governance as contextual factors. The increased enrichment and calibration of CDR assumptions with policy contextualization is an important step towards providing politically robust mitigation pathways (see also, Pianta and Brutschin, 2022). This is a crucial task at a time when policymakers are struggling to credibly operationalize and implement mitigation strategies toward net-zero emissions (Rogelj et al., 2021).

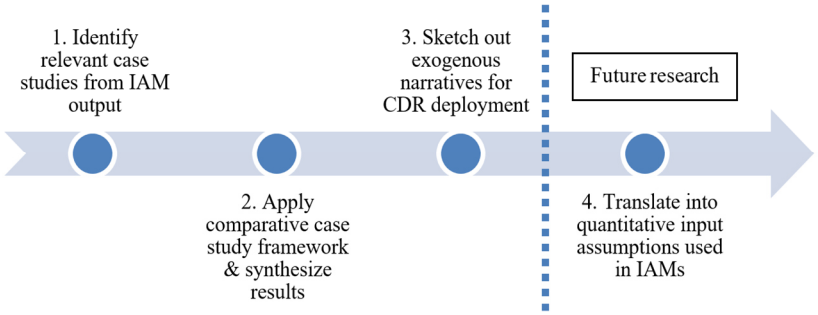
9.3 Toward an ‘iterative strategy’ to develop building blocks for CDR deployment narratives

In recent years, the need for integrating social science knowledge into IAMs has been articulated by many scholars – both from within the modeling community and from the social science community (Cherp et al., 2018; Geels et al., 2016a; Turnheim et al., 2015; Victor, 2015). In the scientific literature, more and more of these “bridging studies” (Hof et al., 2020) can be identified and efforts to apply, operationalize, and further develop such strategies emerge (see e.g., Brutschin et al., 2021; De Cian et al., 2020; Peng et al., 2021b; Pianta and Brutschin, 2022; Roelfsema et al., 2022; Stammer et al., 2021; van Sluisveld et al., 2020).

Trutnevyte et al. (2019) summarize the existing efforts to bridge IAMs and social science knowledge by identifying three main strategies: *bridging*, *iterating*, and *merging,* with an increasing degree of integration. While in the bridging strategy different approaches work in parallel and facilitate brief exchanges, the iterating strategy aims at developing exogenous narratives based on social science knowledge that are then translated into quantitative input

assumptions. The merging strategy goes one step further and aims at structurally modifying models (see Trutnevyte et al., 2019 for details). For this analysis, we follow an iterative strategy and aim at developing building blocks for social science-informed exogenous CDR deployment narratives. As a next step, these could be translated into quantified assumptions for new model runs (for an overview of the research design, see Figure 9.1).

Figure 9.1: Overview of research design following an iterative strategy



To do so, the following section explores the IAMs outputs of the IPCC's sixth assessment cycle (AR6) database to identify regions and case studies that are relevant in the context of CDR scale up (section 3). Subsequently, we will apply and further develop an analytical framework for comparative case studies on CDR policy and governance to provide a bottom-up assessment of the status quo of CDR governance. Based on the case studies and systematic synthesis of the results, we carve out key building blocks for social science-informed exogenous CDR deployment narratives that could improve the assumptions incorporated in IAMs (section 5). We see this work as an initial first step in interdisciplinary work that aims at bridging IAMs and bottom-up case study work with regard to CDR.

9.4 Current scenario generation and CDR

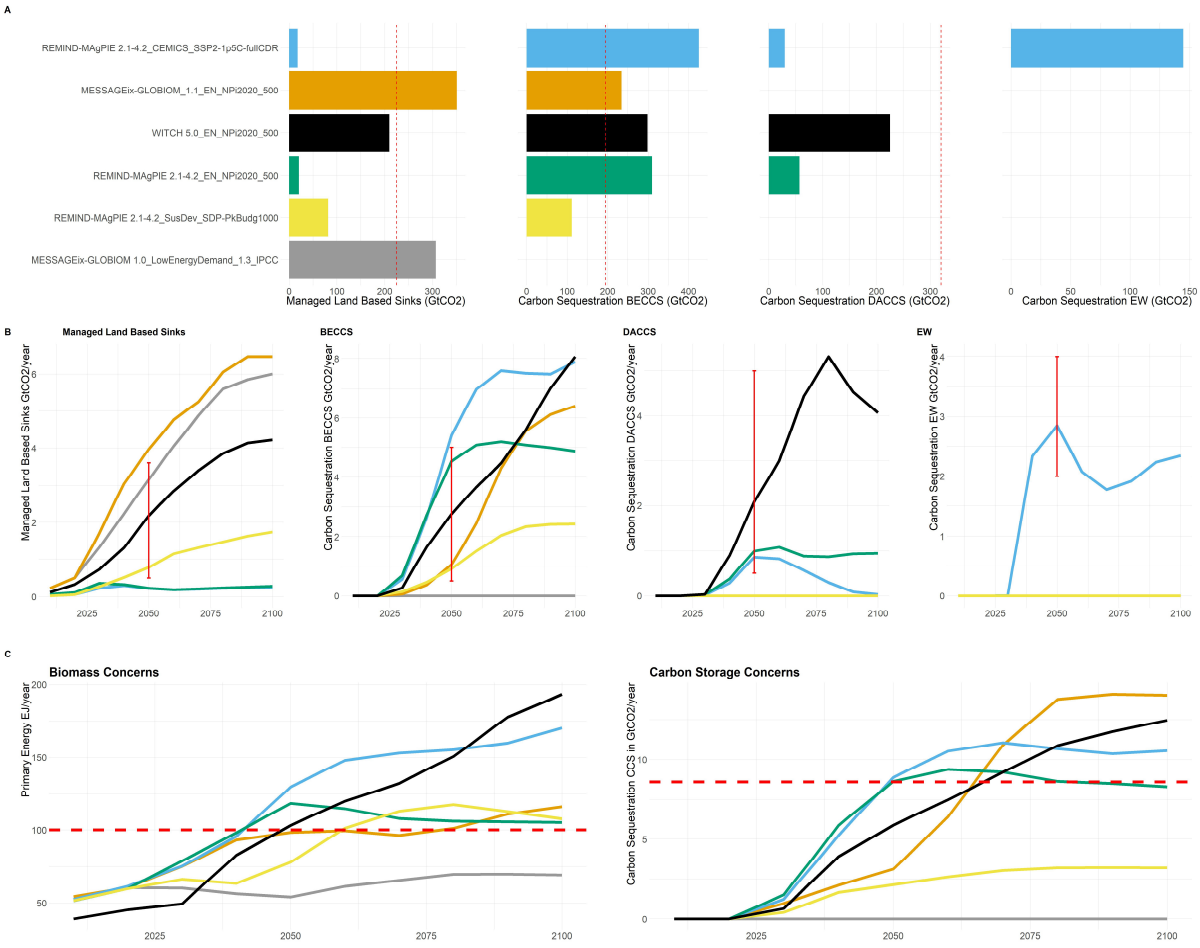
In IAMs, the technology representation and techno-economic parameters differ considerably. In addition to the structural representation and the numerical parameterization, there are different rationalities of projecting techno-economic parameters (Krey et al., 2019). The technological representation of the different CDR approaches has evolved rapidly since the integration of BECCS (Tavoni and Socolow, 2013). Most IAMs include BECCS, and more are starting to model DACCS. However, the assumptions about specific DACCS technologies considered, costs, fuel inputs, and growth rates vary (Fuhrman et al., 2021; Realmonte et al., 2019; Strefler et al., 2021). This is reflected in a large range of possible DACCS deployment

that the current generation of scenarios report, as well as a larger uncertainty among experts regarding which levels of DACCS deployment pathways could be realized (Grant et al., 2021). So far, in the scenario ensemble included in AR6, enhanced weathering has been implemented only in REMIND MAgPIE (Strefler et al., 2018) and C-ROADS models.

In the following we focus on a few selected so called C1 category scenarios from the AR6 database (Byers et al., 2022), which limit global warming to 1.5 °C (>50%) with no or limited overshoot. Some of them are illustrative pathways in Chapter 3 of the AR6 Report (Riahi et al., 2022). When discussing the insights from those scenarios, we first show global patterns and relate them to the recent CDR benchmarks discussed in the literature (Fuss et al., 2018; Grant et al., 2022). We then also show and discuss the patterns reported for five key world regions and highlight the importance of moving the discussion to the regional level.

We focus on six scenarios. We include the scenario “CEMICS SSP2 1.5C full CDR developed by REMIND-MAgPIE because it is among a few scenarios in the C1 category, which includes EW. “SusDev SDP” (SDP) and “Low Energy Demand” (LED) are shown because those are not relying on CCS-based CDR; and three net-zero scenarios with 500Gt carbon budget from the ENGAGE project from WITCH, REMIND and MESSAGE models were included for additional comparison to trace differences across models. In Figure 9.2, in the upper panels (A) we show cumulative rates of CDR deployment through Land Use, BECCS, DACCS, and EW in GtCO2. With a red line we indicate the median values that were calculated based on a recent expert survey (Grant et al., 2022). In the middle panel (B) we display yearly rates of deployment in GtCO2 per year and indicate with a black dot the upper potentials for 2050 that were summarized by (Fuss et al., 2018). In the lowest panel (C), we compare how the select scenarios compare in terms of two main criticisms recently raised in the literature regarding sustainable levels of biomass (whether they exceed 100 EJ per year based on calculations by (Creutzig et al., 2021) and whether the overall carbon storage capacity goes above 8.6 Gt per year (Grant et al., 2022). At the global level, we can trace trade-offs along the modeled CDR options. The LED scenario that does not rely on technological CDR options and solely relies on land use carbon sequestration is above what experts have indicated based on the survey from Grant et al. (2022) but within the upper bound of estimations from Fuss et al. (2018) for the year 2050; a relatively balanced SDP scenario comes close to the sustainable threshold of 100 EJ per year of biomass deployment in the second part of the century. For other scenarios, the BECCS deployment levels can be considered high when looking at the cumulative and yearly indicators.

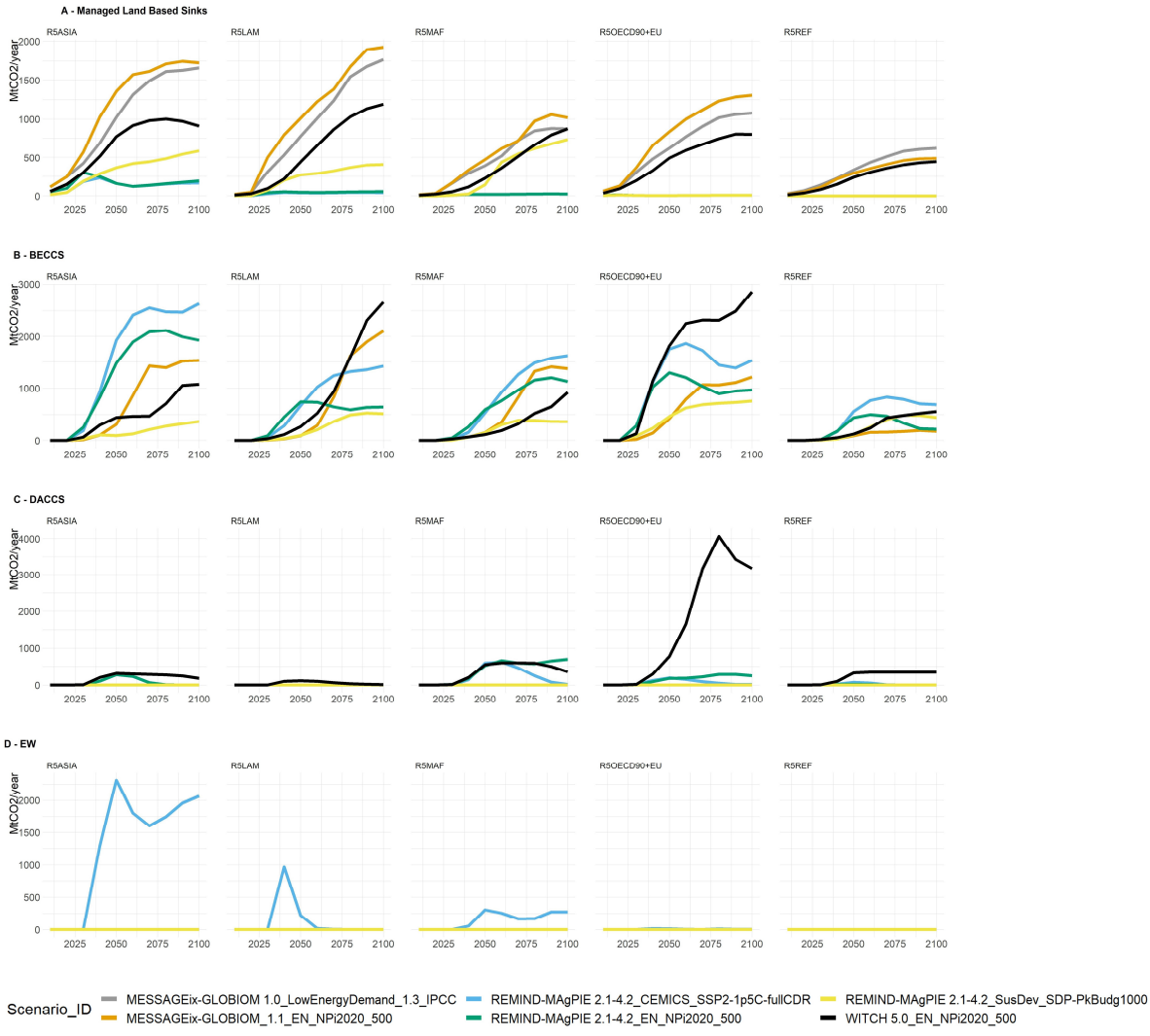
Figure 9.2: Cumulative rates of CDR deployment (land use, BECCS, DACCS, and EW)



Despite the growing body of research, the level of uncertainty about which levels of CDR deployment are plausible to model is high. In Figure 9.2, we explored the trends along key global scenarios. However, to better understand what is feasible, we need more context and higher granularity data, as well as more attention to the temporal part of feasibility (Brutschin et al., 2021). We thus also present regional level-data for the selected scenarios in Figure 9.3. At the regional level, we can also clearly trace trade-offs: scenarios that rely less on land-use-based emission reduction, rely more on BECCS and vice versa. For BECCS, many scenarios assume early take-off of the technology, already in 2025, and a rapid scale-up. There are some interesting model differences. For example, the WITCH-based scenario assumes the earliest and fastest scale-up in the OECD region, while the REMIND MAgPIE-based scenario assumes the timing and near-term scale-up of BECCS to be comparable in ASIA and OECD region. The scenarios shown here assume that BECCS will scale up in Latin America later, but the region is still expected to contribute a large amount of CDR throughout the century.

This summary of the model output reveals that the Global South is expected to contribute large amounts of CDR in current mitigation pathways. Since the social science literature lacks comparative case studies on countries in these regions, our subsequent exploration of recent policy trends in Brazil, China, and India can – together with existing research on OECD countries and future research on other and larger sets of countries – help informing future modeling efforts.

Figure 9.3: Regional cumulative CDR deployment (land use, BECCS, DACCS, and EW)



9.5 Assessing the state of CDR regulation and innovation: toward an analytical framework

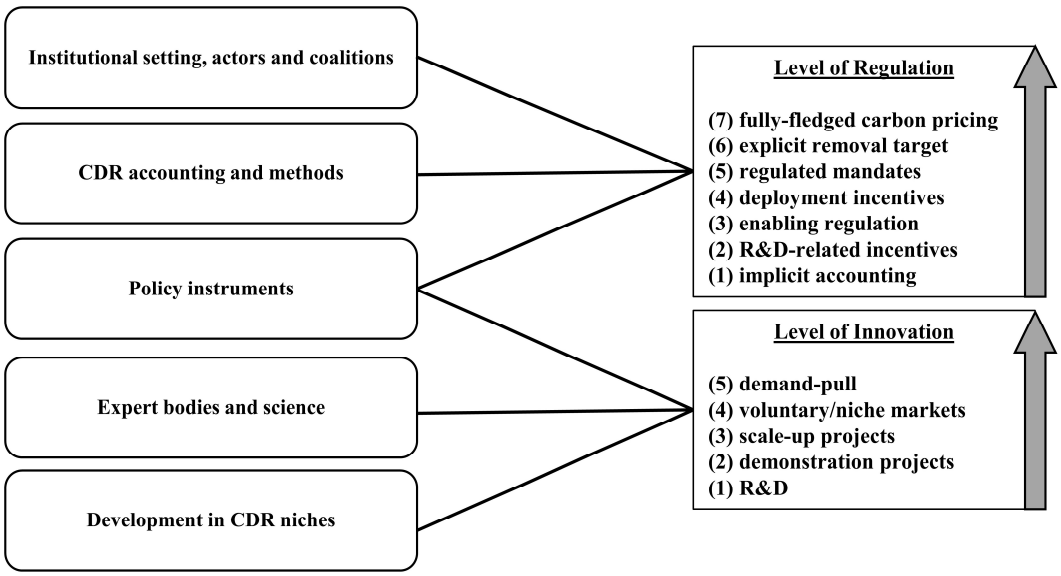
With the growing importance for CDR in mitigation pathways towards net-zero or net-negative GHG emissions, scholars started to explore global diffusion prospects of the portfolio of CDR methods from different angles. So far, literature on CDR policy and governance is in its early stages. While there is a growing body of empirical case studies (Bellamy et al., 2021; Boettcher, 2020; Fridahl et al., 2020a; Fuss and Johnsson, 2021), not all world regions have been covered in this strand of the literature and a bias towards developed countries exist. Following the observation that the world regions Latin America and Asia prove to be pivotal in IAMs to provide CDR capacities in mitigation pathways, in this article, we aim to contribute to filling a part of this research gap by providing case studies of CDR policymaking and governance in three key emerging economies located in these regions, Brazil, China, and India.

The emerging literature on CDR governance and policymaking provides an increasingly fine-grained understanding of actual frontrunners in regulating and incentivizing CDR and what methods are addressed by decision-makers so far (e.g., Bellamy et al., 2019; Buylova et al., 2021; Fridahl et al., 2020a; Honegger et al., 2021; Thoni et al., 2020). Following up on this literature, we aim at further developing an analytical framework by Schenuit et al. (2021) that combines insights from socio-technical transition literature with literature on CDR governance (for details, see ibid.). To explore CDR policymaking systematically, we extend the analytical framework and develop a taxonomy of different levels of regulation and innovation that can be derived from these 5 overarching dimensions (see Figure 4 for an overview). By further developing the approach, we aim to advance emerging comparative research on CDR policymaking that allows us to study larger samples of countries systematically in the future. Since comparative studies are still scarce, future research will have to engage with this conceptual operationalization critically and explore complementary and additional ways of studying these issues will be required.

First, we conceptualized a pillar that assesses the level of CDR-related regulation. Building on existing work on CDR governance, we identified six key building blocks of comprehensive CDR policymaking. To allow a systematic and comparative analysis across countries, we conceptualized it as an ascending ranking where implicit accounting for CDR is the lowest level of CDR regulatory readiness (1) and a fully-fledged carbon price that includes CDR as the highest (6) (see Figure 9.4). In the second pillar, we capture the stages of CDR innovation in different countries. This conceptualization draws on (Nemet et al., 2018), who – based on a review of the broader innovation literature – argue that although actual innovation processes are complex and not necessarily linear, the concept of ‘innovation stages’ is informative for gaining empirical insights into CDR innovations. In this taxonomy, we do not include

the sixths stage “public acceptance” Nemet et al. (2018) for two reasons: First, public acceptance data for CDR specific hardly exist for the countries we focus on here. Second, aspects of varying socio-political prioritization of different methods are covered in the level of regulation (see supplementary material),

Figure 9.4: Analytical framework to study the level of CDR regulation and innovation



Based on and further developed from Schenuit et al. (2021).

To conduct a systematic comparison of cases, we initiated a three-stage research process. First, together with country experts, we collected qualitative snapshots of the state of CDR policy and governance based on the five key dimensions (institutional environment, actors and coalitions; CDR accounting and methods; policy instruments; expert bodies and science; developments in CDR innovations, see the left panel in Figure 4). Based on an iterative process of desk research and exchange with country experts, key observations for all five dimensions were identified and documented in tables (see supplementary material). This material is the backbone of the comparative approach and the resource for the second step. It was used to assess and systematically code what level of regulation and innovation can be observed in the different cases for both Land Use, Land-Use Change, and Forestry (LU-LUCF)-based and CCS-based CDR separately based on the taxonomy presented above (see the right panel in Figure 4). In the third step, the comparison and synthesis of the cases is linked to the broader CDR policy and governance literature and existing conceptual types of CDR policy design (see section 5).

9.6 Governing CDR in Brazil, China, and India: a bottom-up assessment

Following the case selection considerations in Section 3, we applied the analytical framework and conducted the analysis for the emerging economies of Brazil, China and India. We follow the distinction of the main CDR methodologies in the global mitigation pathways (Section 3) between LULUCF-based CDR and CCS-based CDR and assess the level of CDR-related regulation and the stages of CDR innovation separately for them. Below, we summarize the main observations of our analysis and provide summaries on the following three key topics for each country: (1) general overview of the ambition and role of CDR in climate policy, (2) different CDR methodologies and their level of regulation, (3) level of CDR innovation for different CDR methods. More details on each of the case are available in the supplementary material). It is important to note that while the comparison conducted here fills a knowledge gap on CDR policy and governance in the Global South, it can only provide a snapshot of the current status quo and is thus only a starting point for future in-depth research in these countries.

9.6.1 Brazil

Since the early days of multilateral climate governance, Brazil has been perceived as a key actor in climate governance (Franchini and Viola, 2019). This has to do with the risks for climate through deforestation and the mitigation potentials of afforestation and reforestation (Rochedo et al., 2018). Given the importance of the agriculture and forestry sector and their large share in Brazilian emissions, AFOLU-related measures have always had an importance in Brazilian climate policy.[63] The vast Brazilian tropical territory is often included in the national climate change debate. Many in the country see the AFOLU sector as Brazil's "silver bullet" to compensate for hard-to-abate emissions – a fact that is mirrored in the actor and alliances landscape, climate targets, and instruments. Land-based mitigation is expected to contribute substantially to achieving the climate target for 2050 and is also perceived as a possible revenue stream through international cooperation (Baptista et al., 2022).

Level of CDR-relevant regulation

In 2022, the Brazilian Government pledged to achieve net-zero emissions by 2050 in its updated NDC (Brazilian Government, 2022). However, the emissions covered by the target remain ambiguous (CO_2/GHG). The role for CDR became less specified in the updated NDC. While earlier submissions included reference to the target for restoring 12 million hectares of forests until 2030, this specific target has been removed (Brazilian Government, 2022; Ro-

[63] See e.g., Brazil, 2009. Law Nº 12.187, December 29, 2009. Available at: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2009/lei/l12187.html.

meiro et al., 2021). With the new government elected in 2022, Brazilian climate policy in general is expected to become more ambitious.

Existing policy instruments already cover afforestation, reforestation, forest management, and pasture recovery. The Brazilian Policy on Climate Change Law 12187/2009, and its regulation decree n 7390/2010 (replaced by decree n 9.578/2018), included CDR actions in its target (incl. 15 million hectares of degraded pasture, the expansion of 4 million hectares of crop-livestock-forestry integrated systems, and the expansion of 3 million hectares of planted forest area. Furthermore, the Low-carbon Agriculture Program,[64] that aims to develop revenue streams for ecosystem services by farmers includes instruments for trading carbon credits, and the Floresta+ program aims to increase the payments for environmental services related to forest conservation and restoration. Programs such as the National Alcohol Program (Proalcool) (Maroun and Schaeffer, 2012), the Biodiesel National Program (PNPB) (Rathmann et al., 2012), and the RenovaBio Program (Köberle et al., 2022), all encourage the production and use of biofuels. These programs are not necessarily CDR-related, but governance and industry infrastructure built in the context of these programs could be relevant starting points for BECCS deployment. Efforts exist to use the RenovaBio program as an instrument to encourage the development of BECCS in the country (Silveira et al., 2022). However, to date, it does not have clear instruments for that.

For CCS-based CDR, the level of regulation is much lower: As of today, there is no regulatory framework in place for CCS in Brazil and the debate on CCS-based CDR is mostly limited to expert circles (Machado et al., 2021). CCS-related developments so far have been limited to efforts by the fossil fuel industry. Petrobras has a Natural Gas Processing plant in the Santos Basin Pre-Salt Oil Field with CCS that has been operational since 2011 (Turan and Zapantis, 2021) and reinjected 8.7 million tons of CO2 in 2021 and accumulated 30.1 million tons (Petrobas, 2022). The coal industry in the State of Santa Catarina has a research institution (SATC) working in the perspective of understanding and investing in CCS (SATC, 2019). However, the current lack of policy support is perceived as a barrier for large-scale CCS and CDR deployment in the future (Machado et al., 2021). While exploring and developing CCS-infrastructure would be of relevance for some CDR methods (incl. BECCS), these projects are not yet aiming to net-removal of CO2 from the atmosphere but to apply CCS to fossil fuel-based processes.

Level of CDR innovation

Efforts concerning CCS-based CDR innovation are rather limited. So far, not much has happened on CCS-based CDR methods beyond modeling efforts and other scientific studies. Neither are BECCS or DACCS part of substantial policy initiatives, nor are there large Re-

[64] See https://www.gov.br/agricultura/pt-br/assuntos/sustentabilidade/plano-abc/arquivo-publicacoes-plano-abc/abc-english.pdf

search, Development, and Demonstration (RD&D) efforts identified. However, linked to the bioethanol sector, the first demonstration projects are being announced (Bioenergy International, 2021). The picture looks different for LULUCF-based CDR methods. The market uptake of these options is rather high through the increasing importance of voluntary trading schemes and already established incentive schemes. Although still incipient, there may be some space for a demand-pull coming from the private sector (associated with Environmental Social Governance, ESG practices) for LULUCF-based CDR options in Brazil in the future. Apart from LULUCF-based CDR options, which are also being discussed for other reasons (biodiversity, social issues, trade concerns, etc.), the CDR debate has not yet reached the wider public.

In the future, biochar might be an option of interest since biochar research was triggered by the discovery of anthropogenic dark earths (terra-preta) from indigenous pre-Columbian communities in Brazil. Biochar is being used in agriculture in different scales, including to understand how its use affects pasture recovery (Latawiec et al., 2019). Scientists also identified a large potential for EW in Brazil (Goll et al., 2021) which could trigger related debates in the future.

9.6.2 China

As the largest emitter of current annual emissions, developments in Chinese climate policy are receiving considerable attention (Skjærseth et al., 2021). Its efforts are sometimes described as efforts to position itself as “climate leader for the Global South” (Qi and Dauvergne, 2022). The Chinese President's announcement in 2020 to limit emissions before 2030 and achieve carbon neutrality by 2060 and the submission of an updated NDC (Chinese Government, 2021; Xinhua, 2020) was applauded by climate policymakers and experts worldwide. However, in policy practice, the operationalization of the target into actual policymaking is limited (see e.g., Climate Action Tracker[65]), and the substantial challenges of achieving these targets, including domestic politics, become apparent. In the context of the net-zero pledge, existing afforestation measures and their repurposing as CDR policymaking are gaining increasing attention and support.

Level of regulation, politics and public debate

In general, China's level of regulation of land-based CDR is high China has a long history of reforestation programs and efforts to enhance the carbon sink in the LULUCF sector as part of the domestic policy initiatives and instruments. In the NDC, China pledged to increase the forest stock volume by 6 billion m3 from the 2005 levels and mentioned that the enhancement of carbon sinks capability is one of “Ten Key Actions for Carbon Emission Peaking”

[65] See https://climateactiontracker.org/countries/china/net-zero-targets/.

(Chinese Government, 2021, p. 34). Projects that enhance LULUCF removals are usually shaped by top-down, command-and-control regulations (An et al., 2021). The NDCs highlights nature-based solutions to keep consolidating and enhancing ecosystem carbon sinks, including "blue carbon," and mentions that in the future "carbon sink trading will be integrated into the national carbon emissions trading market, and a sound compensation mechanism for ecological protection that reflects the value of carbon sinks will be established" (Chinese Government, 2021). To a limited extent, "sink trading" is already established, a small amount of carbon credits (5% CCER) generated through reforestation can be traded in the newly set up Emission Trading System (ETS) (Shrestha et al., 2022); similar initiatives can be identified at the province level (e.g. (The People's Government of Sichuan Province, 2021). In the context of reforestation, it is important to note that carbon sequestration is not the only motivation. Initiatives such as the Great Green Wall in the Gobi Desert, started in 1978, show that the Chinese Government has been pursuing other objectives with reforestation (here avoid desertification) with such strategies.

CCS-based CDR methods are mostly discussed by expert communities and CDR-specific policy initiatives do not exist. One key element of the expert debate concerns the increasing attention for CCS-based CDR in national modeling (see e.g., modeling results in net-zero study He et al., 2022; Liu et al., 2022). The state government is gradually promoting the RD&D and application of CCUS mainly by building many pilot projects as announced for the first time in 14th Five Year Plan (FYP) (see Jiang et al., 2020). However, so far, existing CCS projects are linked to fossil CO_2 point sources and in most projects CO_2 is reinjected for enhanced oil recovery (Sun et al., 2018; Turan and Zapantis, 2021).

CDR innovation

Although no specific funds for CDR demonstration plants can be identified, reports by national studies on the state of CCUS show that innovation in DACCS and BECCS are moving in the focus of decision-makers (Bofeng and Qi, 2019). Existing and planned pilot plans, however, are not dedicated CDR projects. Liu et al. (2022) state that "direct air capture technology is still immature and expensive and it has not been listed as an efficient effort in any official documents in China yet." At the same time, studies on the developments of CDR-related patent show that, after the US, China holds the most CDR-related patents, with a focus on BECCS, biochar, DAC, and soil carbon management. The numbers started to increase with the adoption of the Paris Agreement in 2015 (for details, see Kang et al., 2022). Moreover, small start-ups can be identified, such as Carbon Infinity (Izikowitz, 2021) and "C4X" an applicant to the X-Prize on carbon removal technologies.[66]

[66] See http://www.ccccx.net/en/about.asp

The level of innovation for LULUCF-based CDR is high since it is already a well-established component of China's climate policy. First attempts of "sink trading" indicate that voluntary markets will become more important; in the context of new carbon intensity targets and the net-zero long-term target, rising demand for LULUCF-based CDR is to be expected.

9.6.3 India

India is the world's third-largest emitter of carbon dioxide and the country has played an increasingly important role in multilateral negotiations in the past decade under the Modi government (Mohan, 2017). Issues related to climate policy have moved up the political agenda in recent years (Dubash, 2019). The Indian government announced a net-zero emissions target for 2070 at COP 26 and has consistently emphasized the importance of the principle of common but differentiated responsibilities under the UNFCCC. Owing to the rapidly depleting carbon budget for 1.5 °C, India also recently demanded that developed countries should go "net-negative", in order to free up carbon space for developing countries (Mohan et al., 2021). With regards to CDR, India is therefore not seen as a frontrunner. However, Indian project developers have been active participants in projects associated with carbon credits under the CDM scheme and established afforestation programs. With some repurposing of existing policies and increased efforts in CDR-relevant research and niche development, India could become a relevant player for CDR deployment in the future.

Level of regulation, politics and public debate

In the context of the Paris Agreement, the Government of India committed in its 2015 INDC to create a carbon sink of 2.5 to 3 billion tonnes of carbon dioxide, setting a dedicated and quantified removal target, which was reaffirmed in the recent NDC update (Government of India, 2022). The promotion of forest restoration is firmly anchored in India's governance architecture. It has a long tradition, but the potential for climate change mitigation was not always the main motivation for it (Roy and Fleischman, 2022).

The National Action Plan for Climate Change (NAPCC), set up in 2008, lists the Green India Mission (GIM), which aims to increase forest cover and contribute to the aforementioned NDC targets. For example, in 2018, India planned to create a 140,000-km tree line on both sides of national highways, grow plantations along the river Ganga and reduce the consumption of wood or biomass as fuel. There are several state-level afforestation schemes too, such as Telangana's Telanganaku Haritha Haram. While the government does have ambitious afforestation plans, the country still lacks well-defined policy instruments at various levels and faces problems with implementation (Roy and Fleischman, 2022). There is also no accountability for the objectives set forth under the NAPCC, with no dedicated ministry responsible for achieving the targets. Several afforestation projects have been funded by the Compensatory Afforestation Fund Management and Planning Authority (CAMPA), a govern-

ment body to manage compensatory afforestation. Possible revenues through programs such as REDD+ shaped the debate and policy proposals in the post-Kyoto and pre-Paris phase (Dutta et al., 2013; Kishwan et al., 2009).

While India has a rather large potential for CCS (Shaw and Mukherjee, 2022) its regulation is not well-established and no demonstration plants are in operation (Global CCS Institute, and CO2RE, 2022). More recently, the issue of CCUS has gained traction and is expected to receive more support (Shaw and Mukherjee, 2022; Vishal et al., 2021) see also next section). So far, observers state a "lack of policy ecosystem" for CCUS (Malyan and Chaturvedi, 2021). However, these recent initiatives are not CDR-specific; CDR-related issues are usually discussed under the umbrella term of CCUS, together with, for example, CCS for coal plants.

CDR innovation

Several CCU and CCS initiatives are underway that could turn out to be relevant for future CDR initiatives. However, also for CCUS India is still at a nascent innovation stage (Vishal et al., 2021); in general, there is marginal interest in a domestic demonstration of the technology in India (Gupta and Paul, 2019). Despite the many barriers of cost and manufacturing, Indian industries and public sector undertakings (PSUs) aim to promote CCS facilities (Malyan and Chaturvedi, 2021). Various institutes have also taken the onus to conduct in-depth research. For instance, Institute of Reservoir Studies is carrying out CO2 capture and EOR field studies in Gujarat, while National Geological Research Institute (NGRI) Hyderabad is testing the feasibility of storing CO_2 in basalt formations (Gupta and Paul, 2019). In general, however, these projects are usually not with direct reference to carbon removal and CCS is also considered as a potential means to allow India to continue its reliance on coal for its energy needs without the associated emissions. The Indian government has joined and supported several international CCS or CCU-related research projects as cooperation. Recently, the government stated that the Accelerating CCUS Technologies (ACT) initiative under Mission Innovation (MI) had played an essential role in bringing back focus on CCS/CCUS in the Indian context by promoting peer technology exchange and allocating funds for R&D.[67] The recent National Electricity Plan also refers to CCS as an option to retrofit coal plants, and mentions "CO_2 removal technology" in the context of "Air Pollution Control technologies" (Ministry of Power, 2022)

With regard to LULUCF-based CDR, voluntary markets are already well-established in India. Both international incentives (through REDD+) and domestic programs (GIM) established incentive structures for enhanced afforestation. Enking International (an Indore based private company), trades on carbon offsets for companies like NTPC, NHPC, Indian Railways, GAIL,

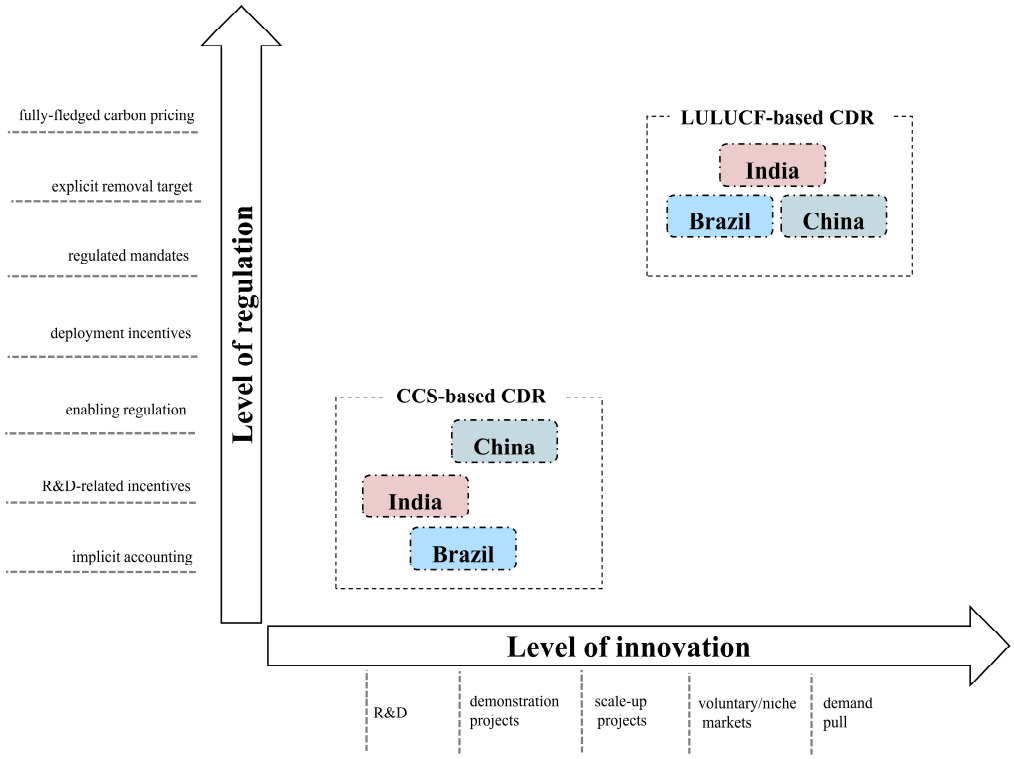
[67] See https://dst.gov.in/carbon-capture-utilisation-and-storage-ccus.

IOC, ReNew Power, Azure Power, Greenko, and many others. Recently, Shell and Enking announced a joint venture for investing $1.6 billion over a five-year period to provide “nature-based” carbon offsets to industries in India (Singh, 2021). Such private-sector agreements could become increasingly common in India in the coming years, allowing companies to announce that they meet their stated net-zero targets.

5.4 Synthesis of case studies

The case studies illustrate that CDR policy and governance do not start from scratch in the countries analyzed. They also show substantial differences across countries and between LULUCF-based and CCS-based CDR regarding the level of regulation and innovation. The following sections provide a synthesis of the case studies and present the results of the systematic coding based on the analytical framework (see Figure 9.5, and for more details on the coding, see supplementary material) and highlight commonalities and differences. Furthermore, we discuss how these results relate to earlier comparative work on different modes of CDR policymaking and how these findings are relevant for next steps in the iterative strategy introduced earlier.

Figure 9.5: CDR governance in Brazil, China and India: Level of innovation (x-axis) and CDR regulation (y-axis) for CCS-based and LULUCF-based CDR identified in the case studies.



For LULUCF-based CDR, we identify some substantial differences across the countries. Based on the taxonomy applied here, the *level of regulation* is the highest in India, where an explicit removal – or carbon sequestration – target is part of the pledges in the NDC and domestic policymaking. The other two countries, however, also score high in the coding of different levels. All three countries have well-established governance structures for afforestation. For China, it is notable that 14th FYP includes a regulated mandate for afforestation (forest coverage percentage - 24.1% in 2025) and “sink trading” is receiving more attention as a deployment incentive. In Brazil, PLANAVEG aims to establish 12 million hectares of restoration of Native Vegetation by 2031 (Brazilian Government, 2017). With regard to the *level of innovation*, both demonstration and large-scale projects have been practiced for a long time in all three countries. The variation in innovation levels observed here stems from differences with regard to certification and trade of removals in different kinds of markets. In Brazil, voluntary markets are established and trading of removal credits is expected to be extended. The same is true in India, where revenue streams linked to afforestation shaped climate politics for a long time. In China, where afforestation policy has long been shaped by top-down characteristics, voluntary markets and the possibilities of trading a limited amount of forest

credits in the recently established ETS emerge as new deployment incentive. For all three countries, we observe increasing attention to LULUCF-based mitigation potentials in the aftermath of the Paris Agreement.

The assessment of the level of regulation and innovation for CCS-based CDR reveals much lower levels. For the *level of regulation*, we find that none of the countries have fully implemented carbon pricing that includes CCS-based carbon removal, an explicit and legally binding removal target, or CDR-related regulatory mandates. CDR-specific enabling regulation is established in none of the cases. However, China regulates CCS for several projects currently running. So far, India and Brazil lack comparable governance structures. Notably, China is the only country that shows some evidence of specific deployment incentives through its "carbon peak pilots". Recent developments in India and China, indicate rapidly growing attention to CCS and CCU by the administration and industry, the focusm, however, is on linking them to fossil fuel-based processes. In Brazil, it remains to be seen to what extent initiatives in the bioethanol sector will lead to CDR-related developments. For the *level of innovation*, we did not identify demand-side driven, voluntary, or niche markets or the scaled deployment of these CDR methods in a single country. China is the only country where we identified explicit CCS-based CDR demonstrations. In Brazil, a BECCS demonstration plant has been announced. China and India are addressing the issue of international cooperation with other countries; examples are India's membership in Mission Innovation on CDR and China's bilateral agreement with the United States (US) that mentioned DAC and CCUS (US and Chinese Government, 2021).

Taken together, the synthesis shows that the three functions the IPCC sees for CDR[68] are only partly addressed. In all three countries, LULUCF-based CDR is a key element of strategies to accelerate near-term mitigation. Policy instruments that incentivize deployment and monitoring, reporting, and verification (MRV) systems are well established. More so than in some OECD countries, where the mitigation potential of the LULUCF sink in the context of net-zero targets is only now being more widely recognized by policy makers (Schenuit et al., 2021). Since CCS-based CDR is not yet well-established regulation is – like in many OECD countries – missing, it does not play a comparable role in plans to achieve short-term targets. In the broader context of CCU and CCS, however, the approaches gain prominence, with China being the country most advanced in piloting different approaches. However, in China and India, where CCU and CCS attract new momentum, the focus is mostly on avoiding fossil emissions rather than achieving net-removals to counter-balance hard-to-abate GHG emissions. The function of net-negative emissions does not yet play a role in the countries analyzed here; except for the example of India which asks developed countries to achieve

[68] 1) accelerate near-term mitigation 2) counter-balancing residual emissions for net-zero', and 3) achieving net-negative emissions.

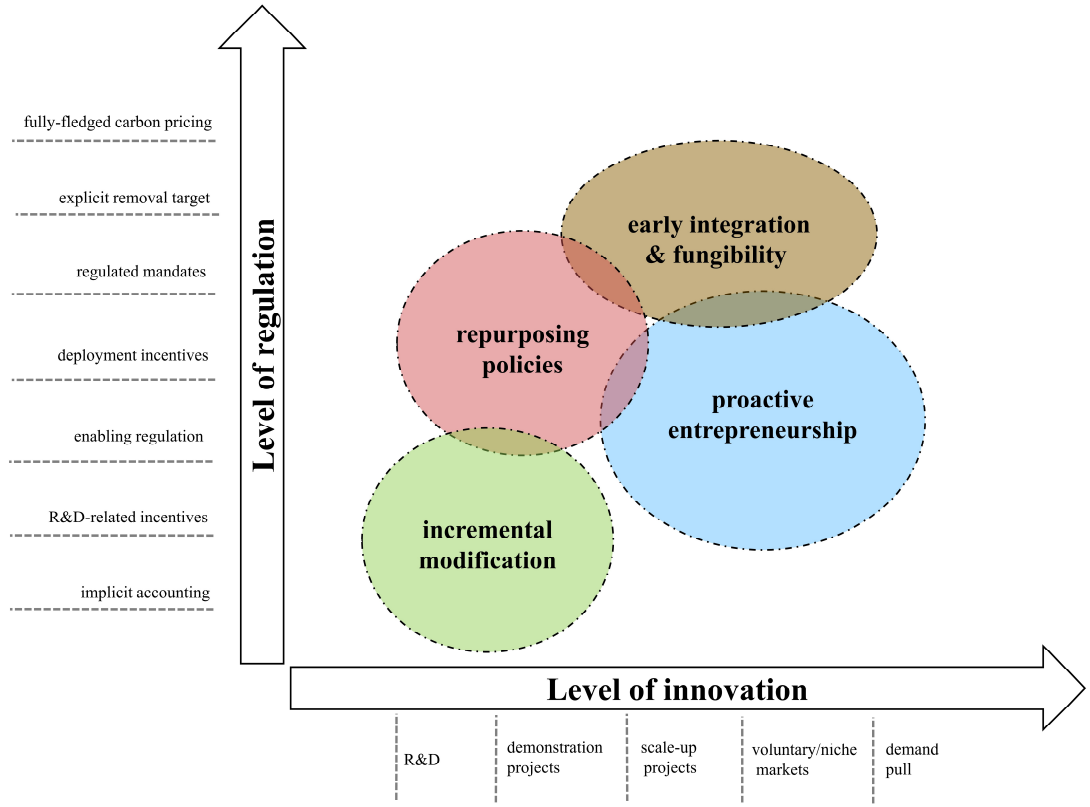
net-negative emissions to free up carbon space for developing countries (Malyan and Chaturvedi 2021b).

The wider CDR governance context and building blocks for exogenous narratives for CDR deployment

These findings contribute to the emerging scientific literature on CDR governance in policy-making. They help to develop further the conceptual differentiation of idealized types of CDR governance as proposed by Schenuit et al. (2021). While the study on 9 OECD cases identified the three types – *incremental modification*, *early integration and fungibility*, and *proactive entrepreneurship* – the case studies on emerging economies show that a fourth mode could be added to differentiate further: *repurposing policies*. In all three cases, we see that CDR-relevant policies aiming at enhancing LULUCF removals are already existing and that in the aftermath of the Paris Agreement and the diffusion of net-zero targets, the approach of achieving mitigation targets through LULUCF removals received more attention. Existing policies e.g., on forest restoration have been repurposed to focus more on their contribution to mitigation – efforts sometimes criticized as reducing complex ecosystems to its capacity to sequester carbon (see e.g., Li et al., 2022; Roy and Fleischman, 2022).

Adding this fourth type of CDR governance to the conceptual differentiation of how countries address CDR highlights that CDR governance does not start from scratch but is taken up in existing governance structures with clear implications for the political economy of CDR. The research conducted here also indicates that governments do not necessarily pursue the same strategy for CCS-based and LULUCF-based CDR. In an attempt to further specify the conceptual differentiation between different modes of CDR governance, Figure 9.6 illustrates where the different types as identified by Schenuit et al. 2021 located are with regard to the taxonomies for the level of CDR regulation and level of innovation. However, it is important to emphasize that this visualization does not represent final results, but should be viewed as a call for further research to further specify, add to, or critique this initial attempt of making sense of the rapidly changing CDR space.

Figure 9.6: Different modes of CDR governance and related levels of regulation and innovation.



9.7 Building blocks of narratives for CDR deployment

In order to inform integrated assessment modeling with social science knowledge on CDR governance, we explore an empirically informed set of four building blocks for exogenous narratives for CDR deployment that can be derived from these findings. Following up on these building blocks in future research and aiming at translating them into quantitative input assumptions would enable IAMs to increase realism about contextual factors of CDR-upscaling and, thus, the political robustness of mitigation pathways. The building blocks identified here should be read as hypotheses based on existing research; in a rapidly evolving CDR space, they might need readjustment over time.

First, narratives for CDR deployment should make regional differentiation as explicit as possible. Model results presented in section 3 point to the fact that some regions are expected to stay above net-zero at the point of global net-zero, while others will have to achieve net negative emissions. This differentiation and its underlying assumptions about *when* and *where which* CDR method will be deployed needs to be openly addressed when crafting assumptions about CDR scale-up narratives. This is important for deriving policy-relevant insights

from emissions reduction pathways and the looming debate on different timings for net-zero and net-negative emissions across countries that included politically contested dimension of equity and historic emissions (Mohan et al., 2021).

Second, the case studies presented in this paper show that such narratives should include assumptions about the delayed deployment of CCS-based CDR. In the set of countries analyzed here, all three countries have a rather low level of regulation and innovation. Rapidly rising numbers in patents and supporting innovation in China show that it could develop into a frontrunner here. However, even here upscaling of BECCS starting in 2025 as indicated in no or low overshoot scenarios, does not seem feasible from current levels of regulation and innovation. Thus, the lack of basic regulation and demonstration projects for CDR and CCS is a significant barrier that should be considered in politically robust deployment scenarios.

Third, deployment narratives must be explicit about sustainability thresholds. we found in these three emerging economies existing governance and incentive structures for LULUCF-based CDR that could accelerate the enhancement of the LULUCF sink in the near future. The level of regulation is, in contrast to CCS-based methods, not a constraining condition for these CDR options. However, since sustainability and negative side effects of large scale CDR are the subject of ongoing research (see section 3), deployment narratives should be explicit and transparent about sustainability constraints applied.

Fourth, since assessments of the level of regulation and niche developments could change rapidly and case studies can only provide a snapshot, a key building block of CDR deployment narratives should be to provide a variety of explicit constraining and enabling assumptions for different CDR methods in different regions that can be applied. Including a variety of assumptions would not only allow to react to new developments in the real world but also to understand trade-offs of delayed CDR deployments for other elements of ambitious mitigation options.

9.8 Conclusion

With this study, we contributed to closing the knowledge gap on the level of CDR regulation and innovation in key emerging economies. We showed that the world regions Asia and Latin America contribute large shares of LULUCF- and CCS-based CDR in mitigation pathways derived from IAMs. Case studies on Brazil, China, and India, as key political players in these regions and influential actors in international climate governance, showed commonalities and differences in how CDR is currently being governed. The countries have in common a high level of regulation LULUCF-based CDR, which has been a key element of mitigation strategies for quite some time and has received more attention in the context of net-zero pledges.

The level of regulation of CCS-based CDR is low in all three countries, with China being in a position to possibly become a frontrunner in the future.

While these comparative case studies can only provide a snapshot, embedding the findings in the wider research on CDR governance and policymaking helped to identify a fourth type of CDR governance. In addition to *incremental modification*, *early integration and fungibility*, and *proactive CDR policy entrepreneurship*, case studies conducted here revealed the mode of *repurposing policies*. These four different modes are not mutually exclusive nor necessarily comprehensive but provide an illustrative analytical conceptualization of *how* and the *degree to which* different countries govern CDR. With increasing research and knowledge on CDR policies and deployment on the ground (Smith et al., *forthcoming*), those findings can help to improve IAMs by guiding the development of exogenous deployment narratives. This study can thus contribute a first step in an iterative strategy of interdisciplinary research between top-down IAMs and bottom-up case study work that aims at improving the political robustness of mitigation pathways.

We propose four building blocks that exogenous deployment narratives of CDR deployment pathways should address. Crafting narratives informed by these building blocks would be an important next step in providing policy-relevant climate science on the route towards net-zero and net-negative emissions societies – especially when the timing of net-zero and equity discussion become more important. Finally, our findings suggest that CDR-related governance structures are changing rapidly. Given the rapid changes, future research should not only provide updates of existing case studies but also study new sets of countries. Moreover, the analytical frameworks should be further developed to allow for large-n comparative studies and take the next step in iterative interdisciplinary research to improve social science and modeling.

10 Carbon Dioxide Removal: Climbing up the EU Climate Policy Agenda[69]

10.1 Introduction

Since the adoption of the Paris Agreement in 2015 and the publication of the IPCC's Special Report on 1.5 °C Global Warming (IPCC, 2018d), net-zero emission targets have diffused rapidly across almost all governance levels. While their scope varies and is often ambiguou s (Fankhauser et al., 2022), the underlying idea of counterbalancing residual emissions with carbon dioxide removal (CDR) is emerging as a new organising principle in climate policy-making. In the EU, net-zero greenhouse gas (GHG) emissions developed from a long-term aspirational pledge in the context of the European Green Deal into a central component of EU climate legislation in the so-called EU Climate Law (Official Journal of the European Union, 2021).

Modeling of net-zero GHG pathways facilitated by the European Commission for its draft EU long-term climate strategy (European Commission, 2018b), as well as national modeling efforts (e.g. for the UK, CCC, 2019 or Germany, Prognos, Öko-Institut, Wuppertal-Institut, 2020), indicate that achieving the target by 2050 or earlier requires significant amounts of CDR. Rapidly growing scientific literature explores numerous methods to remove carbon from the atmosphere (for an overview, see (Babiker et al., 2022), ranging from already established afforestation to more speculative direct air capture combined with carbon capture and storage (DACCS) (for details, see section 2). The need to deploy a portfolio of these methods to counter-balance hard-to-abate emissions e.g. from agriculture, industry or long-haul transport, raises important questions about the operationalization of the net-zero target within EU legislation. Although there are numerous political challenges in the process of accelerating a transition towards net-zero GHG emissions, CDR stands out due to its potential to challenge the prevailing public policy paradigm in EU climate policy (Geden et al., 2018b). Therefore, it is key to explore how removals are and will be integrated into the climate policy mix, how related politics play out, and how other aspects of climate policy will be affected.

There are three key additional reasons why a better understanding of how the EU addresses CDR is required. First, the EU and its representatives perceive themselves (and are perceived) as frontrunners in international climate policy (Skjærseth, 2021). The way the EU is starting to regulate CDR can therefore be anticipated to have an impact on the international debate and governance under the UNFCCC, other fora for international cooperation, and on climate-related regulation in other countries. Secondly, OECD countries with their large

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shares of historic emissions are (in the academic literature, at least) generally expected to be responsible for the implementation of large amounts of CDR (Lee et al., 2021; Pozo et al., 2020). As soon as demands for developed countries to become net-negative are negotiated under the UNFCCC, eyes will also turn to the EU as a key player in deploying and scaling up CDR (Mohan et al., 2021). Thirdly, the issue will get more attention as 2050 approaches. As already stipulated in the EU Climate Law, after achieving net-zero by 2050, the EU will need to achieve net-negative GHG emissions.

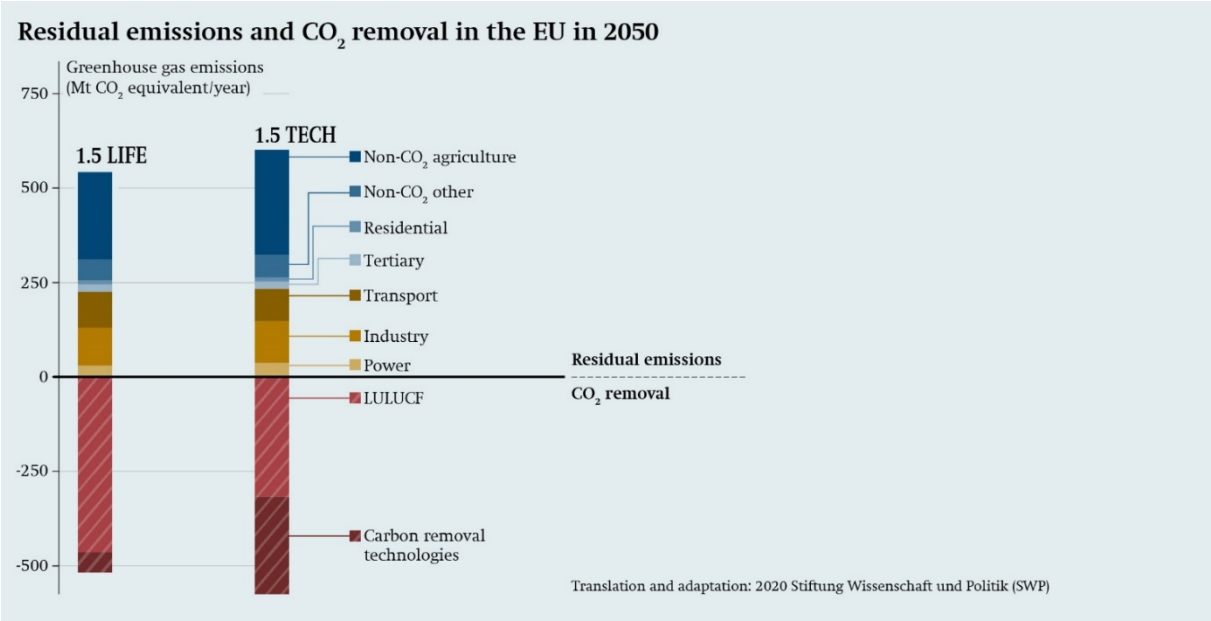
CDR policymaking is a rapidly emerging component of climate policy (Schenuit et al., 2021). To trace its struggle onto and up the EU climate policy agenda, we start by providing a brief overview of CDR-related aspects of the EU's 2030 Climate and Energy Framework as adopted in 2018 and show that CO_2 removal is not entirely new to EU climate policymaking. We then turn to more recent developments, in particular, the EU Climate Law and the new 'Fit for 55' package under the Green Deal to explore relevant actors in EU climate policymaking and their (evolving) political positioning towards CDR. Based on this, the chapter concludes by anticipating future developments in CDR policymaking.

10.2 The status quo: CDR in currently enacted EU climate policy

10.2.1 Carbon Dioxide Removal – an overview

According to the IPCC, CDR describes a set of "anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. […]" (IPCC, 2018d). To limit global warming to 1.5 °C by the end of the century, such activities will be unavoidable to counterbalance hard-to-mitigate, so-called residual emissions (mainly in industry, transport, and agriculture, see figure 10.1), and potentially bring the global temperature down to 1.5 °C after a temporary overshoot (European Commission, 2018b; IPCC, 2022).

Figure 10.1: Residual emissions and CO_2 removal in the EU-27 + UK in 2050



Source: Geden and Schenuit 2020[70]

Several recent assessments of specific CDR methods and their removal potentials helped to structure the debate (Babiker et al., 2022; Fuss et al., 2018; Smith, 2016). Since then, studies and research projects on CDR governance and policy have emerged (e.g., Fridahl et al., 2020b; Schenuit et al., 2021). Research on the economic and political feasibility aspects indicates that CDR deployment will require (Fuss et al., 2020), and has the potential to facilitate, new alliances. At the same time, it can also lead to new, or exacerbate existing, conflicts (Carton et al., 2020; Geden and Schenuit, 2020; McLaren et al., 2019).

In public policy debates, a distinction is often drawn between “natural” and “technological” CDR methods. These framings carry substantial political implications (Osaka et al., 2021) and the terminology used to distinguish the methods in academic publications is still in flux. In an attempt to avoid value-laden terminology, we distinguish between *ecosystem-based* and *geochemical-based* approaches. While ecosystem-based methods aim to strengthen biological sinks such as forests and soils through reforestation and soil carbon sequestration, respectively, geochemical-based methods include different ways to absorb CO_2 and store it permanently (e.g. DACCS or Enhanced Mineral Weathering).

In addition to the general acknowledgement of the necessity of CDR, IPCC’s SR 1.5, the Special Report on Land (IPCC, 2019b), and AR6 Working Group I (IPCC, 2021c) and other

[70] 1.5TECH and 1.5LIFE are two decarbonisation scenarios consistent with net-zero GHG emissions in 2050. While 1.5TECH makes more use of technological options, both for emission reductions and removals, 1.5LIFE has stronger assumptions regarding demand-side measures and enhanced land-based sinks. For details see Commission 2018, p. 325-326.

assessments identified wider implications of CDR measures for sustainability. For ecosystem-based methods, substantial impacts on ecosystems as well as agricultural and food systems are likely (IPCC, 2018d), depending on, among other things, deployment rates. The actual impact on ecosystem services and the sustainable development goals is part of the scientific debate on land-based CDR measures (IPCC, 2021c, 2019b). The geochemical-based method DACCS, for example, does not have a high land impact, but for now, high costs and high amounts of energy use are limiting factors (Fuss et al., 2018; Shayegh et al., 2021).

10.2.2 Climate and Energy Framework 2030

Although the scientific debate on integrating CDR into climate change mitigation policy is much older (Obersteiner et al., 2001), it was the IPCC's Fifth Assessment Report and the Paris Agreement that elevated a rather technical debate into the commentary sections of *Nature* and *Science* (Anderson and Peters, 2016; Fuss et al., 2014; Geden, 2015). The decisive starting point for the discussion were the large amounts of CDR and net-negative emissions assumed in the IPCC 5th Assessment Report's emission pathways compatible with the 2 °C temperature target. When, to the surprise of many observers, an even more ambitious 1.5 °C target level was agreed upon in Paris, it was feared that the required amounts of CDR built into integrated assessment models would be even less feasible and sustainable.

In the years following the Paris Conference of the Parties (COP21), EU policymakers were quite reluctant to deal with the issue of CDR and awaited more expertise, both from the IPCC and from modeling efforts informing the Commission's proposal for a long-term EU mitigation strategy. Accordingly, the 2030 Climate and Energy Framework adopted in 2018 does not include any explicit CDR policy. In the Energy Union Governance Regulation (Official Journal of the European Union, 2021), however, CDR (alias "negative emissions") is mentioned, e.g. in its recitals and Art. 15, which calls for a long-term strategy with a perspective of at least 30 years. In particular, the European Council and the European Parliament as co-legislators asked the Commission to provide various scenarios in its Long-Term Strategy (LTS), including one "on achieving net-zero GHG emissions within the Union by 2050 and negative emissions thereafter" (Art. 15, 2a). Since the Commission's proposal for the LTS (and the accompanying in-depth analysis) has been influential preparatory work for the European Green Deal initiative kicked off in 2019, we will come back to this in the next section. Before we explore the role of CDR in the Green Deal, we briefly summarise the aspects of the 2018 legislation that are of relevance for CDR.

Identifying implicit CDR regulation within the body of already enacted climate policy is important because it reveals that CO_2 removal is not entirely new to EU climate policy. Fur-

thermore, it helps to anticipate prospects of CDR policymaking by exploring legislative and political entry points, path dependencies as well as related politics. We will focus on two of the three main pillars of EU climate legislation: the Land-Use Change and Forestry (LULUCF) Regulation and the EU Emissions Trading System (ETS). The third pillar, comprising national emissions reduction targets under the Effort Sharing Regulation (ESR), does not yet entail specific EU-wide aspects relevant for CDR, except for flexibilities to the LULUCF regulation.

10.2.2.1 LULUCF Regulation

In 2018, EU institutions agreed on the LULUCF regulation for 2021-2030 (2018/841) after intense and complex negotiations. From 2021 onwards, the newly established third pillar of EU's 2030 climate and energy framework regulates emissions and removals in this sector. Negotiations on the inclusion of the sector in EU climate targets officially started with a European Council decision in 2014 (European Council, 2014). A preparatory EU decision (No 529/2013/EU) in 2013 included a general agreement on accounting rules but did not regulate consideration of the sector in the achievement of EU-wide climate policy targets.

The LULUCF sector is known as a very controversial issue area in both international climate negotiations (Krug 2018) and EU policymaking (Savaresi et al., 2020). The main concerns have been uncertainty in reporting, opposition to offsetting and permanence of ecosystem-based carbon sequestration (Nabuurs et al., 2018). In addition, strong Member State-level interests, and low EU regulatory powers in the field of forest policy (Meyer-Ohlendorf and Frelih-Larsen, 2017) prevented an earlier inclusion of the LULUCF sector in EU climate policymaking.

The central building block of the 2018 LULUCF legislation is the so-called ‘no-debit rule’, a binding commitment “that accounted emissions from land use are entirely compensated by an equivalent removal of CO_2 from the atmosphere through action in the sector.“[71] This means that sinks within the LULUCF sector (especially forests) balance emissions from other forms of land use (e.g. from managed cropland or deforestation). To secure verifiable compliance with the ‘no-debit rule’, the Regulation obliges all Member States to apply detailed accounting rules that result in LULUCF credits and debits.

To take into account natural and country-specific characteristics of the sink effects of managed forest areas (e.g. age structure), the regulation establishes a process in which the Member States propose individual reference values, which must be confirmed by the Commission and will then be the starting point for calculations of sink effects and emissions. The reference levels aim to ensure that only human-induced changes (e.g. more sustainable har-

[71] See Commission homepage: https://ec.europa.eu/clima/policies/forests/lulucf_en.

vesting) are generating LULUCF credits and that the mere presence of a large LULUCF sink in the Member States does not automatically lead to a high number of LULUCF credits. These reference values will be set gradually for two phases (2021-2025 and 2026-2030) and afforested or deforested land is accounted for differently. For a comprehensive overview of the accounting rules, see (Böttcher et al., 2021, 2019).

During the legislative process, the integration of the LULUCF sector into the overall target structure was contested. In particular, the linking of different climate policy pillars through new flexibilities proved to be controversial. Countries with large forestry and/or agricultural sectors were very active in trying to establish and shape flexibilities in their interest. NGOs criticized these countries for trying to water down climate ambition. However, these countries had the 2014 European Council decision on the 2030 Climate and Energy Framework as an argumentative reference point for the inclusion of new flexibilities. Here, the Heads of States and Governments had already agreed on a formulation proposing the compensation of emissions in the agricultural sector through afforestation (European Council, 2014). Also, a Commission impact assessment on a future LULUCF Regulation made clear that there is a "need for flexibility towards agriculture" in the ESR (European Commission, 2016, p. 28).

The final LULUCF Regulation includes several flexibilities (Savaresi et al., 2020). Most relevant for CDR is the inter-pillar flexibility between the LULUCF and ESR. If the Member States do not comply with the 'no-debit rule' and no other flexibility option is available, annual emissions allowances from the ESR need to be transferred to balance emissions in the LULUCF sector. At the same time, a limited amount of 280 Mt (i.e., 1 percent of annual ESD emissions from 2005) LULUCF credits can be transferred to achieve the national reduction targets under the ESR. In principle, this flexibility provides the option that fossil fuel and agriculture emissions could be counterbalanced by forestry credits.

Through the established flexibilities, the LULUCF regulation thus already provides an opportunity to account for CDR. It is important to highlight that this integration was not framed as an initiative to anchor CDR as a mitigation measure in EU climate governance by EU policymakers (see Böttcher et al., 2019, p. 30). The flexibilities follow the "purpose […] to help Member States meet their no-debit commitment rather than to compromise the EU's GHG emission reduction targets." (Romppanen, 2019, p. 4). Although the flexibility is strictly limited, the agreed accounting procedures are expected to establish new incentive structures for the Member States, especially if revised Regulations under the European Green Deal follow up on this idea and expand the scope of the inter-pillar flexibility (see section 3).

10.2.2.2 EU ETS

In principle, an emission trading scheme (ETS) would provide an opportunity to govern and incentivise the implementation of CDR. New Zealand's ETS, where forestry CO_2 emissions

and removals are accounted as fully equivalent to emissions or avoided emissions from other sectors (Schenuit et al., 2021), provides an example of how absorbing CO_2 could lead to generating allowances. To date, this is not possible within the current design of the EU ETS and would even contradict the overall design of the EU ETS Directive as outlined in Article 2(1) (Rickels et al., 2021). The most relevant CDR-related aspect of the 2018 EU ETS Directive is the fact that research and demonstration projects on CDR in combination with CCS can be funded through the EU ETS Innovation Fund (about €25 billion, depending on the price for EU ETS allowances).

Therefore, the EU ETS as currently conceived does not provide a clear way forward for the integration of CDR. However, as increasing attention by experts and scholars shows, the political commitment to net-zero GHG emissions and ongoing processes of operationalizing it into EU's climate policy will move the integration of CDR into the ETS up on the political agenda. In the Commission's technology-oriented scenario, outlined in its draft LTS, the EU ETS achieves a net-negative cap of emissions by 2045. The scenario further assumes that in 2050, emissions in the entire ETS will be at minus 50 Mt, achieved with CDR (Rickels et al., 2021). The EU ETS would need to be substantially redesigned to allow and achieve such net-negative numbers.

10.3 Carbon dioxide removal and the European Green Deal

The European Green Deal started as a political strategy of the incoming Commission led by Ursula von der Leyen in 2019. In response to the new momentum for climate action in 2019, sparked in part by the findings of the IPCC's Special Report on 1.5 °C and the major youth protests, the newly elected President of the European Commission declared the political goal of making Europe the first "climate-neutral continent" by 2050. The new Commission further announced its intention to table a proposal for a climate law during her first hundred days in office, as well as to revise existing climate regulations accordingly (European Commission, 2019). To assess the role of CDR as one element of these new developments, we first focus on the EU Climate Law and turn to the political positioning of key actors in a second step. The latter not only allows us to continue tracing how the topic climbed up the agenda of different EU institutions but also helps to anticipate plausible future developments.

10.3.1 CDR in the EU Climate Law

For CDR policymaking, the specific designs of the 2030 and 2050 targets are the most relevant aspect of the EU Climate Law (Regulation 2021/1119, Art. 4 and 2, respectively). The

2030 target is – as originally proposed by the Commission and the Council, but initially opposed by the European Parliament – adopted as a net target that accounts for emissions and removals towards the overall reduction. After strong criticism by NGOs and some MEPs, however, EU legislative actors agreed to cap the contribution of removals to the net target to 225Mt CO_2e (Art 4.1).

The 2050 net-zero GHG emissions target was already agreed upon by Heads of State and Governments in the European Council in December 2019. The fact that Poland insisted on adding a footnote to the conclusions stating that "[o]ne Member State, at this stage, cannot commit to implement this objective as far as it is concerned" (European Council, 2019) , points to important distributional impacts of this target. The fact that it is established as a "Union-wide" target (Art. 2.1) is expected to cause political bargaining about the timing of net-zero in different Member States and is therefore relevant for CDR policymaking. For example, countries with large shares of hard-to-abate emissions might demand to be allowed to achieve net-zero emissions later than 2050, implying that other countries would need to compensate for their delay by achieving net-negative emissions earlier than 2050 (Geden and Schenuit, 2020). An important element of the long-term goal in the Regulation is the wording "[…] the Union shall aim to achieve negative emissions thereafter" (Art. 2.1). The call for Union-wide net-negative emissions after 2050 opens the door to new debates about CDR and the overshoot of temperature targets that have been prevalent in academic discussions and IPCC assessments (IPCC, 2021c, 2018d), but rarely addressed in climate policy.

10.3.2 Policy actors and their positions towards CDR

10.3.2.1 European Commission

As noted in section 2, the Commission started to address CDR proactively with the publication of its long-term strategy (LTS) proposal in 2018 (European Commission, 2018b). Here, CDR is identified as one of the key building blocks of the modelled scenarios compatible with net-zero GHG emissions by 2050. Since then, the Commission proposed several initiatives to address CDR at the political level.

The Commission included straightforward language on CO_2 removal in the draft for the above-mentioned Climate Law (European Commission, 2020a). In particular, the draft stated that the net-zero GHG emissions goal will require "natural and technological" CDR (Recital 12). A slightly different formulation was adopted in the final EU Climate Law (Regulation (EU)

2021/1119, recital 20),[72] allowing policymakers and stakeholders to push for the integration of a wide range of CDR methods into EU climate policymaking in future legislative processes. Subsequently, the Commission's impact assessment of the 2030 Climate Target Plan and proposed reforms in the 'Fit-for-55' package are additional indicators pointing to the Commission's proactive role in establishing CDR policies. The proposed revised LULUCF regulation aims to establish a "2030 Union target for net GHG removals" of 310 Mt for the LULUCF sector, with differentiated removal efforts across Member States (Commission 2021a), that could contribute to the 2030 reduction target. This contribution, however, would be limited to the 225Mt cap as defined in the Climate Law (see section 3.1). This proposal indicates that the Commission is proactively pursuing and testing ideas and concepts to integrate the deliberate enhancement of the LULUCF sink into EU climate policy.

Simultaneously, the Commission has started to support geochemical-based CDR methods and related infrastructures. With the CCS project Northern Lights in Norway, for example, the Commission is engaged in supporting and co-funding a CCS project (European Commission, 2022) that declares that envisaged CO_2 storage infrastructure will be linked to carbon removal programmes (Northern Lights, 2022). The Porthos (Port of Rotterdam CO_2 Transport Hub and Offshore Storage) project in the Netherlands is a second example of a geological storage project supported by EU funds (European Commission, 2021a). Furthermore, the already mentioned EU ETS Innovation Fund is open for CCS and carbon removal projects and some CDR-related projects like CarbFix in Iceland (European Commission, 2021b) or a BECCS project coordinated by Stockholm Exergi in Sweden receive funding from the Innovation Fund (Commission 2022b).

In December 2021, the Commission published a new Communication titled "Sustainable Carbon Cycles" (European Commission, 2021c) aiming to pre-structure the public debate and legislative procedures. The strategy document identifies three main challenges and related key actions required to implement CDR in the EU. First, a comprehensive strategy to scale up so-called "carbon farming". Here, the main idea is to create new revenue streams for land managers in agriculture and forestry to incentivise the increase of carbon captured and stored in plants and soils to 42Mt in 2030. The Common Agriculture Policy and the Cohesion Funds, the two biggest parts of the EU budget, are identified as potential sources for these monetary incentives. Secondly, the Communication highlights the importance of industrial capture, use, and storage of carbon and proposes to set a quantified target for carbon removal of 5Mt in 2030 through methods such as DACCS and bioenergy plus CCS

[72] "[…] Sinks include natural and technological solutions, as reported in the Union's greenhouse gas inventories to the UNFCCC. Solutions that are based on carbon capture and storage (CCS) and carbon capture and use (CCU) technologies can play a role in decarbonisation, especially for the mitigation of process emissions in industry, for the Member States that choose this technology." (Regulation (EU) 2021/1119, recital 20).

(BECCS). Providing increased research funding through the Horizon Europe research and innovation programme as well as supporting frontrunner projects via the ETS Innovation Fund are among the key actions identified to support niche technologies. Lastly, the Commission used the document as an opportunity to specify its initiative for a regulatory framework for the certification scheme for removals. The initiative was first announced in the Circular Economy Action Plan (European Commission, 2020b) and was taken up by the "Farm to Fork" strategy, which already proposed payments for farmers and foresters under the Common Agriculture Policy (CAP) who sequester carbon (European Commission, 2020c). This third element of the new initiative demonstrates the Commission's ambition, not only to promote innovation in the field of CDR deployment but also to position itself as a pioneer in its regulation. However, following the EU's ordinary legislative procedure, it will be the European Parliament (see section 3.2.2) and Member States (see section 3.2.3) that eventually decide on the actual design and implementation of CDR-related reforms of the existing climate policy mix.

10.3.2.2 European Parliament

The European Parliament (EP) is known for striving for ambitious climate policies (Buzogány and Ćetković, 2021). This reputation was also confirmed during the Climate Law negotiations, where the EP Plenary not only opted for a more ambitious target of 60 percent by 2030 but also rejected the option to establish a net emissions logic, i.e. unlimited fungibility of emission reductions and removals (European Parliament, 2020). During this process, the EP did not call for integrating CDR proactively into climate policymaking. However, the EP welcomed the Commission's initiatives on establishing a carbon credit framework for ecosystem-based CDR during the legislative process on the Climate Law (EP 2020 recital 12d). The EP's central role in driving ambition and credibility in climate policymaking (Buzogány and Ćetković, 2021) has led many MEPs, especially in the Committee on the Environment, Public Health and Food Safety (ENVI), to regard CDR with suspicion. The fear that CDR could weaken mitigation ambition and implementation is reflected in EP's position during the EU Climate Law legislative process (European Parliament, 2020) and the final agreement to limit the amount of LULUCF removals allowed to contribute to the 2030 target (Official Journal of the European Union, 2021).

In the aftermath of adopting the Climate Law, however, MEPs started to deal more openly with CDR-related issues. Political positions in the legislative processes under the 'Fit-for-55' package, for example, show that a majority of MEPs acknowledge the need for CDR and, under the pre-condition that emissions reduction remains the principal priority of EU climate policymaking, call for exploring the integration of CDR into EU climate policy instruments such as EU ETS, ESR, and LULUCF regulations. Recent votes in the EP indicate that MEPs

seek to avoid a situation where pressure for emissions reduction decreases as a result of the inclusion of CDR in climate policy (see McLaren et al., 2019; Morrow, 2014). Maintaining the priority of emissions reduction will be a key future challenge in EU climate policy. As the legislative procedures have not yet been completed at the time of writing, a detailed analysis of the EP's positions is beyond the scope of this chapter. Recent EP plenary decisions indicate, however, that in addition to positions of different parties and EP committees, national interests and regional alliances will shape MEPs positions on CDR in future legislation (for an overview of tabled positions, see procedure files ESR (2021/0200(COD), LULUCF (2021/0201(COD), and EU ETS (2021/0211(COD).

10.3.2.3 Member States

Previous developments in EU climate policymaking have been substantially shaped by Member States (Wurzel et al., 2019). Heads of State and Government have set specific guardrails for the 2030 Climate and Energy Framework adopted in 2018 and claimed authority for setting the overall ambition of the new 2030 target. Well before the end of the inter-institutional trilogue negotiations on the target ambition in the Climate Law, the Council submitted a net 55 percent 2030 target to the UNFCCC as an updated EU NDC in December 2020 (European Council and European Commission 2020).

With regards to CDR policymaking, Member States differ substantially in the way they address the issue: while some, like Germany, prefer a rather incremental modification, others, such as Sweden, address the issue proactively and take a pioneering role in regulating and deploying CDR with incentive schemes for BECCS (Schenuit et al., 2021). These differing socio-political preferences and policy approaches towards CDR methods can be observed in the National Energy and Climate Plans (NECPs), which all Member States had to submit as part of the Governance of the Energy Union Regulation (Regulation (EU) 2018/1999, Art. 3 & 4). At the same time, the NECPs reveal that political positioning across Member States is at an early stage and preferences are so far indeterminate. The heterogeneity and provisional nature of current positions towards CDR indicate that new alliances can emerge as the importance of removals in EU climate policy increases. In fact, the first groupings are emerging. For instance, the Netherlands, Norway, Denmark, and Sweden have already published a joint non-paper on CCS that also calls for "[f]urther integrate CO2 removals from negative emission technologies in EU climate policy and analyse policy options for incentivising their development and deployment" (Klima- Energi- og Forsyningsudvalget Danmark, 2020).

Another relevant dimension of Member State positions is the already mentioned timing of national net-zero targets and net-negative commitments. While Sweden and Germany, for example, have set their targets for 2045, Finland aims for net-zero GHG by 2035, followed by net-negative emissions thereafter. A differentiated timing of national net-zero pledges across

Member States is expected to become a relevant and contested issue in future climate policymaking at the EU level. The EU-wide net-zero target by 2050 in the EU Climate Law will almost certainly lead to differentiated net-zero years across Member States since countries with larger shares of emissions in the power, agriculture or industry sectors might be provided a longer transition period to achieve GHG neutrality (see also section 3.1). Political compromises in EU climate policy have often been shaped by such kind of differentiation (Dupont and Oberthür, 2015). CDR thus adds a new layer of potential flexibilities that eases the pressure for emissions-per-capita convergence by 2050.

10.4 Prospects for CDR in the EU's multi-level system

Following the Climate and Energy Framework 2030 legislation adopted in 2018, which aimed at bridging climate and energy policymaking (Skjærseth, 2021), the European Green Deal is now expected to expand interlinkages and coordination between climate policy and other policy fields. Tracing the initial efforts to integrate CDR – mostly led by the Commission, but also by small groups of Member States – indicates that it might evolve into a relevant tool for establishing new coordination across policy domains, especially regarding the Common Agriculture Policy and forestry. In the following, we highlight two familiar and two new dynamics that are expected to shape CDR policymaking in the future.

10.4.1 Familiar conditions

The Commission stands out as the institution that most proactively pursues the integration of CDR into EU climate policy architecture. The Communication on the role of CDR (European Commission, 2021c) to achieve net-zero and net negative GHG emissions indicates that it is planning to remain the driving force for the coming years. It is not the first time that the Commission has initiated and led policy debates and legislative processes to address unconventional elements of climate policy. The most prominent example is the EU ETS, which was a rather unknown and contested instrument in the early 2000s. It entered EU climate policymaking through "entrepreneurial and intellectual leadership" by the Commission (Skjærseth, 2017). In a situation of the asymmetrical distribution of expertise about the ETS as well as indeterminate preferences towards this new kind of instrument, the Commission made use of its "potential as the 'engine' of EU climate-policy development" (Skjærseth, 2017, p. 96). Although CDR is not a new climate policy instrument but an additional tool in the mitigation toolbox, it does have the potential to alter EU climate politics as well, not only in terms of target structures and differentiation of climate ambitions across countries and sectors, but also because of its potential to trigger polarized debates (Colvin et al., 2020). The political negotiations on the net 2030 target are a prime example of this (see section 3.2.2).

In this situation, the entrepreneurial and intellectual leadership by the Commission might – as in the case of the EU ETS – help facilitate a constructive and open debate, political positioning, and maybe agreement on different ways of addressing CDR in EU climate policy. The actual implementation, however, will depend on the EU's two co-legislators: the Council and the European Parliament.

Evolving Member State positions indicate that intergovernmentalism will, as is usually the case in EU climate policymaking, play an important role in the development of CDR policy. In addition to their sheer competence, three main reasons for this lie in 'geographies of net-zero' across Member States. First, Member States differ substantially in their ambitions to achieve net-zero emissions. The Union-wide character of the adopted net-zero target helped to bridge these differences but is expected to have implications on differentiating reduction and removal efforts. Secondly, countries will differ concerning their residual emissions since the amount of hard-to-abate emissions depends on the structure of domestic industries and other sectors. In Ireland, for example, the agriculture sector will be a key source of residual emissions that have to be balanced to achieve net-zero. In other countries, process emissions from cement clinker production in particular are currently perceived to be hard-to-abate. Thirdly, countries have different socio-political preferences for different CDR methods. For example, while BECCS is widely accepted and part of climate-related regulation in Sweden, everything linked to CCS is highly contested in Germany. All three of these dimensions will shape national preferences towards the integration of CDR.

Balancing different preferences and interests has always been a defining characteristic of EU climate policymaking. Thus, it is not expected that the integration of CDR will completely turn the functioning of EU climate policy upside down.

10.4.2 New facets

At the same time, however, the integration of CDR will add new facets to EU climate policymaking. One of them relates to the emergence of new alliances across Member States and sectors. Our analysis of the emergence of the 2018 LULUCF regulation and its flexibilities as well as very different structuration and projected development of LULUCF sinks in Member States (Böttcher et al., 2021) indicate that new alliances beyond the existing *Green Growth* and *Visegrád* groups could form through the positioning in relation to the integration of CDR into the EU's climate policy portfolio. In particular, the new political attention directed towards enhancing the LULUCF sink through a large "carbon farming" initiative will be relevant in this context. The Commission's envisaged CDR certification scheme will play a key role in establishing revenue streams at the interfaces of agriculture, forestry and climate policies. It will shape and be shaped by political and economic interests in these sectors and new alliances across Member States.

A second new facet will be a presumably modified target structure for intermediate mitigation target for 2040. The idea of a newly created EU removal target has been explored by several studies since the importance of CDR received more attention (Böttcher et al., 2021; Geden et al., 2019; Geden and Schenuit, 2020; Meyer-Ohlendorf, 2020). They explore possible policy designs, discuss their implications, and agree that the revision of all major climate legislation in the context of the Green Deal is a window of opportunity for establishing a new sub-target. The new net emissions logic in the Climate Law together with the proposed LULUCF removal contribution target is a new step in this direction. However, whether the EU will adopt a distinct removal target, what type of removals it will cover, and how it will be designed and implemented across sectors are likely to be contentious issues in future climate policy.

10.5 Conclusion

With the Paris Agreement, the IPCC's Special Report on 1.5 °C Global Warming and the European Green Deal, the need to remove carbon to counter-balance hard-to-abate emissions by mid-century and to achieve net-negative emission thereafter received significantly more attention in EU climate policy. Our analysis of the 2018 Climate and Energy Framework and positions of EU institutions reveal that after being governed implicitly in the LULUCF sector, the issue of CDR has climbed up the political agenda and policy actors are now starting to proactively address the need to enhance EU's carbon sink capacity.

So far, EU legislation focused specifically on ecosystem-based CDR methods in the LULUCF sector and the integration of geochemical-based CDR into climate policymaking is limited. However, recent shifts in actor positions indicate that this can be expected to change over the coming years. Policy initiatives in some Nordic countries as well as the policy entrepreneurship by the Commission show that research, demonstration and deployment of geochemical-based methods will accelerate. At the same time, initial political resistance against the inclusion of removals in climate targets, varying socio-political preferences and the 'geographies of net-zero' point to contingencies of when and where different methods will be deployed. In the coming years, political pressure to deploy a broad portfolio of CDR methods could come from outside the EU. Should the U.S., the U.K. or countries like China follow through on their announcements to deploy CDR, expectations towards the EU as a climate leader would increase.

In the medium-term, the EU's intermediate climate target for 2040 and the governance architecture put in place to achieve it will determine the role of CDR in the EU's transition towards a net-zero emissions society. Continuing to explore 'geographies of net-zero' and their politi-

cal implications will be key to anticipating and informing looming discussions on how to regulate CDR and help avoid polarization as the issue continues to climb up the political agenda.

10.6 Additional material for EU in-depth case study

While the published chapter focused on how the issue of CDR has climbed up the EU climate policy agenda. In preparation for this chapter, available material on the 27 EU Member States was evaluated. While this material does not add more case studies, it does point to some relevant differences across the countries. In preparation for the published chapter, the National Energy and Climate Plans (NECPs) of all 27 EU Member States were analysed for the role of CDR in national planning[73]. The results of this analysis, are summarised in the following box.

Analysis 27 National Energy and Climate Plans (NECPs)

As part of the in-depth analysis of CDR policymaking in the European Union, 27 country documents from Member States have been analysed as background material for publication in the handbook chapter. Following the Regulation on the governance of the energy union and climate action (EU/2018/1999), NECPs are 10-year integrated national energy and climate plans (NECP) that Member States had to prepare for the period from 2021 to 2030 and submit by the end of 2019. Although CDR is not explicitly part of the reporting structure for NECP as outlined in the Governance Regulation (Art. 3 and 4), the documents provide relevant insights into how CDR is currently addressed in the 27 EU capitals. Based on a systematic document analysis of all 27 translated final NECPs, we investigated established and planned policies, initiatives, research programs, etc., relevant to CDR. It should be noted that NECPs are only one document Member States have to submit to the EU. National plans and actions should also be taken into account into more detailed analysis (for more details on EU Member States see the recent report (Meyer-Ohlendorf and Spasova, 2022)

However, since the documents follow the similar reporting structure, they provide a first insight on how CDR is being treated in different national context. As the documents amount to more than 7400 pages, we decided to conduct a systematic document search to identify relevant sections of text and analyse these in more detail. Countries use different wordings to describe CDR-relevant aspects in their 2030 Plan, and the translation process is expected to add further ambiguities to the terminology. I decided to search the following broad list of terms: *carbon dioxide removal, carbon removal, carbon farm(ing), CO2 removal, CO2 storage, CCS, GHG removal, carbon sequestration, carbon farming, CO2 capture, direct air cap-*

[73] The documents are available here: https://energy.ec.europa.eu/topics/energy-strategy/national-energy-and-climate-plans-necps_en.

ture (DACCS), bioenergy and CCS (BECCS), afforestation. Based on our analysis of the material, I identify four key observations.

First, the typical terms used in the scientific and expert community to describe the deliberate removal of carbon from the atmosphere to achieve specific climate goals are "negative emissions" and "carbon dioxide removal." These two terms are only used by 9 countries: Belgium, France, Germany, Ireland, Latvia, the Netherlands, Poland, Sweden, and Slovenia. Often the statements identified are very brief and abstract - we, therefore, conducted a more detailed analysis of specific CDR methods.

Second, geochemical-based CDR methods are only addressed by very few countries. The two most relevant methods, BECCS and DAC, are only briefly mentioned by France and Sweden (BECCS)[1] and Germany (DAC). In Sweden, BECCS (here: bio-CCS) is already part of the climate policy mix and the models to achieve net-zero emissions in 2045 (SE, NECP, p.17/p.127). In France, BECCS is part of the domestic modeling efforts of a "possible trajectory for reducing greenhouse gas emissions to achieve carbon neutrality in 2050" (p. 303) – the model contains about 12Mt CO2/y in 2050 (FR, NECP, p. 311) but no specific policy initiative is proposed throughout the NECP to deploy BECCS. Germany's NECPs mention DAC more abstractly, without particular amounts from models, a section on the 2050 long-term target, and efforts to "close the carbon cycle" in the industry (GER, NECP 2020, p.61). This limited coverage of geochemical-based methods reveals that related policies and debates are at a very early stage in almost all Member States.

Third, we observed quite a different situation concerning ecosystem-based methods. All Member States address methods that can be counted to this type of carbon removal methods. The way these methods are addressed, however, differ substantially. While some countries only list the projections of how the LULUCF sink or results of their models, an aspect the NECP structure asked for (e.g., Italy, Slovakia, Cyprus), almost all others mention proposals for future policies or declare intentions to increase efforts in this context. Differences between these initiatives are significant and range from somewhat ambiguous declarations to concrete proposals for economic and political incentives to increase the carbon sink through afforestation or different agricultural practices (e.g., Belgium and Finland, who aim at setting up carbon sequestration and storage markets). Exploring details of the wide range of these initiatives is beyond the scope of this chapter but provides rich material for future analysis.

It should be noted, however, that these policies are rarely explicitly introduced as CDR policies. They implicitly address and cover what is described as ecosystem-based CDR and are therefore relevant to observing how CDR came onto the policy agenda. Most often, they are directly linked to the provision of the LULUCF regulation to achieve the "no-debit rule." This

shows again how important the future of LULUCF legislation is for developing future CDR policies.

Fourth, there are significant differences in how CCS is addressed in the NECPs. Because of its importance to most geophysical-based CDR methods, future CCS policy in the EU will be an essential part of CDR policy and, as the NECPs show, an issue for new alliances among member states. There are four groups of statements on CCS in the analysed documents: First, those that do not mention CCS or reject it (Luxembourg, Finland, Malta, Portugal, Romania). Second, those that mention it only in the context of fossil energy production with coal and gas (Czech Republic, Estonia, Hungary, Poland, Slovakia). Third, the largest group of countries that address it as a possible strategy to "close the carbon cycle" (Belgium, Cyprus, Denmark, Greece, Spain, Croatia, Italy, Lithuania, Latvia, Slovenia Austria (only CCU). The fourth group consists of countries that make a direct link between CCS and possible CDR deployment (Bulgaria, France, Germany, Ireland, Netherlands, Sweden). Again, this can only be a snapshot, and distinctions between these groups are somewhat blurry; governments might also have changed their position already or are not entirely consistent in their positioning. What it does show, however, is the possible different ways of dealing with an issue that not only the IPCC reports but also the Commission sees as essential to achieving net-zero and net-negative emissions in the second half of the century. The second group of countries points to political tension that CCS could be used to prolong fossil fuel use in the EU. Political battles over this issue can be expected once CCS deployment begins. It is worth noting that some countries are already addressing this challenge. In the Netherlands, for example, funding for CCS under the subsidy scheme SDE++ is limited to 2035 – except the CCS project is linked to negative emissions.

This rough snapshot of current positions in EU member states illustrates two things: the heterogeneity when it comes to addressing CDR, and the political positioning in Member States is at an early stage, and preferences are so far indeterminate. The heterogeneity of current positions towards CDR indicates that new alliances can emerge in the context of the increasing importance of removals in EU climate policy. The first groups and alliances are emerging. One example is the group around a non-paper consisting of the Netherlands, Norway, Denmark, and Sweden on CCS, in which they call for "more integration of CO2 removal by negative emission technologies into EU climate policy and analysis of policy options to promote their development and deployment." (Klima- Energi- og Forsyningsudvalget Danmark, 2020). In all four countries, governments and/or companies are involved in demonstration and deployment plans for CCS and its use in the CDR context. New alliances can also be expected in the context of the LULUCF sink, which, as shown above, is likely to play an important role in upcoming legislative processes and CDR policy. Some countries, particularly those with a comparatively significant LULUCF sink potential, will have a strong interest in forming new

alliances with countries that integrate extensive flexibilities to count their LULUCF sinks toward their mitigation targets.

11 Discussion and Conclusion

The contributions of this thesis have demonstrated that whether and how IPCC knowledge is policy-relevant in public policy processes depends largely on the context and the actors involved in making it relevant. By focusing on the issue of CDR and SR15 and how relevance is created in different national contexts, this thesis examined the knowledge politics of an emerging issue that has gained traction and sparked critical debate. It became clear that policy relevance cannot be achieved by the IPCC assessment processes themselves, but that mechanisms, strategies, and struggles of relevance-making play an important role.

The following sections summarise the main findings on the two sub-research questions (11.1.1 and 11.1.2). Section 11.2 summarises the findings on the overarching research question and discusses the contribution to the existing literature. Section 11.3 discusses the limitations of the research design and process before identifying areas for future research in section 11.4. The conclusion in section 11.5 provides an overarching summary of the main findings and contribution of the thesis.

11.1 Summary of key findings

11.1.1 Pillar I: Staging Science – Practices, limits, and contestation of strategic knowledge mobilization

This thesis explored the first research sub-question of how SR15 and related processes of knowledge production and validation were strategically mobilized and contested in climate science, policy and politics by triangulating evidence from three analyses. The analysis of the dramaturgical politics of SR15 (chapter 5) and the governance and policy landscape in which it was embedded (chapter 6), as well as an examination of incentive structures within the scientific community (chapter 7), provided insights into strategic knowledge mobilization efforts related to SR15. Below is a synthesis of the key findings that provide answers to the first research sub-question.[74]

Chapter 5 empirically investigated who puts the IPCC on stage in front of which audiences. The analysis identified three main scripts: (1) SR15 as a tool and rhetorical device to feed momentum for urgency of climate action, (2) SR15 as a politically contested element of hard politics and soft coordination under the UNFCCC, and (3) SR15 as a policy-relevant but not policy-prescriptive resource mobilized for evidence-based climate governance. These three scripts represent the multiple and sometimes conflicting expectations that the IPCC faces from a variety of different actors in different settings. The analysis of the dramaturgical politics of SR15 shows that its production and publication were embedded in broader struggles

[74] Supplementary material for chapter 11 provides an overview table with key results from each chapter to the research sub-question and the overarching research question.

over climate goals, the role of the IPCC, and the level of climate ambition. A key finding of this chapter is that the production and performance of global environmental assessments are inextricably linked, and that an examination of the IPCC that focuses only on the IPCC processes risks failing to take into account the dramaturgical politics at play at the science-policy-politics interfaces. The importance of this dimension for understanding the role of the IPCC is demonstrated by the practical recommendations derived from the analysis. While the chapter identifies some strategies already implemented by the IPCC to deal with incompatible expectations, it also shows that the IPCC is limited in its ability to control the messages that different actors are taking up and justifying with reference to the report. In particular, the chapter finds gaps in strategies to counter misrepresentation of the reports and the spillover of political battles from the UNFCCC into the production and approval of IPCC assessments – a weakness that could prove problematic for the IPCC in the hybrid climate regime.

The dramaturgical analysis of post-Paris climate governance at COP25 in chapter 6 provides an analysis of the political landscape of UN climate governance. Based on the collective event ethnography, the chapter examines the transition to and implementation of the hybrid architecture of the Paris Agreement, with a particular focus on actual performances. The analysis of COP25 highlights the importance of soft coordination in maintaining momentum for ambitious climate action and managing institutional uncertainty in the UNFCCC. This perspective on climate governance provides an important contextualization of the dramaturgical practices and mobilization strategies identified in chapter 5, and shows how they became embedded in efforts to build momentum in UNFCCC governance. The SR15 was a key instrument for these practices, highlighting once again the importance of not only examining knowledge production in a particular context, but also asking how the published report is strategically used for particular issues in different contexts to legitimize particular policy positions or governance structures. More specifically, the findings on the role of the UNFCCC Secretariat and COP Presidencies, in particular their ability to shape the setting and the intended dramaturgies, are relevant as they align well with the staging practices discussed in chapter 5. Furthermore, the typical narrative arc identified for speeches at COP25 and the different roles associated with it (admonisher, accountant, animator) show that scientific expertise – including IPCC reports – as admonishers are a core element of these narratives. While these staging efforts of the IPCC at COPs are not new (Dahan-Dalmedico, 2008), this context is an important element in the study of modes of relevance-making, especially in a climate regime where performances and dramaturgical interventions are important instruments of soft coordination (Aykut et al. 2021).

However, scientists and scientific expertise are not only put on stage externally. Chapter 7 sheds light on social practices and incentive structures within knowledge production and validation processes in climate science that also point to strategic behaviour. Drawing on the

analogy of the ‘the market for lemons’, the chapter argues that a similar development can be observed at science-policy-politics interfaces where scientists face trade-offs in knowledge production processes between public attention through straightforward results and more balanced studies. The case study of an article on the global potential of land-based CDR illustrates how publishing practices can be accompanied by public relations efforts. While these communication efforts are effective in terms of media coverage and uptake in policy initiatives it is striking that the methodological flaws documented in several responses from scientists receive much less attention and remain a scientific debate. Using the example of the carbon budget for the SR15 and the inclusion of CDR in models, the chapter also shows that the strategic mobilization of the IPCC also affects knowledge production processes within science. The chapter therefore suggests that research on the strategic mobilization of knowledge should examine knowledge production itself, taking into account incentive structures and biases, for example towards different disciplines and researchers from the Global North (Corbera et al., 2015; Hughes and Paterson, 2017), as well as "undone science" (Hess, 2016).

Initial synthesis of findings of pillar I

In an effort to further synthesize and discuss these findings in the context of the broader literature, this section differentiates between different mobilization *practices*, *contestation* of these efforts and the *limits* of strategic mobilization (Table 11.1 provides an overview).

Practices

The following practices can be derived from the findings: First, actors seek legitimacy through the mobilization of knowledge. Specifically, this means that actors mobilize the SR15 as such or certain statements from the report to (de)legitimize certain political positions or governance structures. This observation is in line with what Littoz-Monnet (2017) has observed for international organizations: knowledge is strategically mobilized. However, the in-depth study of SR15 shows, that the same product is mobilized by different actors for different purposes at the same time, which is an organizational challenge for an intergovernmental assessment body. Examples for these mobilizations include the procedural alignment with UNFCCC timelines (the Talanoa Dialogue), the diffusion of net-zero targets, the “Unite behind the Science” campaign, and efforts of questioning the IPCC’s fidelity to its mandate (see chapter 5 for details). This resonates with the conceptualization of scientific expertise as a resource for governance (Fischer, 1990) and the contested character of expertise (Kennedy, 2018).

The second key practice of strategic mobilization is *SR15 as a tool for climate diplomacy by other means.* The in-depth study of the report showed that both during the production and

after the publication of the report, SR15-specific discussions were used as a sideshow for climate diplomacy on how to interpret and operationalize the climate targets adopted in the Paris Agreement. For example, we see that SR15 has been mobilized for efforts to shift from 2 °C to 1.5 °C as the key target (Allen et al., 2022). This shows that negotiations over the interpretation of the rather fragile compromise on the temperature target – which included the agreement to invite the IPCC to produce this report – continued after the adoption of the Paris Agreement. The processes to produce the report, as well as those under the UNFCCC that refer to it, were used to further operationalize the diplomatic consensus reached in Paris. Using the IPCC as an intergovernmental organization and the report as hooks for other political objectives highlights the embeddedness of IPCC expertise and the science-policy-politics interfaces in broader political landscapes with competing actor groups (Aykut et al., 2021; Kennedy, 2018). It also provides an instructive example of venue shopping in international politics, where actors seek to identify different settings in which to pursue their policy goals (Pralle, 2003).

Contestation

While the 1.5 °C compromise enabled the adoption of the Paris Agreement, it did not resolve the underlying political conflicts between the various actors in the UNFCCC negotiations (see chapter 5). This strategic mobilization of the IPCC and diplomacy by other means led to significant tensions and struggles within the IPCC processes — both before and after the release of the report. Chapter 5 demonstrated that the IPCC has some strategies for dealing with the challenges due to previous conflicts, including a detailed communications strategy, carefully worded language about its mandate, and deliberate ambiguity in various spokesperson roles. However, the chapter also identified a lack of strategies for dealing with misrepresentation and the spillover of political conflicts. In this context, it is important to note that this is not the first time in multilateral climate negotiations that a political conflict has been shifted to the IPCC through a request for expertise. During the Kyoto Protocol negotiations, when the question of whether mitigation efforts should include the expansion of LULUCF sinks led to significant political conflict (see section 2.3.2.3), the IPCC was asked to prepare a special report on LULUCF. However, this approach of mobilizing the IPCC and asking for more knowledge to resolve politically deadlocked issues carries significant risks for the IPCC and its credibility, as both the political battles over the LULUCF report (see, e.g., Fogel, 2005) and SR15 have shown. These observations suggest that strategic mobilization does not resolve political conflicts[75], but leads to a change in the arena in which they are played out. This politicization of science (Weingart et al., 2000) through the spillover of political con-

[75] For a more general argument on why more scientific evidence might even worsen politically contested decision-making processes, see Sarewitz (2004).

flicts into the IPCC and its processes is a significant risk, especially given the IPCC's history of controversies (De Pryck and Hulme 2022). This facet of contestation over strategic mobilization practices should be considered in the future, particularly in the context of discussions about aligning future IPCC assessment cycles with the global stocktake (Livingston and Rummukainen 2020).

Limitations

In addition to the practices and contestation of the strategic mobilization of the SR15, the research conducted for this thesis also highlights the limitations of the IPCC's mobilization. Two main limiting factors have been identified in this thesis. First, while the IPCC is the main boundary organization in multilateral climate policy, it is also only one of many sources of scientific knowledge and climate expertise. Chapter 7 highlights the market for public attention for policy-relevant climate science, pointing to the efforts of entrepreneurial scientists to professionalize their public relations activities and thus gain wider attention for their studies that align with particular policy preferences, even when the methodological approaches are heavily criticized (e.g., Friedlingstein et al., 2020). In addition, we observe a functional diversification of scientific reports with different topics and different audiences, but considerable overlap with the IPCC in terms of authors (see chapter 5 and Aykut et al., 2020). Since the failure of Copenhagen in 2009, a number of different annual reports have been initiated, most notably the UNEP Emissions Gap Report, the Global Carbon Budget, and the Climate Action Tracker. Their annual updates and dissemination efforts are synchronized with the UNFCCC conference schedule and are very visible. Policymakers and stakeholders have many other references with which to support their positions and do not necessarily need the IPCC to lend scientific authority to their claims. It should be noted that STS research on the role of these different outputs at the science-policy-politics interface is very limited compared to the IPCC. A comparative study of the different practices of relevance-making in relation to different reports would be an interesting empirical follow-up study.

A second limitation arises from what has been described as "detached agreement" (see chapter 2). Multilateral negotiations, including political battles over targets and the associated scientific expertise of the IPCC and its mitigation pathways, may be less relevant to national or sectoral planning and decision-making to implement the transformation[76]. This observation is confirmed by the national case studies on CDR where in many cases national modelling

[76] There are several strands of literature linked to this point. Four main areas are new efforts of cooperation of global IAM teams with national modelling to enhance coordination and harmonization (Fujimori et al., 2021), discussion about the limits of global IAMs for mitigation in countries (Köberle et al., 2022), reconstructions of what role different forms of modelling play in national deep decarbonisation strategies (Lecocq et al., 2022)and the comparison across countries of what role anticipatory expertise plays in domestic national energy transitions (Aykut, 2019).

and expert and advisory bodies play an important role in discussing and preparing national decarbonization pathways (see section on Pillar II). It appears that while the IPCC has the potential to lend legitimacy to the urgency and act as an agenda-setter for overarching frames, other more specific sources of expertise appear to be more relevant to national climate policy. This is not to say that the IPCC is irrelevant as a provider of anticipatory expertise, but – from the findings of this thesis – it seems reasonable to conclude that other forms of expertise in the study of mitigation pathways should receive more attention when studying science-policy-politics interfaces.

Taken together, these observations about the practices, contestation, and limits of strategic knowledge mobilization show that the IPCC as an organization has limited control over what its reports are mobilized for and lacks the capacity to respond to some of the challenges that arise. We have also seen that scientific expertise on 1.5 °C has not resolved the contentious political problems, but has only shifted the location of the struggles. Finally, the limits of strategic mobilization show that the IPCC should be neither underestimated nor overestimated. In a "detached regime" like the Paris Agreement, there are many other sources of anticipatory expertise that are being mobilized and shape decision-making in the national or sectoral context (Table 11.1 for an overview).

Table 11.1: Summary of findings on strategic mobilization of SR15

	Practices	Contestation	Limitations
Strategic mobilization	(De-)legitimize certain policy position or governance structures. Climate diplomacy by other means. Market for public attention at science-policy interfaces and science' self-mobilization	Strategic mobilization cause efforts of counter-scripting More knowledge about 1.5 °C did not resolve fundamental political conflicts IPCC became a venue for these political conflicts	"Bouquet" of policy relevance climate expertise: functional diversification Risk for 'market for lemons' of scientific studies In a "detached agreement", national/sectoral modeling influential in planning and implementing transitions
Conclusion	- The IPCC as an organization has only limited control what its reports are being mobilized for, lacks capacities to respond to misrepresentations as an organization, and relies on constructive engagement of governments. - Strategic mobilization does not solve political conflicts, but leads to change of the venue where struggles take place. - The IPCC should not be overestimated; in a "detached regime", many other sources of anticipatory expertise exist and are being mobilized.		

11.1.2 Pillar II: CDR governance and policymaking in practice: Variety of roles for SR15 in different countries

The second pillar of contributions to this thesis aimed to explore patterns of CDR governance and policymaking and the role of SR15 in national climate policy. These case studies allowed me to explore the role of SR15 in CDR governance and policymaking and helped to answer the overarching question of modes of relevance finding in this context. While the latter is addressed separately in section 11.2, this section provides a synthesis of the comparative work, first on CDR policymaking and governance as such, and in a subsequent section on the role of SR15 in particular.

Idealized types of CDR governance and policymaking

Chapters 8 and 9 provide insights into 9 OECD cases (the European Union and three of its member states, Ireland, Germany, and Sweden, as well as Norway, the United Kingdom, Australia, New Zealand, and the United States), and three emerging economies (Brazil, China, and India). The chapters present the first comparative work on CDR governance and policymaking and include observations on the political economy, path dependencies, and policymaking associated with the integration of CDR into climate policy. In addition to the comparative case studies, the in-depth case study on the EU (chapter 10) – as a case where SR15 played a prominent role in CDR policy – traces how the issue of CDR climbed up the climate policy agenda in the context of the European Green Deal. The key takeaway from the papers was the analytical distinction between four idealized types of CDR policy and governance (see Figure 11.1 and Table 11.2).

While the first paper, with case studies of 9 OECD countries, initially distinguished between incremental modification, proactive CDR policy entrepreneurship, and early integration and fungibility (chapter 8), the second paper on key emerging economies, added the fourth type: repurposing policies. Table 11.1 summarizes the manifestations of the four types based on the continua identified in the synthesis of chapter 8: 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, 4) the type and embeddedness of policy instruments in a wider climate policy context, and 5) government support for niche developments.[77] As noted in chapter 8, it is important to emphasize that the differences between the conceptually distinct

[77] In Chapter 9, the approach of including the level of regulation and innovation was added to the analytical framework and reflected in the synthesis figure. This addition was included as a first step in exploring ways to bridge non-quantifying case study knowledge and quantifying modeling. However, this additional step will not be discussed in detail in this framing chapter, as these bridging efforts are beyond the scope of this thesis. For reflections on possible ways forward in this direction, see the discussion section in chapter 11.

types are intentionally overstated to support analytical clarity[78]. In the real world, there are overlaps and hybrids. Moreover, the approach to CDR policymaking may be contested within countries, so CDR policies may naturally change over time and new types may emerge. Chapter 9 on emerging economies demonstrates how this conceptual distinction can serve as a starting point for further empirical work. As these are only snapshots of the rapidly evolving governance and policy space, future comparative work, for example on a different set of countries, may reveal important changes and additions to this typology (see also section 11.3).

[78] Identifying typologies has a long tradition in social science more generally. For a discussion of methodological merits and criticisms in political science, see e.g., Collier et al., 2012; Elman, 2005; Smith, 2002; Steinberger, 1980.

Figure 11.1: Overview of four 'idealized' types of CDR policymaking

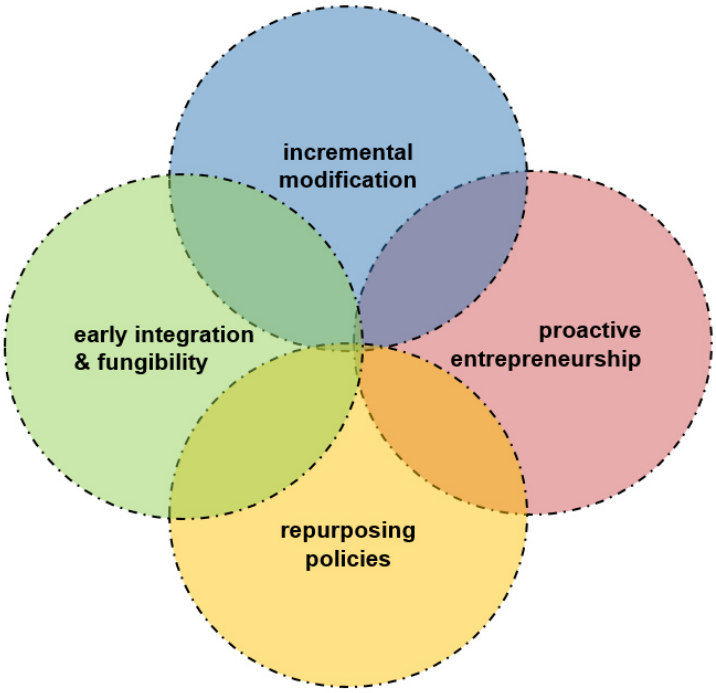


Table 11.2: Three types of integrating CDR into climate policy

	I. Incremental modification	II. Early integration & fungibility	III. Proactive CDR entrepreneurship	IV. Repurposing policies
CDR in mitigation targets	strictly separated	fungible	fungible	fungible
View of CDR among actors of the incumbent regime	restrained integration	proactive integration	proactive integration	pragmatic integration
CDR methods addressed	ecosystem-based only	focus on ecosystem-based	proactive tech-support	ecosystem-based only
Relation of CDR policy instruments to broader climate policy-mix	incremental opening	full integration	specific instruments	full integration
Government support for developing CDR niches	limited support	limited support	nurturing & empowering	limited support

The key finding of the comparative approach is that the integration of carbon removal into climate policy is evolving very differently in different national contexts. While in all cases we have seen CDR climbing up the policy agenda since the emergence of net-zero as a new organizing principle in climate policy, the starting points and the directions of recent initiatives are very different. The results show that in some countries the rise of CDR is much more a continuation of earlier policies than in others. In particular, in countries that are best charac-

terized by ‘early integration and fungibility’, and in countries that are beginning to repurpose existing policies to accelerate sink enhancement, efforts to deliberately remove carbon from the atmosphere are not new to climate policy. Brazil, China, India, as well as Australia and New Zealand have well-established governance structures to consider carbon removal in meeting their climate goals. These countries have CDR policies that address land-based CDR, particularly afforestation, which has been regulated since the beginning of climate change mitigation efforts. Thus, the concept of accounting removals towards climate change mitigation targets is not a new element of climate policy – in stark contrast to how the issue has played out in the European Union. Until recently, supranational climate policy in Brussels only implicitly addressed CDR and had no explicit policy on increasing carbon sinks. Until 2021, the short-term targets set at the EU level for 2030 (or 2020 before that) were gross reduction targets. It was only with the EU Climate Law that the target was changed to one that follows the logic of net emissions, i.e., sinks can contribute – to a limited extent – to the climate target (see chapter 10).

However, it is important to distinguish between CDR methods that aim to improve the LU-LUCF sink and those that rely on CCS or other technologies. While there is a portfolio of different options (Babiker et al., 2022), national climate policy addresses, if at all, the CCS-based options of Bioenergy and Carbon Capture and Storage (BECCS) and Direct Air Capture and Carbon Storage (DACCS). Countries differ significantly in their approach to CCS-based carbon removal. While the US[79] and UK are proactive policy entrepreneurs when it comes to incentivizing these technologies, countries like New Zealand and Australia, which are closer to the type of ‘early integration and full fungibility’ with established LULUCF removal policies, are more reluctant. The EU is an interesting case, as the European Commission is somewhat entrepreneurial in this regard, but so far actual support for research, development and demonstration has been limited to the Innovation Fund. In this context, it should be noted that the CDR policy area is changing rapidly. The case study in Chapter 8, conducted at the end of 2020, showed that Germany can best be described as a country of the ‘incremental modification’ type. However, recent developments indicate that the new government is much more open to the idea of CDR, including CCS-based methods (Schenuit et al., 2022). Finally, it is important to note that in India and China in particular, but not exclusively, CDR and CCU, as well as fossil-based CCS, are often discussed under the umbrella term CCUS (see Chapter 9). One of the main differences is that China and India have much younger coal-fired power plants as potential stranded assets while many high-income countries have already decided to phase out coal-fired power generation from their older coal fleet, which is nearing the end of its lifecycle (Brutschin et al., 2022). Again, we see signifi-

[79] At the time of writing the US case study in chapter 8, the new Inflation Reduction Act was not yet adopted. Another case study written in 2022 documents the new developments in the US, see Smith et al. (forthcoming).

cant differences between the different cases. Not all of them are CDR-specific, some differences are also caused or shaped by the broader political landscape and history of climate policy in these countries – a context that has also shaped the role of the SR15 in these processes.

The role of SR15 in new developments in CDR governance and policymaking

It is clear from the comparative case studies that the role of SR15 varies widely across countries. Three important points can be drawn from the case studies. The first, applicable to all the cases examined here, relates to the proliferation of net-zero targets following the publication of the report. During the first presentation of SR15 after its approval in October 2018, Valerie Masson-Delmotte, co-chair of IPCC Working Group 1, said "if you would like to stabilise global warming to 1.5 °C the key message is that net CO_2 emissions at the global scale must reach zero by 2050 and *that's the most important finding of the report*" (IPCC, 2018c, emphasis added). Since then, more than 100 countries have declared net-zero targets (Net Zero Stocktake, 2021). While the wave of net-zero targets cannot, of course, be attributed solely to SR15, many observers have noted that the publication of the report and its central recognition of net-zero targets played a key role (Allen et al., 2022; Mohan et al., 2021; Patt et al., 2022; Net Zero Stocktake, 2021). The different contributions to this work have shown that SR15 was a key element in the process of translating the complex diplomatic consensus language in Article 4 on "balancing emissions and removals" into the shorthand phrase of "net-zero". We have also seen that the new meaning of the net-zero target had an important impact in stimulating the CDR debate – albeit in different ways in different contexts.

In some cases, SR15 – along with growing domestic expertise – has been an important resource and element of justification for including CDR in climate policy. The European Union is a prime example of this. As part of the European Green Deal, the European Commission has acted as a policy entrepreneur on CDR since the publication of the long-term strategy, which played an important role in preparing policy initiatives for 2019 (see Chapter 8). Citing the IPCC, the long-term strategy showed that both land-based and CCS-based technologies are needed to achieve the net-zero target in the EU (European Commission, 2018). This new attention to carbon removals as an element of mitigation strategies also led to a significant shift in the design of climate targets. With the 2021 Climate Law, the EU agreed on a net target for 2030, adopted the net-zero target for 2050, and codified a net-negative target for the period after 2050.

A similar shift can be observed in Germany. In 2018, shortly after the publication of the report, policymakers were initially reluctant to talk about the issue of negative emissions, al-

ways emphasizing the risk of lowering emissions reduction ambition. The Climate Law adopted in 2019 was silent on the issue.[80] However, the revised 2021 Climate Law, includes a separate target for land-based removals (Art. 3), and the government that took office in 2021 is working on a carbon management strategy that includes CCS-based carbon removals (Schenuit et al., 2022). In Germany, too, the debate is now rapidly gaining momentum and the need for CDR to achieve net-zero is recognized by almost all actors, often with direct reference to the report. A recent example is the G7 statement under the German Presidency (G7 Climate, Energy and Environment Ministers, 2022). However, it is important to note that over time and as scientific expertise on CDR increases, actors also refer to many other sources such as national expert panels or modeling efforts. This suggests that the role of the IPCC has been important role in putting the issue on the agenda, but in operationalizing it for national policy making, other sources become more important.[81]

This observation is also supported by the second overarching point: in cases where CDR was already an element of mitigation strategies, SR15 played a much less visible role. The main countries with established governance structures for the inclusion of removals in climate policy are China, India, and Brazil, but also New Zealand and Australia. These countries already had advisory bodies and expert committees, or national expert communities on carbon removals prior to SR15. In general, therefore, the idea of carbon removal was not as new as, for example, in the EU context. In Brazil, for example, afforestation has been an element of mitigation strategies since the beginning of climate policymaking (which, in part, caused the political turmoil in the Kyoto Protocol discussed earlier in section 2.3). Another interesting example is New Zealand, where carbon removals from afforestation are already part of the national emissions trading system. It is therefore not surprising that the overarching message of SR15 that removals will be required has received less attention in these countries. However, there are, two caveats to this statement. First, there might be additional reasons why the Special Report did not play an important role in these countries that are not related to CDR as a policy issue. For example, Jasanoff's work on “civic epistemologies” (2005), or Renn’s “style[s] of using scientific expertise” (Renn, 1995), offer instructive insights into the ways in which the interfaces between science and policy in general can vary from country to country (see also Beck, 2012 for an instructive case study on Germany). Given the

[80] In addition to official documents analyzed for the case study in chapter 6, this observation was also made during interviews with four Members of the German Parliament from CDU, SPD, Greens, Liberals and AfD were conducted in late 2018/early 2019 after the publication of the report.

[81] Recent examples for this are EU expert group on carbon removals (https://climate.ec.europa.eu/news-your-voice/news/commission-looking-experts-advise-carbon-removals-2022-07-06_en), commissioned studies on the monitoring, reporting, and verification (McDonald et al., 2021). In Germany, several organizations have provided expertise in CDR and NGOs and other stakeholders commissioned studies (Böttcher et al., 2021; Prognos, Öko-Institut, Wuppertal-Institut, 2020). In the new long-term strategy submitted to the UNFCCC, the German government refers to national fundings line on CDR and the process of writing a long-term strategy on negative emissions (German Government, 2022).

focus on CDR, a systematic comparison of these more general conceptualizations was beyond the scope of this thesis. However, this type of comparative work would be of great value for future studies on the IPCC; especially in the context of net-zero as a new target design that has been adopted by many countries. The second limitation concerns the portfolio of carbon removal methods. None of the countries has a governance structure in place for CCS-based removals, and the instruments they have established deal only with land-based options.

Third, there is another development related to the net-zero discussion that is also relevant to CDR. Discussions about the timing of net-zero targets following the release of the report have sparked debate in emerging economies about how equity considerations and historical emissions should inform these timelines (Lee et al. 2021; Malyan and Chaturvedi, 2021). India has been the most vocal player in this debate, calling for developed countries to achieve net-zero and net-negative emissions sooner so that developing countries like India have more “carbon space” in mitigation pathways consistent with the Paris targets (Mohan et al. 2021 and Chapter 7). The carbon budgets calculated by the IPCC were one of the key reference points for these claims by India (Malyan and Chaturvedi, 2021). This points to controversial debates and shows that hard-to-abate residual emissions do not only exist in sectors. In the future, we are likely to see a debate and calls for so-called climate leaders counter-balance other countries' emissions.

Overall, these three observations show that there is no clear and definitive answer to the question of how SR15 has influenced CDR policy and governance in the 12 cases. While we see it being used as a key resource in some cases (e.g., European Union, Germany), it is much less relevant in others (e.g., China, India, Brazil, US). Furthermore, the debate over the timing of net-zero demonstrates that the report has been used for very different CDR-related claims. Rather than identifying a uniform impact of SR15, the empirical case studies show that CDR policies are shaped by the national characteristics of climate policies and organized interests for which SR15 is only one possible resource. Moreover, the case studies show that references to SR15 are typically used to make rather general claims about the importance of CDR. When it comes to specific questions of how CDR policy is defined and how it is embedded in the broader governance structures of climate policy, national modeling efforts, advisory bodies, and expert communities appear to be much more relevant knowledge providers. All of these observations demonstrate once again that policy relevance is a relational process: IPCC expertise is not in and of itself policy-relevant but must be *made* policy-relevant. The strategies, mechanisms, and struggles involved in these practices, and how this affects the opening and narrowing of the solution space, are discussed in the following section.

11.2 Mechanisms, strategies and struggles – studying different modes of relevance-making

After presenting the main findings on the two research sub-questions, this section summarizes what the chapters can contribute to answering the overarching research question. It is important to emphasize that these findings are based on work that focuses on SR15 as a specific IPCC product and CDR as a specific topic. Therefore, these results have limited generalizability. To make more general statements about the IPCC as such, these findings would need to be confirmed in future work on other IPCC products and topics. However, by synthesizing the results along the three modes of relevance-making presented earlier, it is possible to make empirically informed statements.

11.2.1 Mechanisms: Policy relevance through procedural embeddedness and provided stages

Throughout this work and the different contributions on SR15 and CDR, the following two key mechanisms have been observed.

The first mechanism captures the embeddedness of SR15 in the climate policy processes of the UNFCCC. The timing of the Talanoa Dialogue at a time of institutional uncertainty in a climate regime in transition, provided visibility to the UNFCCC's SR15 processes. In addition to being embedded in this formal decision, the UNFCCC Secretariat and the COP Chair provided a multiplicity of stages for the IPCC, from the IPCC's own pavilion to speaking engagements in high-level negotiating sessions. In the country case studies, SR15 was not directly embedded in the policy processes related to CDR. However, in the OECD country case studies, it prompted policymakers, non-governmental organizations and think tanks to engage with CDR. In addition, national advisory bodies began to address CDR after the publication of the report. Since then, CDR policy activities have increased significantly, and in some countries the situation has already changed since the case studies were published (e.g., Germany and the United States). No prominent reference to SR15 was found in emerging economies. However, the net-zero target design, which the report helped to disseminate, drew more attention to existing carbon removal policy instruments and some efforts to promote innovation in CCS-based carbon removal.

The second mechanism of relevance-making concerns government engagement in the IPCC processes, both in the review phase and in the approval meeting. Regarding the IPCC in general, these processes have been well studied by STS scholars (De Pryck and Hulme, 2022). Hansson et al. (2021) have examined the review process with respect to BECCS in particular, highlighting some dynamics of how governments engaged in the IPCC review process. In addition to these familiar mechanisms of engagement, chapter 5 has noted the involvement of some governments in funding research explicitly for the assessment report. In

this case, governments engage in knowledge production so that IPCC reports become the subject of public policy before they are actually produced. This involvement of governments in funding research tailored to specific IPCC reports needs to be examined more closely in the future, especially since the IPCC claims to only “assess” the existing literature. Another interface between the IPCC and national governments that has received little attention by IPCC scholarship is the national focal points. Their efforts in providing translations of reports, organizing the national author groups, and disseminating the results have not, to my knowledge, been studied comparatively across different countries. As an important hinge between the processes of the national administration and the IPCC, these actors would deserve more attention in the future.

11.2.2 Strategies: policy relevance through staging and mobilizing

With regard to strategies as a mode of relevance-making, i.e. deliberate efforts to mobilize the IPCC's SR15 to (un)substantiate or (de)legitimize a particular position, three key findings can be summarized from the chapters.

First, in the context of SR15, we observed strategies aimed at staging the IPCC as an “admonisher” to emphasize the urgency of climate action. Some examples of this have been observed in speeches by the UNFCCC Secretariat or the UN Secretary-General at high-level COP events, and by youth activists with their “Unite behind the Sciences” campaign. However, there are other examples of SR15 being used strategically for other purposes: Saudi Arabia's efforts to weaken the role of the report by preventing the “welcome” decision at COP24 was the culmination of a long-standing strategy to use SR15-related processes to challenge the more ambitious 1.5 °C target. It also represents efforts to use weaknesses in the production process to delegitimize the IPCC’s embeddedness in new UNFCCC processes (see chapter 5). India's strategy of calling for more “carbon space” for the carbon budget and asking the historically largest emitters to become net-negative so that net-zero can be achieved in India later (Mohan et al., 2021) was another interesting example of how SR15 has been used strategically to make a more general point about historical emissions and equity in climate change efforts. These examples of a variety of different strategies illustrate once again that IPCC reports are strategically mobilized and put on stage for different, sometimes contradictory, political purposes and can thus direct incongruent expectations towards the IPCC.

Second, SR15 has been an important reference point for strategic efforts to demand and shape policy initiatives related to setting a net-zero goal, and thus indirectly for related new initiatives for CDR. This thesis has illustrated the role that the momentum generated by SR15 has played in translating the diplomatic consensus on the long-term mitigation goal of balancing emissions and removals into the catchy net-zero phrase in the aftermath of the report. Over time, the proliferation of net-zero targets also led to increased attention to the issue of

CDR in all of the cases examined here. The case studies also showed that the influential framing and conceptualization that CDR is needed to counterbalance hard-to-abate residual emissions received more attention in policy circles and was used in new policy initiatives. Completely new policy initiatives were developed, especially in countries that had not previously explicitly addressed removals, suggesting that SR15 emerged as a key reference to justify the need for and legitimacy of including CDR as an issue (see above). In other countries, it led to new attention being paid to already existing policy instruments aimed at enhancing removals.

Finally, relevance-making strategies are also at play in the scientific community. The incentive structures within the scientific community and the structuring effect of IPCC reports in terms of research agendas show that scientists and research institutes have an incentive to conduct IPCC-relevant research, which then raises their profile both in the scientific community and in policy circles once it has been validated by the IPCC (see chapter 7, also Hughes and Paterson, 2017).

11.2.3 Struggles: policy relevance through counter-scripting and interpretation politics

The third mode of establishing relevance refers to struggles over or contestation of IPCC knowledge or the organization as such. Two main types of struggles have been identified in the contributions to this thesis.

The first captures practices of instigating political struggles to perpetuate older political disagreements. The interventions of the small alliance that challenged the mandate of the IPCC during the decision to approve SR15, and the subsequent escalation of the conflict by Saudi Arabia at COP24, are the most prominent examples of this practice of instigating struggles that have a longer history. However, rather than weakening the report, efforts to counter the dominant script only increased the media coverage and attention that the report has attracted.

The second type of struggle highlighted by the chapters relates to definitional and interpretive disagreements related to SR15. The issue of CDR is a prime example in this regard. Definitional politics played out during the drafting of the assessment, and subsequent interpretive struggles shaped the debate in several countries. During the various drafts of the report, the wording of the definition of the link between CDR and emission reductions was constantly changed (for details, see Section 2.3 and for an in-depth analysis of review comments see Hansson et al., 2021). In the aftermath of the report, when interpretation struggles about the need for CDR unfolded, parts of these discussions in expert and policy circles were about whether or not CDR it is a ‘legitimate’ mitigation option or not. However, it is important to emphasize that critical debates about whether or not CDR should be included in the mitigation

toolbox were mostly present to countries that had not yet incorporated LULUCF-based carbon removals in their climate policies. These struggles have been less visible in countries that have engaged in carbon removals earlier. This again points to the relational character and context-specificity of policy relevance, which of course applies to all modes of relevance-making identified in the previous section (see Table 11.3 for an overview).

Table 11.3: Modes of relevance-making and types observed in context of SR15 and CDR

Modes	Mechanisms	Strategies	Struggles
Types	Procedural embeddedness in UNFCCC/SBSTA	Staging the IPCC to (de-)legitimize policy positions or governance structures	Incite political struggles publicly to counter-script embeddedness of SR15; spillover to IPCC processes
	Providing of opportunities for the IPCC at COPs for self-staging	Key resource and reference in the strategic efforts of diffusing net-zero (and indirectly CDR)	Definitional and interpretation politics with regard to what counts as mitigation
	Engagement of governments in IPCC processes (review/approval) and through research funding	Relevance-making in the scientific community and structuring/scheduling effects	

All in all, the summary of findings on mechanisms, strategies and struggles in the production of relevance shows that political relevance as defined in this thesis cannot be produced within the IPCC, but emerges in relational processes within a broader political environment characterized by competing actor groups. In the case of CDR in particular, it is striking that the report played a very different role in the debates in different countries. What these findings on the overarching research question mean for future developments and what contribution the work makes to existing work will be discussed in section 11.5. Before doing so, the limitations of the research design and avenues for future research are reflected upon.

11.3 Limitations of research design and process

The research design chosen for this work has three major limitations. First, the goal of examining how SR15 is used as a resource for CDR-related policy was a moving and rapidly changing target. Since late 2018, when the research process began, the CDR debate in climate policy has fundamentally changed in many countries, as demonstrated by the case

studies. Examining these ongoing processes proved to be the most challenging part of the research process, allowing only a snapshot in time with the risk of being immediately outdated. The most illustrative example is the case of Germany, where data collection began in late 2018 and CDR was actively ignored by policymakers and stakeholders. Less than four years later, the German government acknowledged the need for CCS-based CDR methods and announced a long-term strategy for hard-to-abate residual emissions. While comparing snapshots of the state of CDR governance and policy is a novel contribution to the field, examining the emergence of CDR policy with some temporal distance may reveal insights that have been overlooked in this work.

A second challenge concerns the material available for the SR15 production process. A planned paper on how the CDR-related text in the various drafts of the report came about did not materialize. Initially constrained by the late release of the files of the various drafts as well as the review comments, a comprehensive analysis of CDR across all drafts proved too costly in terms of time and research capacity, and was therefore not feasible without a larger team of researchers. Nevertheless, the material served as a basis for the analysis conducted in this thesis and provided important background for the interviews, document analysis, and case studies. The brief textual comparison included in this thesis reflects the definitional politics within the IPCC (see Table 2.1). The rich source of publicly available material can provide insights into the knowledge politics within the IPCC – also beyond the issue of CDR. It is a valuable source of material that could be used in the future by a larger team of researchers or for technically supported text mining and analysis approaches.

Third, access to IPCC processes was limited. Neither the report production process nor the approval meeting could be observed first hand. The expert interviews, official documents, and background discussions helped to identify key struggles in these processes. But the analysis in chapter 5 would obviously have been improved by access to the approval meeting. In general, for some of the issues raised during the research project, it would have been better to start the research process earlier than 2018, when the report was published. However, as argued throughout the thesis, exploring how the report is used as a resource in different types of struggles after its publication also provided relevant insights into the science-policy-politics interfaces, including into the IPCC's limited control over messaging and limited policy relevance. Based on the observation that the production and performance of the report are inextricably linked, a research project that systematically examines both the production and the subsequent use and mobilization of the report would be a very interesting contribution in the context of the upcoming 7th Assessment Cycle.

11.4 Future research

In the course of working on this dissertation, four main areas of interest for further research have emerged. First, there is a need to further explore the analytical lens of dramaturgical policy analysis. Having conducted two separate studies from this perspective, the question arises as to which of the identified patterns of soft coordination in the UNFCCC and IPCC staging practices are unique to the issue of climate governance. Further elaboration of the terminology and concepts used here would also be worthwhile.

Second, with respect to the IPCC, it would be worthwhile to design research projects that cover both the co-production and co-performance of IPCC products, linking insights on mechanisms, strategies, and struggles of relevance-making from both pre-publication and post-publication perspectives; especially in the context of ongoing negotiations to align IPCC procedures with the Global Stocktake. Given the functional diversification of policy-relevant climate expertise, it would also be worthwhile to expand STS research on the science-policy-politics interfaces by considering other reports such as the UNEP Emissions Gap Report, the Climate Action Tracker, or the Global Carbon Budget, which are generally considered influential but do not have the intergovernmental processes as the IPCC and are less studied.

Third, with respect to the CDR, it will be critical to understand how the definitional and interpretation politics will be addressed in the 7th Assessment Cycle. Of particular interest will be how the CDR-relevant issue of overshoot will be addressed. This debate, which has been largely ignored by policymakers (see chapter 8) and is likely to lead to significant conflict, including over how to address the issue of solar radiation modification. It would therefore be particularly interesting to look at the issue of overshoot from the perspective of bounded policy relevance, and examine where the issue of overshoot is taken up and where it is ignored.

Finally, the fourth area of possible future research concerns the approach of comparing case studies in CDR governance and policymaking. Interesting follow-up work includes refining the analytical framework and the set of idealized types, producing case studies on different groups of countries, and conducting in-depth studies on fewer dimensions of the analytical framework. This would provide more detail on ongoing changes, such as in the landscape of actors and emerging alliances. In chapter 10, initial steps were taken to explore how insights from the case studies could improve IAM modeling in the future. This interdisciplinary collaboration may prove to be an interesting area of research to combine non-quantified knowledge from the case studies with integrated assessment modeling.

11.5 Conclusion: IPCC's bounded relevance in mitigation politics

Since the IPCC was established in 1988, political debates on climate change have evolved considerably. The IPCC has played an important role in these developments as the focal point of the interface between climate science, policy, and politics (De Pryck and Hulme 2022). In the context of a surge of discussions about a more solution-oriented character of the IPCC, scholars have put forward different conceptualizations of the body's role in climate policy: while some describe it as narrowing down the solution space (Beck and Oomen 2021), others describe its self-declared efforts to map the entire solution space as an opportunity to open up debates about possible solutions (Edenhofer and Kowarsch 2015). To determine which conceptualization – narrowing down or opening up – better describes what the IPCC does and what it is used for, this thesis examined the IPCC's policy relevance in practice: Starting with a definition of policy relevance that takes public policy and governance processes seriously, it asked what mechanisms, strategies, and struggles have made the IPCC relevant in collectively binding decisionmaking.

In general, the findings presented in all chapters of this dissertation have shown that the IPCC Special Report on 1.5 °C of Global Warming and the issue of Carbon Dioxide Removal (CDR) provide insightful case studies for examining the practices of relevance-making and the various ways in which IPCC knowledge does or does not shape debates about a particular issue. By combining insights from STS with approaches from political science, this thesis sought to identify ways in which the IPCC's policy relevance can be studied in actual policy-making. Building on the findings of the dramaturgical analyses and comparative case studies conducted, the following concluding remarks aim to link the findings to ongoing debates in STS and climate policy.

I conclude this thesis with the notion of "bounded policy relevance."[82] Building on Hermansen et al. (2021), my work examines three modes of relational practices of relevance-making. The results of this thesis have shown that the IPCC's products cannot be policy relevant in and of themselves; they are *made* policy relevant. The findings demonstrate the importance of the broader political context and actors in how these modes of policy relevance-making unfold in different countries. In a call for greater consideration of these dimensions in future analysis of IPCC's role in science-policy-politics interfaces, the notion of bounded policy relevance aims at shifting attention to first, the agency of actors in making IPCC reports policy relevant and second, the spatiality, i.e., the importance of local context. I will hereinafter explain what I mean by bounded policy relevance by raising three questions which synthesize

[82] Terminology inspired by Herbert Simon's "bounded rationality" (1957). While Simon highlighted the cognitive limitations of decision-makers, the "bounded" here stands for the (varying) political limitations and conditions for IPCC's knowledge to be made relevant in processes of collectively binding decision-making.

key context factors for exploring how IPCC's policy relevance is embedded in the broader political landscape.[83] In the following sections I will elaborate on the questions: Policy relevance (1) of what exactly? (2) Relevance-making by whom and to achieve what goal? (3) Where?

Policy relevance of what?

The research conducted in this thesis has shown that it is important to be specific about the policy relevance *of what exactly*. The IPCC reports address a multitude of different issues and concepts, each of which has its own knowledge politics and/or history in science and actual policymaking. Some examples include the debate over the assumptions in models about solar (Grubb et al., 2021; Pietzcker et al., 2017) or nuclear power (van Sluisveld et al., 2018), or the controversy over figures such as the one illustrating burning embers (Mahony and Hulme, 2012). Each of these issues has its own specificities which need to be taken into account when exploring how IPCC reports become relevant in political debates and processes. It is therefore important to not to stop at studying the policy relevance of, for example, SR15 as such, but to specify which issue or framing is being addressed.

With regard to the issues examined in this thesis, it became clear that the overarching concept of net-zero was taken up in public policies and thus proved to be a policy-relevant element of SR15.[84] Specifically with regard to CDR, it also became clear that the framing "hard-to-abate residual emissions have to be counterbalanced by removals", which is closely linked to the net-zero concept, was taken up in policy and poltics and paved the way for CDR to move up the climate policy agenda. However, the case studies also showed that only this facet of CDR became politically relevant. In contrast, another facet – the overshoot pathways and net negative emissions required in almost all pathways assessed for SR15 – was rarely taken up in public debates or policy processes, with India's call for equity in carbon spaces through negative emissions in the Global North being a prominent exception.

This brief example shows that the IPCC's policy relevance should be understood as "bounded" in the sense that there is selectivity in which topics and which elements of the reports are taken up and made relevant. Thus, when the policy relevance of the IPCC is claimed, ques-

[83] This way of presenting the contextualisation was inspired by the work of Jewell and Cherp (2019) on the key dimensions of relevant context for studying "political feasibility"; they raised the questions: "(a) "Feasibility of what?," (b) "Feasibility when and where?," and (c) "Feasibility for whom?."

[84] As outlined earlier, it should always be noted that this development towards net-zero as a target is a more general development with a history starting well before negotiations in Paris or SR15. The IPCC's SR15 did not invent this, but contributed to popularizing it. The debates about "cumulative emissions" in climate science in the late 2000's (Allen et al., 2009; Meinshausen et al., 2009) were a key contribution to facilitating the rise of net-zero as a concept; for a comprehensive overview by scientist involved in the emergence of the concept of net-zero, see (Allen et al., 2022).

tioned, or investigated, policy makers, IPCC representatives, and STS scholars should always be clear about what exactly they are referring to.

Policy relevance-making by whom and what for?

A second dimension of bounded relevance concerns the question of who is engaged in policy relevance-making and for what reasons. It aims to highlight the agency of actors involved in what Hermansen et al. (2021) describe as the relational processes of relevance-making.

That the IPCC and its products are mobilized for various political purposes has been shown in detail throughout this thesis, including the motives of staging the IPCC as an admonisher to lend scientific authority to the urgency of climate action. However, we have also seen how the SR15 report was challenged during its production and after its release in order to demonstrate the fragility of the governance structures of the new Paris Agreement – a different form of policy relevance-making. A similar trend can be seen for the net-zero target: since the report's adoption, the net-zero target has been supported, promised, and embraced by all sorts of actors, from youth activists to the fossil fuel industry – often with direct reference to the report – but of course on the basis of completely different interests. While this also highlights the ambiguity of the concept of net-zero emissions as such, it is also another example of the IPCC being strategically mobilized by a variety of different actors pursuing very different goals.

With regard to CDR more specifically, the case studies have shown that whether and to what extent SR15 became relevant and was discussed in CDR-related policy processes was shaped by national styles and path dependencies in climate policy, as well as context-specific socio-political preferences. However, it also became apparent that certain actors play a crucial role in mobilizing IPCC knowledge in processes and can use it to further their policy goals. The most notable example of this might be the European Commission, which – despite the fact that GHG removals as part of mitigation strategies have been controversial in the EU since the Kyoto negotiations (Lövbrand, 2009) – has engaged as a 'policy entrepreneur' to enable a shift in target structures and proactive CDR policies (see chapter 10).

Simply claiming that the IPCC's knowledge is policy-relevant is insufficient and hides the political interests involved in it. Therefore, in addition to the question of what exactly is policy-relevant, as described above, it should always be considered who is advocating for the resource to become policy-relevant and for what reasons (Fischer, 1990). Taken together, focusing on the agency of actors in relevance-making processes helps to illuminate scientific expertise as part of political struggles (Kennedy, 2018) and as a currency mobilized by competing groups of actors (Aykut et al., 2019). I have shown in this thesis that these questions of how, by whom, and for what purposes the IPCC is mobilized become even more important

in a performative climate regime in which discursive, symbolic elements (Aykut et al., 2021) and momentum generation are core elements (Rajamani and Bodansky 2019).

Where is the IPCC policy-relevant?

Finally, the thesis has pointed to the spatiality of the IPCC's policy relevance. Inspired by Mahony and Hulme's (2018) notion of epistemic geographies, in conjunction with an understanding of relational processes of relevance-making, this thesis has presented case studies that have demonstrated the need to distinguish between different contexts when claiming or investigating IPCC's policy relevance.

This is particularly relevant in a climate regime that I previously described as a 'detached regime' (see section 2.3), in which local context and politics may be more important to practical decisions about low-carbon transformation than multilateral developments under the Paris Agreement (Victor et al., 2019; Aklin and Mildenberger 2020). The case studies highlight the different roles the SR15 played in different national or supranational policymaking contexts. While SR15 has been influential in legitimizing and disseminating certain concepts in countries that had not previously addressed carbon removal, it has been far less influential in shaping CDR policy in countries that had previously addressed the topic.

A second observation regarding spatialities can be derived from this thesis: Both the in-depth study of the EU and the synthesis of case studies from OECD countries and emerging economies have shown that in a world of net-zero pledges, there is a structuring and relational effect that can be described as *geographies of net-zero* (see chapter 10). We have seen that countries differ in terms of their; (1) climate ambitions, (2) the residual emissions that are deemed difficult to abate given the structure of domestic industries and other sectors, (3) different socio-political preferences, and the degree of existing regulation for different CDR methodologies, and (4) historical emissions. Differentiations across these dimensions are already shaping and are expected to further shape the positions of certain countries on CDR; and should be taken into account when exploring how alliances are forming on this issue.

These considerations of geographies of net-zero show that 'where' is an important dimension in exploring how IPCC's policy relevance is bounded in practice – not only in terms of the local context of climate policy and politics, but also in terms of the relational character of positions in climate politics.

Bounded policy relevance

The three questions outlined above have highlighted how conceptualizing policy relevance as bounded through contexts and the agency of actors can improve the understanding of

what exactly IPCC's policy relevance means in practice. The research conducted in this thesis on IPCC's policy relevance on the specific issue of carbon removal in different countries revealed that the IPCC is not just narrowing down or opening up as such.

Throughout the thesis we have seen that the production and performance of IPCC reports are inextricably linked. IPCC knowledge can be mobilized for very different political causes and whether it has a narrowing down or opening up effect on mitigation policy and politics depends on how the knowledge is being made policy-relevant. While it is indeed crucial to explore biases in knowledge production – e.g., overly optimistic assumptions about carbon removal technologies – it is also important to study what happens to and with this knowledge in practice. Struggles over how to interpret, select, and make IPCC knowledge visible and relevant to public policy are as important for the narrowing down or opening up effect on the solution space as the modeling practices.

If someone claims policy relevance – be it the producer of a given research output or someone who is strategically mobilizing it – more emphasis should be put on the agency and spatiality of these claims and ask: What exactly is made policy-relevant, by whom, and where? I believe that asking these questions would help make political interests in relevance-making transparent, which would not only help to protect the IPCC as a unique organization at the core of science-policy-politics interfaces, but also to unmask vested interests in the current hype about carbon dioxide removal.

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13 Supplementary Material

Additional Publications

Peer-reviewed publications related to the dissertation topic but not part of the cumulative package.

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Chapter 5

Appendix I. Empirical material

Appendix I.I: The IPCC at COPs: Overview of empirical material

a. COP24:

Date	Event	type	Observed in person	Webstram / Document
04.12.2018	SBSTA-IPCC Special Event on SR15	Plenary		http://unfccc-cop24.streamworld.de/videos/sbsta-ipcc-special-event-unpacking-new-scientific-knowledge-and-key-findings-ipcc-special
05.12.2018	IPCC side event: Climate Science Policy	Side-event		Fully transcribed; video available upon request by UNFCCC
06.12.2018	IPCC statements to wrap-up of preparatory phase of Talanoa Dialogue	Plenary		Observation notes; IPCC Chair Lee statement: https://apps.ipcc.ch/outreach/documents/446/1544451297.pdf stream: https://unfccc-videocloud.azurewebsites.net/videos/talanoa-dialogue-wrap-preparatory-phase
06.12.2018	IPCC press conference Press conference on Sixth Assessment cycle products	Press-conference	X	Observation notes; webstream: https://unfccc-videocloud.azurewebsites.net/videos/sixth-assessment-cycle-products
08.12.2018	UNFCCC Executive Secretary and COP 24 President	Press-conference		Stream: https://unfccc-videocloud.azurewebsites.net/videos/unfccc-executive-secretary-and-cop-24-president
10.12.2018	Emerging Science on 1.5 °C: The Impacts between 1.5 °C and 2 °C and the risk of tipping points	German Pavilion	X	Observation notes
10.12.2018	Planetary Boundaries and Global Commons – managing risks and solutions	Side-event	X	Observation notes; video available upon request by UNFCCC
10.12.2018	ICEF and New Scenario Explorer for IPCC SR1.5: Initiatives showing the way towards zero emissions	Side-event	X	Observation notes; video available upon request by UNFCCC
10.12.2018	Union of Concerned Scientist: Why the Science Matters: Integrating Recent Science Reports into the Paris Agreement	Press-conference		Stream: https://unfccc-videocloud.azurewebsites.net/videos/why-science-matters-integrating-recent-science-reports-paris-agreement
11.12.2018	UNEP Emissions Gap Report launch	Side-event	X	Observation notes; Full transcription; ; video available upon request by UNFCCC
11.12.2018	IPCC Chair statement: opening of the political phase of Talanoa Dialogue	Plenary		Statement: https://www.ipcc.ch/site/assets/uploads/2018/12/181211-TD-political.pdf Webstream: https://www.ipcc.ch/site/assets/uploads/2018/12/181211-TD-

				political.pdf
11.12.2018	IPCC Chair statement: High-level segment of COP24	Plenary		Statement: https://www.ipcc.ch/site/assets/uploads/2018/12/181211_statement_high_level.pdf Webstream: https://www.ipcc.ch/site/assets/uploads/2018/12/181211_statement_high_level.pdf
11.12.2018	What if we miss the target (Bug)	Side-event	X	Observation notes
11.12.2018	SBSTA Side Event with UNFCCC, EU, WMO and IPCC climate information for decisionmakers	Side-event	X	Observation notes, fully transcribed; video available upon request by UNFCCC
11.12.2018	The Future of the IPCC	IPCC/WMO Pavilion	X	Observation notes
12.12.2018	Understanding SR1.5 – Chapter 2: Mitigation pathways	IPCC Pavilion	X	Observation notes
12.12.2018	Demystifying negative emissions technologies (EU- Pavillion)	EU Pavilion	X	Observation notes
13.12.2018	How can we meet the 1.5C target and what are the consequences if we don't	EU Pavilion	X	Observation notes
13.12.2018	Oxford, Netzero event Achieving net-zero: metrics and policies aligning with Energy, Industry and Agriculture with 1.5 Degrees	Side-event	X	Observation notes

Pavilion Program: https://apps.ipcc.ch/outreach/aboutevent.php?q=446

COP24 venue map: https://apps.ipcc.ch/outreach/documents/446/1543389575.png

b. COP25

Date	Event	type	Observed in person	Transcript / Webstream
02.12.2019	IPCC Chair statement to ceremonial opening of COP25	Plenary		https://www.ipcc.ch/site/assets/uploads/2019/12/IPCC-Chair-opening-COP25.pdf
02.12.2019	IPCC Statement to the Subsidiary Body for Scientific and Technological Advice (SBSTA), IPCC Secretary, Abdalah Mokssit	Plenary		https://unfccc-videocloud.azurewebsites.net/videos/sbsta-opening-plenary (start: 1:02:10)
03.12.2019	EmissionsGap and NDC Enhancement_	Side-event	X	Observation notes
03.12.2019	AFOLU and the GST	Side-event	X	Observation notes
03.12.2019	Climate science for policy making	Side-event	X	Observation notes
03.12.2019	Bridging the Fossil Fuel Production Gap	Side-event	X	Observation notes
03.12.2019	What makes a good carbon credit	Side-event	X	Observation notes
03.12.2019	Co-Chair participation in Earth Information Day Plenary Session	Plenary		https://unfccc-cop25.streamworld.de/videos/earth-information-day (start: 29:30)
04.12.2019	IPCC press conference	Press-conference	X	Observation notes
04.12.2019	“Science for Policymaking”	Side-event	X	Observation notes; video available upon request by UNFCCC
04.12.2019	SBSTA-IPCC Special Event on SRCCL	Plenary	X	Observation notes; https://unfccc-cop25.streamworld.de/videos/joint-sbsta-ipcc-special-event-special-report-climate-change-and-land-srccl-0
04.12.2019	Negative Emissions: The Emerging Debate	Side-event	X	Observation notes
05.12.2019	From data to policy: unlocking the power of indexes for sustainable development and climate action	EU Pavilion	X	Observation notes
05.12.2019	SBSTA-IPCC Special Event on SROCC	Plenary		https://unfccc-videocloud.azurewebsites.net/videos/joint-sbsta-ipcc-special-event-

				special-report-ocean-and-cryosphere-changing-climate-srocc
06.12.2019	SBSTA scope of next periodic review	negotiations	X	Observation notes
06.12.2019	Unpacking the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate	IPCC Pavilion	X	Observation notes
07.12.2019	Nature Based Solutions for Negative Emissions	Side-event	X	Observation notes; video available upon request by UNFCCC
09.12.2019	Decarbonization of the Economy: Energy System Transformation	IPCC Pavilion	X	Observation notes
09.12.2019	SBSTA SBI Periodic Review	Negotiations	X	Observation notes
10.12.2019	Unite behind science	Side-event	X	Observation notes; webstream https://unfccc-videocloud.azurewebsites.net/videos/unite-behind-science-event-greta-thunberg-and-luisa-neubauer

Pavilion Program: https://apps.ipcc.ch/outreach/aboutevent.php?q=476

COP25 venue map: https://unfccc.int/sites/default/files/resource/Plano%20General%20Recinto%20COP.pdf

Appendix II: Performances, patterns and evidence

Script I: SR15 as policy-relevant but not policy-prescriptive resource for evidence-based climate governance

Performance	Staging	Setting	Actors	Evidence	Pattern
IPCC agreeing on the invitation following the official IPCC process of planning for AR6.	After the invitation by UNFCCC the IPCC included the proposal in the official IPCC procedure of Special Report proposals	Official decisions at IPCC-43 Plenary, Nairobi, Kenya, after a preparatory process of assessing different Special Report proposals	IPCC Plenary	Special Report proposals: (IPCC XLIII/INF. 7 2016); Decision on SR15: IPCC/XLIII-6 see IPCC-43 2016)	Debates about the formal mandate and capacity to provide a report on 1.5 °C
References to the formal mandate like a continuously repeated mantra shaped the debate throughout the whole assessment production process:	Throughout the whole process (agreeing on SR15, scoping, different drafts, approval) references to the official mandate of being policy-relevant but not policy-prescriptive	IPCC Plenaries, SR15 review procedures	IPCC leadership, IPCC authors, expert and government reviewers	Report of IPCC-43 2016; Review comments[85]; for details on approval session see ENB 2018b; see also Hermansen et al. 2021)	Debates about the formal mandate and capacity to provide a report on 1.5 °C
SR15 as a resource to pursue evidence-based policy making under the UNFCCC in the aftermath of the approval	Ritualized interactions between IPCC and UNFCCC bodies, esp. SBSTA, incl. special events providing stages for senior SR15 authors and government delegations to exchange on the report. References to findings in UNFCCC documents esp. Glasgow Climate Pact adopted at COP26	COPs starting with COP24 in Katowice as well as subsequent intersessionals in Bonn. Especially at COP24 dedicated SBSTA-IPCC event "SBSTA–IPCC special event: Unpacking the new scientific knowledge and key findings in the IPCC Special Report on Global Warming of 1.5 °C"	SBSTA, UNFCCC representatives, IPCC leadership, IPCC senior authors, government delegations	COP24 SBSTA-IPCC special event summary report (IPCC 2019b); The Glasgow Climate Pact (COP26 2021); see also overview of IPCC at COP24 and Annex of observed events	Institutionalized cooperation between UNFCCC/SBSTA and IPCC
IPCC's self-description includes reference to the formal mandate "Policy relevance but not policy prescriptiveness", as well as reference to the invitation to provide SR15, highlighted esp. in official negotiation settings under the UNFCCC but also other public appearances.	Standard talking point in by IPCC leadership representatives when talking about especially when the IPCC is brought to stage in UNFCCC official negotiation settings.	COPs starting with COP24 in Katowice, official negotiation settings but also side-events, and other events such as press conferences.	IPCC leadership and authors, UNFCCC; national focal points	Lee speeches at COPs (see overview of material for references); COP24 SBSTA-IPCC special event summary report IPCC 2019b; see also de Pryck 2021	Institutionalized cooperation between UNFCCC/SBSTA and IPCC
IPCC's self-staging in the Pavilion and Outreach events in countries	Joint pavilion with WMO at COPs starting with COP24 provides new stage for the IPCC at COPs and the opportunity to stage its own reports, authors, IPCC	At COP24 rather ad hoc and spartan way at the very end of the venue, at	IPCC leadership, IPCC authors, scien-	For Pavilion programs see hyperlinks provided in Ap-	Self-staging of the IPCC

[85] Review comments are available here: https://www.ipcc.ch/sr15/download/.

	leadership etc.	COP25 it was much more professionally designed and very prominently placed venue that developed into contact and meeting point for IPCC authors, stakeholders and journalists	tists, stakeholders	pendix 1	
Statements by UNFCCC officials and country delegations that refer to the IPCC as the main source of universal knowledge about climate change and resource for evidence-based policy making under the UNFCCC and other political entities	Since COP24 SR15 is being referred in multiple negotiation tracks to as the main source for the state of climate science. The IPCC is brought to stage to justify all kind of political demands and interests different actors have, usually accompanied by cherry-picking of aspects of the report that suit the specific claim.	All kind of settings related to the UNFCCC process; since SR15 was scheduled to inform the Talanoa dialogue many references to the report in this negotiation track, but the performance not limited to this process.	Country delegations, UNFCCC representatives, UN Secretary General	E.g. remarks by UN Sec Gen (Guterres 2019) at the closing of the High-Level Segment of the Talanoa Dialogue, COP24; see Inputs from countries and other actors to Talanoa Platform[86]; see also high-level segment statements at COP24 (e.g. (European Union 2018; India 2018; Marshall Islands 2018; Russia 2018; Turkey 2018)	Institutionalized cooperation between UNFCCC/SBSTA and IPCC
New and professionalized outreach efforts by the IPCC aiming at wider audiences, incl. new social media strategy, in-person meetings about the reports in countries and new efforts to strategic communication of authors plus acessible figures	IPCC's self-staging also in social media as well as outreach events, also tools for authors to communicate the findings of the report in 'their' science and policy communities	Different social media platforms, esp. Twitter and Facebook; in-person outreach events in different countries to inform about key findings of the report; decentralized through providing authors with tools for communication	IPCC secretariat, IPCC authors	See IPCC communication strategy (IPCC 2018); progress reports (IPCC 2019a; 2020; 2021) for social media efforts; reflections by former head of communication Lynn (Lynn and Peeva 2021) Communications handbook for IPCC scientists, (Corner, Shaw, and Clarke 2018); and for an assessment of the efforts (Pidcock et al. 2021)	Self-staging of the IPCC
IPCC as part of a "bouquet of expertise": References to the IPCC as one source of scientific expertise on climate change while also referring to other assessments and reports with different focus.	Bring the IPCC on stage next to efforts and reports such as the Global Carbon Budget, UNEP Emissions Gap Report, Climate Action Tracker as more policy-prescriptive outlets compared to the IPCC assessment reports. Especially at COP24, "parenting" of the IPCC by its founding organizations UNEP and WMO.	Mostly a multitude of COP side events, both official UNFCCC events where the IPCC acts as a co-host, or events where other reports are being launched and references to the IPCC SR15 were included in the presentations.	Scientists, IPCC authors and IPCC leadership, other international organizations (UNEP, WMO)	E.g. side event "Climate Science for Policy" at COP24, UNEP launch Emission Gap report side event (see Appendix 1 on event documentation for more details on web streams, transcripts, observation notes)	Debates about the formal mandate and capacity to provide a report on 1.5 °C
Challenging the prevalent script by	Provoking incidents of counter scripting throughout the	IPCC plenaries, SR15	Saudi-Arabia led	See Hickmann 2018, ENB	Debates about

[86] See https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement/2018-talanoa-dialogue-platforme.

articulating allegations of "policy-based evidence making" throughout the process of producing and disseminating the SR15	process since COP21, throughout the assessment production process, incl. the review phase, approval session, and taking up the report in UNFCCC processes.	production and review process, COP24-COP26, intersessionals	alliance with fluid participation	2018a; 2018b; 2019) Saudi Arabia review comments for SR15; Statements by Saudi Arabia, US and Egypt attached to meeting report of approval session (IPCC-48 2018)	the formal mandate and capacity to provide a report on 1.5 °C

Script II: SR15 as politically contested element of hard politics and soft coordination under the UNFCCC

Performance	Staging	Setting	Actors	Evidence	Pattern
Decision and political compromise on inviting the IPCC to produce a SR on a genuinely political target at COP21	Diplomatic effort and strategy to secure support for PA	UNFCCC, COP21	UNFCCC, signatories	See COP21 2015, 21; Guillemot 2017; Livingston 2018; ENB 2015; Young 2019	SR15 as a subject of political bargaining about 1.5 °C goal
Alignment of publication with UNFCCC time schedule and new representation of IPCC at COPs	Diplomatic effort and strategy to bridge transition phase of implementing the agreement keep up the Paris momentum among signatories and negotiatiors	UNFCCC negotiations; IPCC plenary	UNFCCC, signatories, IPCC Bureau and plenary	See. COP21 2015, 21; IPCC-43 2016; Ourbak 2017; Ourbak and Tubiana 2017; Livingston and Rummukainen 2020b	IPCC processes as venue of performing fragility/stability of PA
Challenging the decision on accepting the invitation in IPCC plenary	Efforts to cause political conflicts in the plenary, resulting in a much longer title of the report with references to sustainable development and poverty eradication	IPCC-43	Saudi Arabia	See ENB 2018a; IPCC-48 2018	IPCC processes as venue of performing fragility/stability of PA
Attempts to use the review process to shape the outcome of the report	Using the different review rounds and discussions in the IPCC plenary to raising questions about the quality of underlying science, knowledge gaps, links to NDCs and IPCC's mandate more generally	IPCC assessment production process	Most outspoken: Saudi Arabia + small alliance	See IPCC Review documents listed, (ref. in Appendix I)	IPCC processes as venue of performing fragility/stability of PA
Forum shopping in IPCC procedures to stage conflict by countries opposing the 1.5 target: In IPCC and UNFCCC procedures	Attempts to questioning the quality of the report further escalated in the approval session: Stir up political conflict, voice substantial disagreement within IPCC approval plenary; incl. challenging its mandate. Also delay/obstruct UNFCCC's acknowledgement of the report and using SR15 as tool to perform political disagreement about the 1.5 °C target and Paris governance structure	IPCC Review process; IPCC-43; IPCC-48; COP24; media reporting	Saudi Arabia + small alliance	See IPCC review comments; (Livingston and Rummukainen 2020a; IPCC-48 2018; Goswami 2018, ENB 2018a; 2018b; 2019)	IPCC processes as venue of performing fragility/stability of PA // SR15 as

	as such				a subject of political bargaining about 1.5 °C goal
SR15 as a key rhetorical device in the diplomatic effort to "keep 1.5 °C alive" under the UNFCCC	Argument put on stage for different considerations: show that the Paris architectures works; AOISIS for new commitment for climate action; developed countries also to limit attention for contentious negotiation items such as loss and damage: acknowledging to have failed on 1.5 °C would alter negotiation dynamics on these issues under UNFCCC	COP24, COP25 and esp. COP26	UNFCCC leadership, COP Presidencies, esp. UK in 2021	See Espinosa 2019; COP26 2021; Forster et al. 2022; UK Government 2021b; 2021a	SR15 as a tool to "keep 1.5 °C alive" politically
Most vulnerable states / ENGOs stressing that since SR15 it is clear what needs to be done to secure survival of most vulnerable people	Referring to SR15 findings and esp. the differences between 2 °C and 1.5 °C to highlight the inequalities, loss and damage, distributional politics inscribed in impacts ongoing climate change	Since COP24 plenaries, but also side-events and other public statements	Organized civil society, delegations from most vulnerable countries	See e.g. Climate Action Network 2018; Young 2019	SR15 as a tool to "keep 1.5 °C alive" politically
Textual operationalization of 1.5 °C and also the balance targets (Art. 4.1) into net-zero by 2050 and deep decarbonisation	Set up a process that helps establishing a common understanding of what targets agreed in PA actually mean	COP24 and COP26	UNFCCC, IPCC, COP Presidency	See COP26 2021 Decision -/CP.26; IV.17 COP26 (final decision); Forster et al. 2022	SR15 as a subject of political bargaining about 1.5 °C goal
Reference to instigate and facilitate ratcheted NDCs during Talanoa Dialogue and pre-COP26	Hold PA signatories together show that the Paris architecture works and reduce insecurity of Paris Agreement as a multilateral framework that was under pressure while big emitters where dropping out	COP24-26	UNFCCC leadershipt	For official decision after Talanoa dialogue, see CP.24 FCCC/CP/2018/1 (UNFCCC 2019a); see also Guterres 2019; Espinosa 2018; 2019; Lee 2018; Ourbak and Tubiana 2017	SR15 as a tool to "keep 1.5 °C alive" politically // IPCC processes as venue of performing fragility/stability of PA

Script III: SR15 as a tool and rhetorical device to feed the momentum for urgency of climate action

Performance	Staging	Setting	Actors	Evidence	Pattern

SR15 as a source for urgency and emergency framings derived from SR15, High-level statements by heads of UNFCCC Espinosa and UN Guterres and country representatives as well as youth activist that link emotional calls for action with facts from the IPCC report (incl. 12-year deadline)	Put new report and IPCC on stage to increase pressure on negotiations through feeding media coverage	COP24, COP25, COP26;	UNFCCC secretariat; FFF, ENGOs, celebrities, prominent scientists in high-level events, side-events etc.	See e.g. Espinosa 2018; Guterres 2019; Climate Action Network 2018; see speech by Rockström and Thunberg at Climate Emergency Event (UNFCCC 2019b; Thunberg 2019)	SR15 as main reference for declarations and framing of climate emergency
Main theme of COP25 "Time for Action" presented with direct links to SR15 (and the other two special report published by the IPCC in 2019)	Visible in the official logo of the COP25 presidency; logo in the shape of a resolving carbon clock,	COP25	COP Presidency	See e.g. Aykut et al. 2020	Derive and spread a new deadline-framing from the report
"Unite behind the science" as a performance practice through sharing large audiences Friday for Future Activists have during COPs with IPCC representatives and scientist.	Event in Climate Action Hub at COP25: deliberate share of extensive attention main activist receive at COPs with scientist	COPs	FFF, media, IPCC scientist	See stream of event "Unite behnd the science organised by Friday for Future acitivist see (Climate Action Hub 2019)	Increase visibility of IPCC and science more generally to substantiate demands for climate action
Unprecedented media coverage, focus on urgency and remaining years	Higher news value; new knowledge about 1.5 °C and its relation to 2 °C	world	Media	See Boykoff and Pearman 2019; IPCC 2019a; Lynn and Peeva 2021; Pidcock et al. 2021	SR15 as main reference for declarations and framing of climate emergency
'Climate Emergency' declarations referring to SR15	References to SR15 in policy documents that state a 'climate emergency	various	World-wide at all political levels	For an overview of declarations, see climateemergency-declaration.org	SR15 as main reference for declarations and framing of climate emergency
Public responses by IPCC authors rejecting the framing of a year-based deadline (12-years left)	Statements in media reporting or opinion pieces that explain why they disagree with the framing. They do not officially represent the IPCC in their statements but their affiliation and role as senior author is being mentioned	media	IPCC senior authors	See e.g. Allen 2019; Woodward, Borenstein, and Yen 2019)	Derive and spread a new deadline-framing from the report
Friday for Future youth protests, around the world and at COP – unite behind the science as a major claim and SR15 as key resource for deriving the claims	At protest around the world one of the key claims. At COPs: including	global	Youth activists	See e.g. Thunberg at Climate Emergency Event at COP25 (UNFCCC 2019b); see also (Marquardt 2020; Boykoff and Pearman 2019); reporting on banning activists from the	Increase visibility of IPCC and science more generally to substantiate

				COP venue (McGrath 2019)	demands for climate action
Use SR15 to shift political attention from 2 °C to 1.5 °C ("every fraction of degree matters")	The differences identified between 1.5 °C and 2 °C identified by the report used as a argument to shift from 2 °C to 1.5 °C	Since the publication of Sr15 and COP24	UNFCCC, civil society, youth activist; AOSIS	See e.g. Roberts 2020; Young 2019; Espinosa 2021; Osaka 2022; Thunberg at Climate Emergency Event at COP25 (UNFCCC 2019b)	SR15 as a subject of political bargaining about 1.5 °C goal

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ANNEX I.II: Survey & Interviewees

Administration	Survey
Administration	Survey
Administration	Survey
Administration	Survey
Author (Coordinating Lead Author)	Survey
Author (WG Co-Chair)	Survey
Journalist	Survey
Journalist	Survey
Journalist	Survey
Journalist	Survey
Journalist	Survey
NGO	Survey
NGO	Survey
Scientist	Survey
Scientist	Survey
Scientist	Survey
Scientist	Survey
Scientist	Survey
Scientist	Survey
Scientist	Survey
Author (Lead Author)	Interview
Administration national	Interview
International Organisation	Interview
Member of Parliament (Bundestag)	Interview
Member of Parliament (Bundestag)	Interview
Member of Parliament (Bundestag)	Interview
Member of Parliament (Bundestag)	Interview
Member of Parliament (Bundestag)	Interview

ANNEX I.III: List of key documents considered in document analysis

IPCC

Communication & Outreach		
Year	**Title**	**Link**
2012	IPCC-35: Communication Strategy	https://www.ipcc.ch/site/assets/uploads/2018/05/IAC_CommunicationStrategy.pdf
2016	IPCC-43: Report Communication and outreach activities	https://www.ipcc.ch/site/assets/uploads/2018/05/100320160938-INF.5_ComsOutreach.pdf
2016	IPCC-43: Report Expert Meeting on Communication, 9-10 February 2016, Oslo, Norway	https://www.ipcc.ch/apps/eventmanager/documents/37/100320160939-INF.6_EM%20ComsOslo.pdf
2016	IPCC-44: COMMUNICATIONS FOR THE SIXTH ASSESSMENT REPORT (AR6)	https://www.ipcc.ch/site/assets/uploads/2018/05/110320161247-Doc.5-ComsAR6.pdf
2016	IPCC-44: COMMUNICATIONS FOR THE SIXTH ASSESSMENT REPORT (AR6) Communications and the scoping processes	https://www.ipcc.ch/site/assets/uploads/2018/04/200920160708-Doc.5-Coms_scop_processes.pdf
2016	IPCC-44: COMMUNICATIONS FOR THE SIXTH ASSESSMENT REPORT (AR6) Review of the IPCC Communications Strategy	https://www.ipcc.ch/site/assets/uploads/2018/04/200920160710-Doc.6-ReviewComsStrat.pdf
2016	IPCC-44: Report Communication and outreach activities	https://www.ipcc.ch/site/assets/uploads/2018/04/200920160713-INF.2-ComsOutActivities.pdf
2017	IPCC-45: Report Communication and outreach activities	https://www.ipcc.ch/site/assets/uploads/2018/04/160220171028-INF1-ComsActivities.pdf
2017	IPCC-46: Progress Report Communication and outreach activities	https://www.ipcc.ch/site/assets/uploads/2018/04/280720171145-INF.-8ProgressComs.pdf
2018	IPCC-47: Progress Report Communication and outreach activities	https://www.ipcc.ch/site/assets/uploads/2018/04/130220180603-INF.7-Coms.pdf
2019	IPCC-49: Progress Report Communication and outreach Activities	https://www.ipcc.ch/site/assets/uploads/2019/01/010520190905-INF.-9Coms.pdf
2020	IPCC-52: Progress Report Communication and outreach Activities	https://www.ipcc.ch/site/assets/uploads/2019/12/240120200407-INF.-2ProgressReportComs.pdf

Decision process on SR15 + approval		
Year	**Title**	**Link**
2016	IPCC-43: Special Reports - Proposed themes for Special Reports during the Sixth Assessment Report (AR6) cycle [IPCC-XLIII/INF. 7]	https://www.ipcc.ch/site/assets/uploads/2018/05/140320160519-INF.7_ThemesSRAR6.pdf
2016	IPCC-43: Special Reports Commentary from the Co-chairs of Working Groups I, II and III on each of the proposals for Special Reports contained in document IPCC-XLIII/INF. 7 [IPCC-XLIII/INF. 8]	https://www.ipcc.ch/site/assets/uploads/2018/05/150320160536-INF.8_ComCochairsSR.pdf

2016	IPCC-43: Special Reports - Commentary from the Co-Chairs of Working Groups I, II and III on clusters of proposals for Special Reports contained in document IPCC-XLIII/INF. 7 [IPCC-XLIII/INF. 9]	https://www.ipcc.ch/site/assets/uploads/2018/05/140320160521-INF.-9_ClusterproposalsSR-1.pdf
2016	IPCC-43: Matters related to the UNFCCC and other international bodies: Follow-up to the 21st Conference of the Parties to the UNFCCC (COP-21)	https://www.ipcc.ch/site/assets/uploads/2018/05/100320160926-INF.4_FollowupCOP21.pdf
2016	IPCC-43: Decision IPCC/XLIII-6. Sixth Assessment Report (AR6) Products. Special Reports	https://www.ipcc.ch/site/assets/uploads/2018/05/p43_decisions.pdf (p.11)
2016	IPCC-44: AR6 Products Outline of the SR15	https://www.ipcc.ch/site/assets/uploads/2018/04/210920161009-Doc.11-Outline1.5.pdf
2018	IPCC-48: Acceptance of the actions taken at the 1st joint session of WG I, II and III, SR15, Approved Summary for Policymakers	https://www.ipcc.ch/site/assets/uploads/2018/12/061120180206-Doc.-5-Approved-Summary-for-Policymakers.pdf
2018	IPCC-48: Report of the 48th session of the IPCC, Incheon	https://www.ipcc.ch/site/assets/uploads/2018/12/final_report_p48.pdf

The different draft versions of the report (first order draft, second order draft, final government draft, draft submitted to IPCC-48) as well as review comments provided by experts and governments are available under this link: https://www.ipcc.ch/sr15/download/

UNFCCC

Year	Title	Link
2015	Decision 1/CP.21 (II.21)	https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf#page=2
2018	Decision 1/CP.24 (IV. 24-29)	https://unfccc.int/sites/default/files/resource/cp24_auv_1cp24_final.pdf
2019	Summary report on the SBSTA–IPCC special event: Unpacking the new scientific knowledge and key findings in the IPCC Special Report on Global Warming of 1.5 °C	https://unfccc.int/sites/default/files/resource/FINAL_Summary%20Report_SR1.5_16May2019.pdf
2019	SBSTA-50: Reflections note by the Chair of the SBSTA	https://unfccc.int/sites/default/files/resource/SBSTA50reflectionsnote.pdf
2019	SBSTA-50: Report of the SBSTA its 50th session, held in Bonn from 17 to 27 June 2019 (VI.C)	https://unfccc.int/sites/default/files/resource/sbsta2019_02E.pdf
2019	COP25: Decision 1/CP.25 (4-6)	https://unfccc.int/sites/default/files/resource/cp2019_13a01E.pdf
2021	COP26: Decision 1/CP.26 (IV. 15-21)	https://unfccc.int/sites/default/files/resource/cp2021_01_adv%20..pdf

ENB

Reports on COPs		
Year	**Title**	**Link**
2015	Paris Climate Change Conference - November 2015 (UNFCCC COP 21)	https://enb.iisd.org/climate/cop21/enb/
2016	Marrakech Climate Change Conference - November 2016 (UNFCCC COP 22)	https://enb.iisd.org/marrakech-climate-change-conference-cop22
2017	Fiji / Bonn Climate Change Conference - November 2017 (UNFCCC COP 23)	https://enb.iisd.org/fiji-bonn-climate-change-conference-cop23
2018	Katowice Climate Change Conference - December 2018 (UNFCCC COP 24)	https://enb.iisd.org/katowice-climate-change-conference-cop24
2019	Chile/Madrid Climate Change Conference - December 2019 (UNFCCC COP 25)	https://enb.iisd.org/chile-madrid-climate-change-conference-cop25
2021	Glasgow Climate Change Conference (UNFCCC COP 26)	https://enb.iisd.org/glasgow-climate-change-conference-cop26

Reports on IPCC sessions		
Year	**Title**	**Link**
2016	43rd Session of the Intergovernmental Panel on Climate Change (IPCC-43)	https://enb.iisd.org/climate/ipcc43
2016	44th Session of the Intergovernmental Panel on Climate Change (IPCC-44)	https://enb.iisd.org/climate/ipcc44
2017	45th Session of the Intergovernmental Panel on Climate Change (IPCC-45)	https://enb.iisd.org/climate/ipcc45
2017	46th Session of the Intergovernmental Panel on Climate Change (IPCC-46)	https://enb.iisd.org/climate/ipcc46
2018	47th Session of the Intergovernmental Panel on Climate Change (IPCC-47)	https://enb.iisd.org/climate/ipcc47
2018	48th Session of the Intergovernmental Panel on Climate Change (IPCC-48)	https://enb.iisd.org/climate/ipcc48
2019	49th Session of the Intergovernmental Panel on Climate Change (IPCC-49)	https://enb.iisd.org/climate/ipcc49
2019	50th Session of the Intergovernmental Panel on Climate Change (IPCC-50)	https://enb.iisd.org/climate/ipcc50
2020	51st Session of the Intergovernmental Panel on Climate Change (IPCC-51)	https://enb.iisd.org/climate/ipcc51
2020	52nd Session of the Intergovernmental Panel on Climate Change (IPCC-52)	https://enb.iisd.org/climate/ipcc52

Chapter 6

1. List of events attended and coded

N.	EVENT	DATE	SESSION	CODED	SEGMENTS
HIGH-LEVEL AND PRESIDENCY EVENTS					
1	Moving Towards the Enhanced Transparency Framework (ETF)	04.12.2019	(13:15-14:45)	X	23
2	Pre-2020 Stocktake – Technical Part	04.12.2019	(15:00-18:00)	X	38
3	Pressing the Record on Climate Action	05.12.2019	(10:00-13:00)	X	32
4	COP 25 Presidency's Open Dialogue between Parties and observer organizations	07.12.2019	(15:00-17:30)		
5	Presidency Open Dialogue on the role of Science	07.12.2019	(15:00-17:30)	X	46
6	Presidency event organized by the Ministry of Finance: Coalition of Ministers of Finance for Climate Action Santiago's Action Plan Launch	09.12.2019	(15:00-18:00)	X	71
7	High level segment	10.12.2019	(09:15-17:00)	X	264
8	Going net-zero	10.12.2019	(15:00-16:00)	X	18
9	High-Level Event on Climate Emergency	11.12.2019	(9:00-10:00)	X	63
10	Pre-2020 Stocktake: High-Level Part	11.12.2019	(10:00-13:00)	X	50
11	Global Climate Action High-level event	11.12.2019	(15:00-17:30)	X	109
12	UN Heads of Organizations Leadership Dialogue: Turning the tide on deforestation	12.12.2019	(11:00-12:15)	X	10
13	Presidency stock-taking plenary	12.12.2019	(12:30-13:25)	X	27
14	Presidency Stocktake	14.12.2019	(9:30-11:00)	X	55
15	Presidency Stocktake	15.12.2019	(00:00-00:20)	X	7
NEGOTIATIONS					
16	SBI/SBSTA informal consultations on report of the Executive Committee of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts and the 2019 review of the Mechanism	03.12.2019	(10:00-11:00)		
17	SBI informal consultations on matters relating to National adaptation plans	03.12.2019	(11:00-12:00)		
18	Koronivia Workshop	03.12.2019	(15:00-18:00)	X	15
19	SBI/SBSTA informal consultations on the scope of the next periodic review of the long-term global goal under the Convention and of overal progress towards achieving it	03.12.2019	(16:00-17:00)	X	15
20	SBI/SBSTA informal consultations on report of the Executive Committee of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts and the 2019 review of the Mechanism	04.12.2019	(10:00-11:00)		
21	SBI informal consultations on matters relating to provision of financial and technical support	04.12.2019	(12:00-13:00)		
22	SBI informal consultations on matters relating to National adaptation plans	04.12.2019	(15:00-16:00)		
23	SBI/SBSTA informal consultations on report of the Executive Committee of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts and the 2019 review of the Mechanism	04.12.2019	(17:00-18:00)		

24	SBI/SBSTA informal consultations on the scope of the next periodic review of the long-term global goal under the Convention and of overall progress towards achieving it	05.12.2019	(11:10-12:00)	X	33
25	SBI/SBSTA informal consultations on report of the Executive Committee of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts and the 2019 review of the Mechanism	05.12.2019	(12:00-13:00)		
26	SBSTA informal consultations on matters relating to Article 6 of the Paris Agreement	05.12.2019	(15:00-16:00)		
27	SBI/SBSTA informal consultations on report of the Adaptation Committee	05.12.2019	(16:00-17:00)		
28	SBSTA informal consultations on CTF for tracking progress in implementing and achieving NDCs under Article 4 of the Paris Agreement (discussion without pre-empting decisions on Art.6)	05.12.2019	(16:00-17:00)	X	54
29	SBSTA contact group on methodological issues under the Paris Agreement	05.12.2019	(17:00-18:00)		
30	SBSTA informal consultations on matters relating to Article 6 of the Paris Agreement	06.12.2019	(10:00-11:00)		
31	SBI informal consultations on matters relating to National adaptation plans	06.12.2019	(11:00-12:00)		
32	SBSTA informal consultations, Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention	06.12.2019	(12:00-13:00)	X	11
33	SBI/SBSTA informal consultations on the scope of the next periodic review of the long-term global goal under the Convention and of overall progress towards achieving it	06.12.2019	(15:00-16:00)	X	30
34	SBI/SBSTA informal consultations on report of the Executive Committee of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts and the 2019 review of the Mechanism	06.12.2019	(16:00-17:00)		
35	SBI informal consultations on matters relating to National adaptation plans	07.12.2019	(10:00-10:30)		
36	SBI/SBSTA informal consultations on report of the Adaptation Committee	07.12.2019	(11:00-12:00)		
37	SBI/SBSTA informal consultations on report of the Executive Committee of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts and the 2019 review of the Mechanism	07.12.2019	(12:00-13:00)		
38	SBSTA informal consultations on CTF for tracking progress in implementing and achieving NDCs under Article 4 of the Paris Agreement (discussion without pre-empting decisions on Art.6)	07.12.2019	(12:00-13:00)	X	11
39	SBI/SBSTA informal consultations on report of the Executive Committee of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts and the 2019 review of the Mechanism	07.12.2019	(12:00-13:00)		
40	Open ended, informal consultations with the Presidency on COP agenda items 2(b) Adoption of the rules of procedure, 14 (b) Consideration of proposals by Parties for amendment to the Convention under Art. 15, Proposal from Papua New Guinea and Mexico to amend Articles 7 and 18 of the Convention, and 16 (d) Decision-making in the UNFCCC process	07.12.2019	(14:30-15:30)		

41	SBI/SBSTA informal consultations on the scope of the next periodic review of the long-term global goal under the Convention and of overal progress towards achieving it (Fourth informals)	07.12.2019	(16:00-17:00)	X	2
42	SBI/SBSTA informal consultations on the scope of the next periodic review of the long-term global goal under the Convention and of overal progress towards achieving it	07.12.2019	(16:00-17:00)	X	28
43	SBI/SBSTA informal consultations on report of the Executive Committee of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts and the 2019 review of the Mechanism	07.12.2019	(18:00-19:00)		
44	SBSTA informal consultations on matters relating to Article 6 of the Paris Agreement	09.12.2019	(10:00-12:00)		
45	SBI/SBSTA informal consultations on the scope of the next periodic review of the long-term global goal under the Convention and of overall progress towards achieving it	09.12.2019	(12:00-13:00)	X	28
46	Multilateral Assessment working group Part II	09.12.2019	(15:00-17:00)	X	12
47	Technical drafting group on WIM	12.12.2019	(9:00-13:30)		
48	Presidency consultations on COP Agenda Item 13 gender and climate change	12.12.2019	(16:30-17:00)		
PLENARY MEETINGS					
49	Ceremonial opening of the COP	02.12.2019	(10:30-11:30)	X	33
50	SBI first plenary meeting	02.12.2019	(15:00-16:00)	X	8
51	SBSTA first plenary meeting	02.12.2019	(18:15-18:40)		
52	Joint first plenary meeting of COP, CMP, CMA, SBSTA and SBI to take up statements from Member States	02.12.2019	(18:40-21:00)	X	31
53	SBI Closing Plenary	09.12.2019	(20:00-21:00)	X	15
54	SBSTA Closing Plenary	09.12.2019	(22:30-23:30)	X	12
55	COP/CMP/CMA closing plenary, part 1.	12.12.2019	(18:00-20:00)	X	17
SIDE EVENTS					
56	Sustainable and resilient cities roundtable	02.12.2019	(12:30-14:00)		
57	The role of CDM in decarbonizing cities and its co-benefits	02.12.2019	(13:15-14:45)	X	10
58	Global climate action: indigenous rights, territories and resources	02.12.2019	(13:15-14:45)		
59	Forest and landscape restauration	02.12.2019	(17:13-17:45)		
60	El camino hacía una ciudad sostenible y resiliente al cambio climático	03.12.2019	(10:00-11:30)		
61	Finance fit for Paris (3fP). Enabling transformation by financial regulation. A global perspective	03.12.2019	(13:15-14:45)	X	36
62	Raising ambition for climate action in Latin America through transformation of food systems	03.12.2019	(13:15-14:45)		
63	Building an inclusive Global Stocktake: Independent and trans-parent assessments for greater ambition	03.12.2019	(16:45-18:15)	X	36
64	Research and independent non-governmental organizations (RINGO) meeting	04.12.2019	(09:00-10:00)		
65	Carbon Neutral Transitions and Standards as a Measure, Reduce, Compensate Toolkit	04.12.2019	(11:30-13:00)	X	19
66	Science for Policy-Making	04.12.2019	(13:15-14:45)		
67	Negative Emissions: The Emerging Debate	04.12.2019	(18:30-20:00)	X	18
68	Satellites in support of national Green House Gas (GHG) report-ing and Global Stocktake.	06.12.2019	(11:30-13:00)	X	31

69	Negative Emissions Dialogue in Enabling Frameworks	06.12.2019	(14:00-15:00)		
70	Laying down the foundations of an inclusive Global Stocktake. Independent data, transparency and Analysis.	06.12.2019	(14:30-16:00)	X	14
71	Marrakech Partnership for Global Climate Action Energy	07.12.2019	(10:00-13:00)	X	28
72	Nature Based Solutions for Negative Emissions, Global Tree Potential and Landscape Restoration	07.12.2019	(11:30-13:00)	X	11
73	Rally for Natural Climate Solutions	07.12.2019	(14:00-14:45)	X	28
74	Climate Justice and Law in a Climate Emergency	07.12.2019	(15:00-16:30)		
75	Decarbonization of the economy: energy system transformation	09.12.2019	(09:30-11:00)		
76	Global Covenant of Mayors Day	09.12.2019	(09:30-18:00)		
77	From NDCs to Climate Emergency – multilevel and collaborative action accelerating global ambition	09.12.2019	(10:30-13:00)	X	50
78	Approaching the Shift of Financial Flows per Article 2.1.c of the Paris Agreement	09.12.2019	(11:00-11:45)	X	12
79	Business Ambition for 1.5 °C and a Just Transition to a Net-Zero Emissions Economy	09.12.2019	(12:00-12:45)	X	43
80	Ambition and action for 1.5 degrees: non-Party stakeholders and Paris Agreement implementation	09.12.2019	(13:15-14:45)	X	34
81	Enhancing the engagement of the private sector in adaptation planning and implementation	09.12.2019	(13:15-14:45)	X	9
82	Climate Change Adaptation and Risk Management in a Multi-Level Governance Context	09.12.2019	(15:00-16:30)		
83	Subnational Strategies in North America for Meeting the Paris Agreement.	09.12.2019	(16:45-18:15)		
84	One UN for Climate Compatible Cities: City Climate Action! Activating the potential of settlements for low-carbon-carbon resilient nations.	09.12.2019	(18:30-20:00)	X	5
85	The Investor Agenda: Investors, companies and Governments stepping up climate ambition for 2020	09.12.2019	(18:30-20:00)	X	73
86	Results of the coal commission in Germany. A Blueprint for participation of civil society?	10.12.2019	(12:30-13:45)		
87	The Emissions Gap Report 2019: Key Findings and Ways Forward	10.12.2019	(13:15-14:45)	X	26
88	Press Briefing of the High Ambition Coalition	10.12.2019	(17:00-17:30)		
89	UN Global Climate Action Award Ceremony	10.12.2019	(18:00-20:00)	X	25
90	From Climate Neutral to Climate Positive	11.12.2019	(12:00-12:45)	X	5
91	Technology Needs Assessments linkages with Nationally Determined Contributions	11.12.2019	(13:15-14:45)		
92	How to align financial markets with the Paris Agreement towards 1.5 °C	11.12.2019	(16:45-18:15)		
93	Fridays for Future: Final press conference	13.12.2019	(14:00-14:30)	X	28
	Total amount of segments coded				1709
	Total amount of events coded				52

2. Common Observation Matrix: Example for a CLIMACOP sheet

Researcher: Stefan Aykut

Date / Time: 03.12.2019 (13:15-14:45)

Event Title / ***Agenda***: Finance fit for Paris (3fP) – enabling transformation by financial regulation. A global perspective.

Abstract/ Objectives*:*

Tuesday, 03 Dec 2019	13:15 - 14:45 Room 5	**Organization 1** Mr. Speaker e-mail Phone Number **Organization 2** Mrs Representative e-mail **Phone Number**	**Finance fit for Paris (3fP) – enabling transformation by financial regulation A global perspective** Financial regulation can support the Paris goals through shifting billions toward a low-carbon and climate-resilient economy. The 3fP – Tracker tool provides transparency across jurisdictions, and helps define the global knowledge frontier, including for non-state actors. **Speakers:** [List of Panelists and organizations]

Organizers: I4CE, Frankfurt School of Finance and Management

Type of event (negotiations / high-level event, side event, etc.): side event

Number & type of participants (men/women, negotiators or NGOs, etc.): room half-empty, diverse public, mostly formal

General atmosphere (cordial, tense, focused): cordial

Photo:

3. Codebook

Code System

1 Practice	Number of segments coded
1.1 Scripting	368
1.2 Staging	384
2 Roles	
2.1 Admonisher	286
2.2 Accountant	312
2.3 Animator	346

We only coded scripting and staging, because performing was ubiquitous at COP25 and coding this would have provided little additional information. Simultaneously, setting happens in the background before the COP convenes. Coding was conducted in two rounds. Researchers first coded documents that others had produced. Each author then checked the coding of their own documents.

1 Practice

1.1 Scripting

The code is applied when an actor addresses rules which are to be set up or specified, or cites existing rules and norms which the new contents ought to oblige to.

Example for scripting accounting topics:
Scripting concerns discussions on *what* should be accounted for, *how* it should be accounted for, on *what* the role of accountant is and *how* it should be enacted, such as: “the report should include information on emissions from high intensity farming, for which parties should collect data on both carbon dioxide and methane emissions”.

1.2 Staging

The code is applied when an actor refers to statements or actions of another actor or source of information, thereby bringing it "to the stage".

If this code applies, attach a comment refering to both actors: *citing/staging actor --> cited/staged actor*

Example for scripting accounting topics:
Staging concerns displays of (best) practices of accounting and of examples of accountants, such as: “*NGO X* has provided great insights by using *method Y* to calculate the carbon emissions from swamplands”.

2 Roles

2.1 Admonisher

The code is applied when an actor stresses the time pressure which parties face to solve the climate crisis or the remaining effort still to be undertaken. It is not applied when this pressure is conjured for the negotiations at the COP themselves.

Examples from the semantic universe: urgency, threat, concern, irreversible, gap, clock ticking, time, ambition (*depending on context*), compliance (*depending on context*)

2.2 Accountant

The code is applied when an actor addresses which information is to be collected/factored in for reports and might serve as a basis for further decision making.

Examples from the semantic universe: (ac)counting, report(ing), communicate, registry, transparency, taking stock

2.3 Animator

The code is applied when an actor highlights the feasibility of the measures needed to cope with climate change, including the chances which might arise from the endeavor.

Examples from the semantic universe: good practices, co-benefits, cooperative action, opportunities, enabling, voluntary, facilitative, progress, key

3 Combination of Practices and Roles

1 Scripting	Number of segments coded	Share of codes compared to text corpus
1.1 Admonisher	54	8%
1.2 Accountant	178	25%
1.3 Animator	103	15%
2 Staging		
2.1 Admonisher	112	16%
2.2 Accountant	54	8%
2.3 Animator	199	28%

Chapter 9

Brazil

LULUCF-based CDR

Level of CDR regulation	+	0	-	Note
Implicit accounting	+			Forest part of climate policy since the beginning [A.1-3, B.2]
R&D-related incentives	+			Research is, inter alia, part of programs ABC+ and Floresta+ [C.1]
Enabling regulation	+			CDR-relevant (but not specific) policy instruments and reporting schemes in place [A.1-3; C.1]
Deployment incentives	+			Financial CDR-relevant (but not specific) incentive structures are established [C.1]
Regulated CDR mandates		0		Discussion about the 12 million ha reforestation target [B.1]
Explicit removal target			-	No quantified removal target established
Fully-fledged carbon pricing			-	No fully-fledged carbon pricing with regard to removals

CCS-based CDR

Level of CDR regulation	+	0	-	Note
Implicit accounting	+			2025 and 2030 targets are net emissions reduction targets [B.1]
R&D-related incentives		0		Emerging discussions about BECCS under RenovaBio, not established yet [C.1]
Enabling regulation			-	No regulatory framework in place for CCS in Brazil [C.1]
Deployment incentives			-	Emerging discussions about incentives for BECCS under RenovaBio, not established yet [C.1]
Regulated CDR mandates			-	CCS-based CDR not part of climate policymaking
Explicit removal target			-	CCS-based CDR not part of climate policymaking
Fully-fledged carbon pricing			-	CCS-based CDR not part of climate policymaking

LULUCF-based CDR

Level of niche innovation	+	0	-	Note
R&D	+			Well established research community and support [E.1]
Demonstration projects	+			Many projects from demonstration to large-scale [B.3; C.1; E.1]
Scale-up projects	+			Many projects from demonstration to large-scale [B.3; C.1; E.1]
Voluntary/ niche-markets	+			CDR-relevant (but not specific) voluntary markets well established, supported by government [E.1-2]
Demand-pull		0		CDR-relevant (but not specific) demand-pull exists, but still incipient [E.3]

CCS-based CDR

Level of niche innovation	+	0	-	Note
R&D		0		Only CCS by some companies in the fossil fuel sector [E.1]
Demonstration projects		0		Only CCS by some companies in the fossil fuel sector [E.1]
Scale-up projects			-	No scale-up efforts identified
Voluntary/niche-markets			-	No voluntary/niche-markets identified
Demand-pull			-	No demand-pull, only conceptual expert debate on high numbers in global mitigation pathways

A. Institutional setting, actors and coalitions	Brazil
A.1 Overall institutional and political setting in climate policy	- **Brazil is perceived as a key actor in climate governance since the early days of multilateral climate governance, (Franchini/Viola 2019).** This has to do with both the risks for climate through deforestation but also the mitigation potentials of afforestation and reforestation (Rochedo et al. 2018). - **The climate change debate in Brazil, since its very beginning in the 1990s, always included the role of forests** since forest loss is a big part of Brazil's GHG emissions (Silva Junior et al. 2021; Schaeffer and Vianna Rodrigues 2005). - **CDR entered the national debate in the process of creating the Brazilian climate change policy** (Schaeffer and Vianna Rodrigues 2005). The Brazilian policy on Climate Change law, 12187/2009, and its regulation decree n 7390/2010 (replaced by decree n 9.578/2018) included CDR actions in its targets. For example, with its compromise to recover 15 million hectares of degraded pasture, to expand 4 million hectares of crop-livestock-forestry integrated systems, to expand 3 million hectares of planted forest area. - **The vast Brazilian tropical territory is often included in the national climate change debate**. Many in the country see the AFOLU sector as Brazil's "silver bullet" to compensate for hard-to-abate emissions (for modelling of net zero pathways in Brazil see e.g. (Köberle et al. 2020).
A.2 Macro-political developments in international climate governance	- **Brazil was very active and key player during UNFCCC negotiations that have links to CDR,** especially with regard to the *Reducing emissions from deforestation and forest degradation* (REDD+) and *Clean Development Mechanism* (CDM) under the Kyoto Protocol (Friberg 2009; Lederer 2011) and Article 6 of the Paris Agreement (Schneider et al. 2019).
A. 3 Actors and coalitions in CDR-related climate policymaking	- **Afforestation, reforestation and land use have been historically perceived as very sensitive topics by the government**, given the traditional high rates of deforestation in the country since the 1970s, in particular, in the Amazon region (Silva Junior et al. 2021; Schaeffer and Vianna Rodrigues 2005). - **Additionally, the agriculture and livestock sector is essential for the national economy** and Brazil presents a considerable potential to remove carbon while recovering degraded pasture, therefore, the Brazilian government has pushed the nature-based CDR issue into the domestic climate policy debate since the very beginning (see below). - **Brazil also has a long history of biofuels production and use and actors in this sector are relevant for climate policymaking.** There is a growing debate being held by academics in the country on the possibility of deploying BECCS at scale in the national context, although this discussion has not acquired a high level of importance at policy level yet (Silveira, Costa, and Dos Santos 2022; Moreira et al. 2016).

B. CDR accounting and set of methods	Brazil
B.1 Climate target and role for CDR (domestic and NDC)	- **Climate neutrality target in 2050**. Without specifying the amount of carbon removal that will be needed (Brazilian Government 2022a). While the previous version of the NDC included a quantified target for restoring 12 million ha of forests, the new version does not provide such specification (Romeiro, Genin, and Felin 2021; Unterstell and Martins 2022). - **2025 and 2030 targets in the NDC are defined as net emissions reduction targets** (Brazilian Government 2022a) - **The BPCC law, 12187/2009, and its regulation decree n 7390/2010** (replaced by decree n 9.578/2018)**, included CDR-related actions in their targets.** For example, with the inclusion of the recovery of 15 million hectares of degraded pasture, the expansion of 4 million hectares of crop-livestock-forestry integrated systems, and the expansion of 3 million hectares of planted forest area.
B.2 Accounting practices of CDR toward target	- **GHG removals due to change in land use/cover and timber forest products are estimated based on IPCC's methodologies**. There is no clear delimitation of maximum potential for carbon sinks within national targets. - **In 2022 the Brazilian government issued decree n 11075 to establish a National System for Greenhouse Gas Emission Reduction** (Sinare) which purpose is to serve

	as a single center for recording greenhouse gas emissions, removals, reductions and offsets, and where certified emission reduction credits should be trade, transfer, transactioned and retirement. (Brazilian Government 2022c).
B.3 Methods addressed and differences in accounting	- **LULUCF-based removals are the most prominent group of CDR methods in Brazil and already part of established governance structures (see below) and can be accounted as mitigation**. The national report to the UNFCCC accounts for removals in the LULUCF sector, and therefore could help to achieve climate mitigation targets. - **A discussion of BECCS is emerging** (Silva Junior et al. 2021). Other CDR methods (e.g. DACCS) are being considered in domestically modelled mitigation scenarios (Baptista et al., 2022).
B.4 Grouping/separation and framings of different methods	- **LULUCF-based CDR methods** (afforestation, reforestation, pasture recovery, integrated agricultural systems) are the main focus of the climate debate and already addressed in climate policy - **BECCS, DACCS and even the basalt enhanced weathering potential**, for example, are mostly restricted to academic exercises in the country (e.g. Beerling et al. 2018, Oliveira et al. 2019).
B.5 Socio-political prioritization of different methods	- **LULUCF-based methods are widely accepted method of climate mitigation;** it is part of climate policy from the beginning (see above) - **In the case of BECCS, government and actor from relevant sectors (esp. ethanol) are generally in favour** (Meneghini and dos Santos 2022)**, social movements are generally against options that drive competition for land** (WRI Brasil 2019)**.** The debate on CCS-based CDR methods has not yet reached the general public.

C. Policy instruments	**Brazil**
C.1 Policy approach (type of instrument)	- **Several policy instruments exist that are of relevance for LULUCF-based CDR.** While not dedicated or introduced to regulate CDR explicitly but for environmental services more generally (see e.g. Dockendorff et al. 2022), governance structures establish incentives for enhancing the LULUCF sink. It is important to note, however, that efforts to achieve the previously announced reforestation targets have been halted from 2019 onwards, and will depend on future government support - The natural vegetation protection law is an important legislation. It regulates land use and management on private properties in Brazil. Although it was not initially thought as a climate policy the updated version of the law (12651) includes the carbon credit terminology. The law requires landowners to maintain a part of their properties as natural vegetation cover (% depends on biome) and "permanently protected areas" important for ecosystem services provision, such as, prevention of soil erosion and conservation of water resources (including buffer areas around springs and rivers, hilltops, and areas with steep slopes). "Permanently protected areas" deficit should be restored and could be important for CDR. - The *ABC + program* (Low-carbon Agriculture Program) that aims to promote sustainable agriculture through strategies of adaptation and mitigation of greenhouse gas emissions; at developing revenue streams for ecosystem services (mainly related to low-carbon farming techniques but with some forest replanting) by farmers linked to instruments for trading carbon credits - Brazil has a long history of forest protection programs, including PPCDam (West and Fearnside 2021) and the Amazon Fund (Correa, van der Hoff, and Rajão 2019), both frozen by the Bolsonaro administration. The current government discontinued both programs and created the *Floresta+,* voluntary payment program aiming to increase the payments for environmental services related to forest conservation and restoration; Floresta+ Carbono (Ordinance No. 518) aims at supporting voluntary carbon markets and to avoid double counting - National Plan for Native Vegetation Recovery (PLANAVEG) that aims to articulate, integrate and promote policies, programs and actions that induce the recovery of forests and other forms of native vegetation; and to promote the environmental regularization of Brazilian rural properties, under the terms of Law No. 12,651, in a total area of at least twelve million hectares, until December 31, 2030 (Brazilian Government, 2017). - In consequence, many restauration programs exist. Recently, the BNDES has launched the "Floresta Viva program", a joint initiative for ecological restoration of Brazilian biomes. - **CCS-based:** As of today, there is no regulatory framework in place for carbon capture and storage in Brazil. it is important to define who will be the actors responsible for each stage and how they will be regulated. - National Alcohol Program (Proalcool), the Biodiesel National Program (PNPB), and the RenovaBio Program, all encourage the production and use of biofu-

	els. RenovaBio is the National Biofuels Policy (Law No. 13,576/2017). In the context of the RenovaBio program experts see a trajectory for establishing incentives for BECCS, it is, however, early in the debate. - **New initiatives to provide monitoring and reporting of removals,** on the on hand the National System for Greenhouse Gas Emission Reduction (Brazilian Government 2022c) and see above under accounting).
C.2 Timing (sequential, immediately, long-term)	- LULUCF-based already implemented (see above) - CCS-based will come later, not decided yet (see above)
C.3 Major political struggles in public policy processes	- **Forest related NGOs typically criticize LULUCF-based CDR options as compensation policies that have the potential to undermine climate ambition**. In general, they argue LULUCF-based CDR deployment should not be seen as a justification for continue GHG emissions, but as a necessary condition to achieve climate targets and reach important sources of international funding. - **The biofuels and BECCS debate is closely associated with the agriculture sector, which is a very conservative and influential sector with strong path-dependencies in the country**. As such, it is very likely the sector will also need to be "convinced" to invest in BECCS in Brazil. - **More generally, deforestation is on the rise in Brazil (Silva Junior et al. 2021), reducing the net removals of the AFOLU sector in Brazil.** A shift in socio-political prioritization, e.g. trough a new government, LULUCF-based CDR could get new support and enhance the sink capacity (Soterroni et al. 2018)
C.4 Relations to other policy instruments/targets (discursively/ politically/legally)	- **In general CDR is – other than in some OECD countries discussed as part of a portfolio of mitigation options,** complementary to other more traditional mitigation options (Rochedo et al. 2018). - For specific links to other instruments, see above.

D. Expert bodies and science	**Brazil**
D.1 Role of expert bodies and science more generally (incl. national modelling)	- **National experts linked to numerous public and private institutions, such as universities, research institutes, government bodies and NGOs have been quite active in the climate policy debate and decision-making processes,** also playing important roles in the development of Brazil's national communications to the UNFCCC. - **Domestic modelling exercises have demonstrated the importance of including CDR practices and technologies to achieve "climate neutrality" in 2050** (Köberle et al. 2022; Baptista et al. 2022; Rochedo et al. 2018). The BLUES integrated assessment model, for example, includes 473 MtCO2/year of CDR in one of its 1.5 scenarios in 2050, mostly related to reforestation and BECCS (434 MtCO2/year), while one of its NDC scenario draws 153 MtCO2/year in 2050, 112 MtCO2/year of which are BECCS.
D.2 role of IPCC reports in shaping the debate	- **The UNFCCC and the IPCC have historically played important roles in the discussion of the potential for CDR development and deployment in the country,** as Brazil has always included GHG removals due to change in land use/cover and timber forest products based on the IPCC (2006) methodology in its national communications to the UNFCCC. Brazil has always considered the role of conservation units and indigenous lands units to estimate GHG removals of managed land, in accordance with IPCC guidelines.

E. Development in CDR niches	**Brazil**

E.1
Developments in "protective spaces" that shield, nurture, empower
	- **International voluntary emissions compensation schemes that include LULUCF-based CDR such as afforestation/reforestation are well established** in Brazil and encouraged by the Government (see e.g. Floresta+ CARBONO above). In addition to efforts of strengthening carbon sink trading, the government also supports efforts to establish new MRV infrastructure (see National System for Greenhouse Gas Emission Reduction (Brazilian Government 2022c) and see above under accounting) and a new initiative PronaSolos aiming at gathering soil data (Brazilian Government 2022b). In general, a large scientific community on issues related to environmental services, incl. CDR (Ferreira et al. 2014).
	- **There is limited progress on CCS-based CDR**, some discussion about BECCS as part of the RenovaBio program but except for that regulation is missing. For CCS, as a component of CDR methods, there is some R&D ongoing,
	  - The coal industry in the State of Santa Catarina has a research institution (SATC) working in the perspective of understanding and investing in CCS as a way for the industry to survive in the longer term. SACT already has a pilot CCS plant and is developing and researching the technology in the south of the country.
	  - Brazil does not have public access to data on deep saline aquifers, even though Petrobras has drilled hundreds of points in Brazil. This information is not publicly available in the country. Thus, the first CCS project in Brazil with face large difficulties.
	  - Petrobras has a Natural Gas Processing plant in the Santos Basin Pre-Salt Oil Field with CCS that has been operational since 2011 for Enhanced Oil Recovery, with a capture capacity of 4.6 Mtpa CO2. (Global CCS Institute, 2022)
	–
	- Biochar research was triggered by the discovery of anthropogenic dark earths (terra-preta) from indigenous pre-Columbian communities in Brazil. Biochar is being used in agriculture in different scales, including to understand how its use affect pasture recovery (Latawiec et al., 2019)

E.2 Emerging business cases	- **Voluntary carbon markets are established as a revenue stream and supported by government actions**. However, not all of the credit-generating practices rewarded here count as CDR. - **No clear business case yet for CCS-based CDR**, but strong bioeconomy could – if combined with CCS – be an avenue towards future business cases
E.3 New actors that demand change in incumbent climate regime	- **Although still incipient, there may be some space for a demand-pull coming from the private sector (associated with ESG practices) and from NGOs for LULUCF-based CDR options**. Apart from that, demand-pull is very limited for CDR specifically. –

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China

LULUCF-based CDR

Level of CDR regulation	+	0	-	Note
Implicit accounting	+			Carbon intensity target is a net emission targets [B.1]
R&D-related incentives	+			Established research community and support for improving MRV [C.1]
Enabling regulation	+			CDR-relevant (but not specific) policy instruments and reporting schemes in place [B.1; B.4; C.1]
Deployment incentives	+			Several incentives, incl. new efforts for 'sink trading' [B.5; C.1]
Regulated CDR mandates	+			Commitment for afforestation increase by 6 billion m3 from the 2005 levels [B.1]
Explicit removal target		0		While specific afforestation targets announced, amount of CDR not specified [B.1]
Fully-fledged carbon pricing			-	Only very limited amount of forestry credits under ETS [C.1]

CCS-based CDR

Level of CDR regulation	+	0	-	Note
Implicit accounting	+			Carbon intensity target is a net emission targets [B.1]
R&D-related incentives	+			Reports and modelling shows increasing support for CDR-relevant research [B.5; C.1]
Enabling regulation		0		CCUS key element of recent policy documents [B.5; C.1]
Deployment incentives		0		Support for CCUS pilot projects, not directly CDR [C.1]
Regulated CDR mandates			-	No clear mandates for CCS-based CDR
Explicit removal target			-	No explicit removal target for CCS-based CDR
Fully-fledged carbon pricing			-	No fully-fledged carbon-pricing for CCS-based CDR

LULUCF-based CDR

Level of niche innovation	+	0	-	Note
R&D	+			Established research community and support for improving MRV [C.1]
Demonstration projects	+			Well established afforestation/reforestation project in place [B.5; C.1]
Scale-up projects	+			Well established afforestation/reforestation project in place [B.5; C.1]
Voluntary/ niche-markets	+			Voluntary markets are established and part of planned projects [C.1]
Demand-pull		0		CDR-relevant (but not specific) demand-pull exists, but still incipient [E.3]

CCS-based CDR

Level of niche innovation	+	0	-	Note
R&D	+			Increasing attention in scientific community and government experts [B.5]
Demonstration projects	+			Some small-scale CDR-related projects, larger projects for 'CCUS' [E.1]
Scale-up projects			-	No specific CDR project scaled-up, only 'CCUS'
Voluntary/ niche-markets			-	No voluntary market for CCS-based CDR
Demand-pull			-	No explicit demand-pull for CCS-based CDR

A. Institutional setting, actors and coalitions	China
A.1 Overall institutional and political setting in climate policy	- **Rising international influence and domestic politics of implementing transition:** Since adoption of the Paris Agreement, climate policy a prominent issue on the political agenda, manifested in the updated NDC and national pledge of climate neutrality by 2060 (Skjærseth et al. 2021). Chinas influence in global climate governance increased substantially (Qi and Dauvergne 2022a) and moved from being a follower towards a leadership role (Wang-Kaeding 2022). At the same time, transition will be challenging and cannot be taken for granted. Part of the reason are substantial dependency on coal and other possible stranded assets but also complex sets of internal contestation across different provinces, see e.g. (Engels 2018).
A.2 Macro-political developments in international climate governance	- **Formal commitment to Paris Regime, but critical throughout its implementation:** While the pre-Paris agreement between China and the US is perceived a key enabler of the Agreement, China did not indicate to leave the Paris Agreement after US withdrew. However, in the negotiations, it is part of substantial disagreements between 'developed' and 'developing' countries – e.g. with regard to CBDR (Rajamani 2018), loss and damage (Calliari, Surminski, and Mysiak 2019), or the inclusion of wording on phasing-down coal (Brutschin et al. 2022)
A. 3 Actors and coalitions in CDR-related climate policymaking	- **Government is key actor in promoting "nature-based solutions" as mitigation option and promoting innovation in CCU/CCS/CDR:** For more details, see next section

B. CDR accounting and set of methods	China
B.1 Climate target and role for CDR (domestic and NDC)	- **New climate target, adopted in 2020 submitted as NDC – expand LULUCF removals and support CCS / CCU:** peak emissions before 2030, become carbon neutrality before 2060, goal to reduce carbon intensity by 65% compared to 2005 (Xinhua 2020) and enhanced the NDC (Chinese Government 2021b). There is increasing awareness (e.g. in context of 2060 carbon neutral pledge) of but not a specified mandate or binding target for CCS-based CDR methods. - **Part of the new NDC is a commitment for afforestation increase by 6 billion m3 from the 2005 levels;** the enhancement of carbon sinks capability is one of "Ten Key Actions for Carbon Emission Peaking" (Chinese Government 2021b, 34). The 14th FYP includes a mandatory goal for afforestation (in the form of forest coverage percentage, in the current 14th FYP – 24.1% in 2025) (Chinese Government 2021a). - **For CCS-based CDR methods there is no particular pledge in the NDC.** The document does however refer to existing and emerging CCS and CCU, described as "carbon peak pilots" (Chinese Government 2021b, 38), see below for details) – which would establish CDR-relevant infrastructure.
B.2 Accounting practices of CDR toward target	- **Mitigation targets in China are usually defined as "carbon intensity" and also cover removals** - Emissions *and* removals can be accounted as substitutes in this accounting method - Enhancing sinks is addressed as part of mitigation, or "control of GHG emissions" (see e.g. NDC)
B.3 Methods addressed and differences in accounting	- LULUCF-based already addressed - CCS-based not explicitly (see above)

B.4 Grouping/separation and framings of different methods	- **For LULUCF-based removals the framing of "Nature-based Solutions" gained prominence in China** - Existing practices and new initiatives are now framed like NbS with mitigation function and several co-benefits (Qi and Dauvergne 2022b) - **CCS-based removals are mostly discussed under the umbrella term "CCUS"** - Under this heading, components of CDR methods such as CCS are addressed but focus is so far on the other elements, in particular CCU, CCS with fossil-based CO2 e.g. coal, and CCS linked to enhanced oil recovery (for details see below)
B.5 Socio-political prioritization of different methods	- **LULUCF-based removals: Afforestation in particular is part of well-established program**s, that had government support even before their mitigation potentials was part of the justification (Wang et al. 2010) and gained new prominence in the context of the nature-based solution framing (Qi and Dauvergne 2022b). Questions about the effectiveness of existing programs (e.g. Three Norths Forest Shelterbelt Program) exist (Wang et al. 2010; Qiu et al. 2017) and criticism of unintended consequences has been documented (Zhen and Hu 2017; J. Liu et al. 2019). At the same time, however, substantial amount of carbon sequestration related to these projects have been identified (Lu et al. 2018) (Zhou et al. 2017) - **For CCS-based CDR specifically, not much can be said about socio-political prioritazion**. This is due to the fact that CDR methods are usually discussed under the umbrella term CCUS (see e.g. (Bofeng and Qi 2019; G. Liu et al. 2022). CCUS is part of the 14th Five-year-plan (FYP) and 2035 long-term goals" (第十四个五年规划和2035年远景目标纲要) issued on March 13, 2021, CCUS is clearly mentioned as one of the key areas for developing pilot projects (Chinese Government 2021a). CCUS is also part of the NDC, where different pilot projects are being mentioned ((Chinese Government 2021b, 38) and was mentioned – together with direct air capture – in the bilateral agreement with the US published in 2021(US and Chinese Government 2021). It is important to note however, that these projects are not CDR methods. Under the umbrella term CCUS, the older debate of CCS in China (Jiang et al. 2020) gains new attention (Xu and Dai 2021). However, there is a long debate in China about CCUS for its safety concern and potential negative environment effects (Li et al. 2014).

C. Policy instruments	**China**
C.1 Policy approach (type of instrument)	- **Projects that enhance LULUCF removals are usually shaped by top-down, command-and-control regulations** (An et al. 2021). More and more, incentive policies play a role as well, including the possibility of using afforestation to generate forest carbon offsets (CCER), and get revenue from selling CCER in the ETS (the usage of 5% offsets for yearly compliance (but only limited to certain types of CCER, forestry CCER could be allowed) (Shrestha et al. 2021). Sichuan provincial government, for example proposed a strategy that in addition to objectives to enhance the LULUCF sink also promote new MRV system and new incentive structures farmers and foresters through establishing a voluntary market for forestry and grass carbon sinks (The People's Government of Sichuan Province 2021). In the context of reforestation, it is important to note that carbon sequestration is not the only motivation: Initiatives such as the Great Green Wall in the Gobi Desert, started in 1978, show that the Chinese Government is pursuing other objectives with reforestation (here avoid desertification) with such strategies. - **Policies for CCS-based CDR methods are in its infancy.** However, CDR-relevant governance structures, esp. support for innovation in this area, are emerging rapidly. The state government is gradually promoting the R&D and application of CCUS mainly by building many pilot projects first (see e.g. fir the first time 14th FYP, "Project list supported by green bonds 2021 version" (绿色债券支持项目目录年版 in Chinese, policy document "Technology development plans for supporting carbon peak and neutrality goals 2022-2030" (**科技支撑碳达峰碳中和**实施方案 2022-2030 in Chinese), issued by nine Chinese ministries/institutes, including Ministry of Science and Technology (MOST), National Development and Reform Commission (NDRC)). One of the main challenges identified by the government (NDC?) and experts that would also be relevant for CDR applications that require CCS is the high costs for geological sequestration (Bofeng and Qi 2019). Global CCS database list 13 porjects in construction or operational, most of them linked to enhanced oil recovery (Global CCS). The pilot projects are built mainly by China's state-owned large oil and coal companies, like PetroChina, Sinopec, Shenhua Energy, etc., required/encouraged by the Chinese government.
C.2 Timing (sequential, immediately, long-term)	- LULUCF removals already established, including relevant governance structures - CCS-based removals: medium- to long-term; relevant infrastructure is emerging in pilot plans, but mostly CCU and CCS, not dedicated CDR projects yet
C.3 Major political struggles in public policy processes	- nA

C.4 Relations to other policy instruments/targets (discursively/ politically/legally)	- LULUCF-based CDR has been a key component of mitigation strategies for a long time - CCS-based CDR is not well embedded in existing instruments, but discussed under the heading of CCUS and “carbon peak pilots” in the NDC (Chinese Governement 2022)

D. Expert bodies and science	**China**

D.1
Role of expert bodies and science more generally (incl. national modelling)
	- CCUS has been the topic of several high-level reports and work by think tanks and CDR specifically has been addressed in national modelling linked to the 2060 carbon neutrality pledge (He et al. 2022; 2020). The proposed CCUS supporting policies from the academic community mainly include:
	  - Further prompting the commercialization of CCUS technologies mainly by building more large-scale projects (currently CO2-EOR is almost commercialized in China)
	  - Design financial incentives (like soft loan, tax incentive, subsidies) for CCUS projects
	  - R&D in the entire chains like CO2 capture, compression, transportation, injection and storage (in suitable geologic formation) to form comprehensive/matured industrial chain
	  - Make the national plan of CCUS spatial/location arrangement

D.2 role of IPCC reports in shaping the debate	- The report has been mentioned in the context of the new net-zero pledge. However, in the above mentioned discussions about nature-based solutions and CCUS, the report did not play a visible role. More focus is on national modelling and national expert and advisory bodies.

E. Development in CDR niches	**China**

E.1
Developments in "protective spaces" that shield, nurture, empower
	- LULUCF based removals are already well established; recently more efforts to include LULUCF-based removals in the national ETS; a direction also mentioned in the NDC (“Carbon sink trading will be integrated into the national carbon emissions trading market”) (Chinese Government 2021b, 37)
	
	- CDR, CCU and CCS are discussed together and from policy documents it is not always clear whether it is explicitly dealing with CDR. However, since CCU and CCS-related infrastructures are of relevance for CDR, key initiatives will be listed below to identify the approach the Chinese government taking here:
	  - First start-ups can be identified such as Carbon Infinity (Izikowitz 2021) and C4X an applicant to the X-Prize.
	  - Numbers of DAC-related patents started to increase with the adoption of the Paris Agreement in 2015 (for details, see Kang et al. 2022)
	  - The first CCUS pilot project in China was in operation in 2004 in Shanxi province.
	  - The CCUS mainly applied in four sub-sectors in China, namely fossil fuel power generation, steel (self-use and EOR is also a driver), cement and petrochemical. A problem is that some of the built pilot projects stopped in operation because of low profits. Only the large stated-owned energy companies in China can afford the operation of CCUS pilot projects.
	  - So far (as of 2021), there are 49 CCUS projects in China, 38 of them are in operation and 11 are under construction. The 38 built projects can capture CO2 about 2.96 Mt/year and injection CO2 (storage) about 1.2 Mt/year. The 38 projects include 15 capture projects (only 1 project with high concentration CO2 source), 9 utilization projects and 14 storage projects. In the 15 capture projects, 11 are in power sector, 3 in cement sector, and 1 in coal processing sector. As for the project scale, 29 of the 38 projects are less than 0.1 Mt/year, and only 2 of the 38 projects are around 0.5 Mt/year (Global CCS Insitute Database)
	  - China has no see-bed storage projects yet.
	  - The CO2 transportation in China is currently mainly by tank trucks and ships, and the first pipeline transportation in China will be in operation in 2023 (about 100 km). The CO2 storage currently used in China includes EOR, EGR, ECBM, deep saline aquifer, etc. Relatively, the maturation order of storage technologies from high to low in China is underground leaching, EOR, ECBM, deep saline aquifer, and EGR. (Global CCS Insitute Database)
	  - On Sept 2, 2022, a CO2-EOR pilot project in China (done by Sinopec) started in operation which is the largest CCUS project in the count (National Energy Administration 2022). This project can capture and store CO2 about 1 Mt per year. (the other CCUS pilot projects are usually 0.1-0.5 Mt per year). The Sinopec also plans to construct two other 1 Mt scale CCUS pilot projects during the 14th Five-year-plan period (2021-2025).
	  - No official funds for R&D specifically for CDR but academic research funds can be applied to
	  - Again no specific funds for CDR demonstration projects but are examples of projects securing financing for demonstration projects (DAC demonstration Q1 2022)

	- In China's "Project list supported by green bonds 2021 version" (绿色债券支持项目目录2021年版 in Chinese), (People's Bank of China and National Development and Reform Commission 2021). - The latest policies/goals on CCUS are mentioned in the newly issued (on June 24, 2022) policy document "Technology development plans for supporting carbon peak and neutrality goals 2022-2030" (科技支撑碳达峰碳中和实施方案 2022-2030 in Chinese), issued by nine Chinese ministries/institutes,(Ministry of Science and Technology (MOST) et al. 2022) . In the plan, it is mentioned that the relevant policy incentives should focus on promoting the energy efficiency and reducing the cost of CCUS related technologies; for the first time, a relevant goal is set that is "reduce the energy intensity per unit captured CO2 by 20% by 2025 and by 30% by 2030 from the 2020 level". Also, in this plan it mentioned that the government is now highly encouraging the pilot projects of combining CCUS (collected/captured from oil refining facilities) with oil production at oil fields to achieve the co-benefits of CO2 storage and higher oil production by inserting the captured CO2 into poor oil fields (namely, CO2-EOR). The plan also briefly mentioned that the government will design and issue CCUS technical standard system and establish the National CCUS Technology R&D Center, but no details so far.
E.2 Emerging business cases	- A problem is that some of the built pilot projects stopped in operation because of low profits. Only the large stated-owned energy companies in China can afford the operation of CCUS pilot projects. However, several initaitives have been identified and support for "carbon peak pilots" could establish incentive structures.
E.3 New actors that demand change in incumnet climate regime	- Partly. After the announcement of 2060 carbon neutrality pledge in September 2020, enterprises and corporates are increasingly under the pressure to commit to carbon neutral targets. But there are not many concrete plans on CDR yet beyond the promises. - CDR-relevant (but not specific) demand-pull exists and is expected to become stronger in the context of the new set of climate targets. So far, however, still incipient [E.3]

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India

LULUCF-based CDR

Level of CDR regulation	+	0	-	Note
Implicit accounting	+			Carbon intensity target is a net emission targets [B.1]
R&D-related incentives	+			Established research community and support for improving MRV [D.1]
Enabling regulation	+			Policy instruments, initiatives, reporting schemes for afforestation schemes in place [B.5; C.1]
Deployment incentives	+			Revenue streams for afforestation key element of rationale behind policy initiatives [C.1]
Regulated CDR mandates	+			Long history of afforestation mandates [C.1]
Explicit removal target	+			NDC includes explicit removal target quantifying t CO2 [B.1]
Fully-fledged carbon pricing			-	No fully fledged carbon-pricing established

CCS-based CDR

Level of CDR regulation	+	0	-	Note
Implicit accounting	+			Carbon intensity target is a net emission targets [B.1]
R&D-related incentives		0		New activities and joint initiatives, but focus on CCUS, not CDR-specific [E.1]
Enabling regulation			-	Lack of CDR-specific policy ecosystem, also for CCU and CCS
Deployment incentives			-	Lack of CDR-specific policy ecosystem, also for CCU and CCS
Regulated CDR mandates			-	Lack of CDR-specific policy ecosystem, also for CCU and CCS
Explicit removal target			-	No CCS-based CDR-specific removal target
Fully-fledged carbon pricing			-	No fully fledged carbon-pricing established

LULUCF-based CDR

Level of niche innovation	+	0	-	Note
R&D	+			Established research community and support for improving MRV [C.1]
Demonstration projects	+			Well established afforestation/reforestation projects in place [B.5; C.1]
Scale-up projects	+			Well established afforestation/reforestation projects in place [B.5; C.1]
Voluntary/ niche-markets	+			Voluntary market for afforestation credits stablished and revenues part of policy rationale [C.1]
Demand-pull		0		Demand-pull exists for afforestation, but not necessarily CDR-specific [E.1]

CCS-based CDR

Level of niche innovation	+	0	-	Note
R&D	+			Increasing attention in scientific community and government experts [B.5, E.1]
Demonstration projects			-	Only for CCUS, not CDR-specific [E.1]
Scale-up projects			-	No specific CDR project scaled-up, plans for CCUS scale-up [E.1]
Voluntary/ niche-markets			-	No voluntary market for CCS-based CDR
Demand-pull			-	No explicit demand-pull for CCS-based CDR

A. Institutional setting, actors and coalitions	India
A.1 Overall institutional and political setting in climate policy	- **Climate change has moved up the political agenda in India in recent years. Under the Modi government, India has set ambitious domestic targets for renewable energy and played a more leading role in international climate negotiations, as part of its broader foreign policy goals (Mohan 2017). Despite this, climate change as a domestic issue continues to** operate "under the electoral radar" (Pillai and Dubash 2021) given the large socio-economic challenges that take priority. - **Long before climate changed entered domestic politics, forests have been a contested aspect of Indian politics and complex set of interests and path-dependencies** (Lele and Krishnaswamy 2019) (Roy and Fleischman 2022). Thus, governance structures related to forest restoration and its CDR-relevant facets have been established before (Lele and Krishnaswamy 2019), incl. at the international level, where India had been a main driver of included reforestation under REDD+ (Aggarwal 2011)
A.2 Macro-political developments in international climate governance	- **Given its rather small share in historic cumulative emissions, India is one of the key proponents of the principle of common but differentiated responsibilities debate under the UNFCCC (Rajamani 2017).** As such, it has made no promises to reduce its overall emissions in the near to medium term. - **The role of forests as carbon sinks had shaped India's positions in international negotiations before** (Aggarwal 2011) the rise of net-zero targets under the Paris Agreement provided new importance to this already established option of enhancing the sink (Government of India 2022). The initiative of Mission Innovation launched in 2015 also put more emphasis on CCUS as part of mitigation strategies in India (Malyan and Chaturvedi 2021a; 2021b) although this is simply tied to the large reliance on coal for India's energy needs and CCS as an option that enables this to continue without the associated emissions.
A. 3 Actors and coalitions in CDR-related climate policymaking	- **Given the long history and importance of forestry and land use politics in India, the issue is subject to contestation at almost all political levels**, from local communities to high-level politics (Roy and Fleischman 2022; Aggarwal 2011). related governance structures are well established in government policies; dedicated actors, instruments exist (see below).

B. CDR accounting and set of methods	India
B.1 Climate target and role for CDR (domestic and NDC)	- **In 2022, the Indian Government issued an update of its NDC including a net zero by 2070 target** (Government of India 2022). It has also demanded that developed countries counterbalance continuing emissions from developing countries by going "net-negative", given their large responsibility for historic emissions (Mohan et al. 2021). - **The NDC also include a target to reduce the emissions intensity of India's economy by 45 percent by 2030 compared to 2005 levels** (Government of India 2022)**.** - **With regard to CDR, the government pledged in 2015 and reiterated in 2022 to establish an "additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030**" and thus sets an explicit removal target (Government of India 2022).
B.2 Accounting practices of CDR toward target	- **Mitigation targets in India are usually defined as "carbon intensity" and also cover removals** - Emissions *and* removals can be accounted as substitutes in this accounting method (Government of India 2022) - **While LULUCF-based CDR have been included in accounting for mitigation, accounting for CCS-based CDR (or CCUS) are not defined under various mitigation policy measures** because CCS is not seen yet as a tool for net CDR in India.
B.3 Methods addressed and differences in accounting	- LULUCF-based already addressed - CCS-based not explicitly (see above)
B.4 Grouping/separation and framings of different methods	- L**ULUCF-based CDR is usually discussed as part of expanding tree cover and forest restoration** - **CCS-based removals are mostly discussed under the umbrella term "CCUS"**

B.5 Socio-political prioritization of different methods	- **Forest restoration well established but also quite contested at various political levels** contentious (see C.3). While the mitigation capacity is not questioned, struggles exist about the strong new focus on carbon as main criteria for reforestation (Roy and Fleischman 2022) and adverse effects are being observed (Aggarwal and Brockington 2020) - **For CCS-based CDR, the public debate is very nascent,** recently rising attention for CCUS indicate that these option could be used to achieve climate targets and avoid stranded assets (Vishal et al. 2021). It is, however, important to highlight that these are no CDR-specific debates, an issue that is only rarely addressed (Chaturvedi and Malyan 2022; Gosh 2021). Rather, CCS is envisaged as an add-on to coal fired power plants that allows India to continue its reliance on coal for its energy needs.

C. Policy instruments	**India**
C.1 Policy approach (type of instrument)	**LULUCF-based** - As part of National Action Plan on Climate Change (NAPCC), one of 8 overarching goals was the National Mission for a Green India (NMGI) was launched in 2008 (Jha 2012). It aims to sequester 2.523 billion tonnes of carbon by 2020-30 (the lower bound of the range mentioned in the NDC), involving adding 30 million hectares in addition to existing forest. possible revenues through programs such as REDD+ shaped the debate and policy proposals in the post-Kyoto and pre-Paris phase (Kishwan, Pandey, and Dadhwal 2009; Dutta et al. 2013). India has been actively working on implementation projects. These projects have been funded by the Compensatory Afforestation Fund Management and Planning Authority (CAMPA) a government body to manage compensatory afforestation, the National Afforestation Programme (NAP) and others. The effectiveness and negative side effects have been discussed in the scientific literature (Roy and Fleischman 2022). - As part of the Green India Mission (GIM), India in 2018 planned to create a 140,000-km tree line on both sides of national highways, grow plantations along the river Ganga and reduce the consumption of wood or biomass as fuel. There are several state-level afforestation schemes too, such as Telangana's Telanganaku Haritha Haram. While the government does have ambitious plans, the country still lacks well defined policy instruments at various levels. It is also important to note that targets under the NAPCC have no accountability or tracking. For instance, to create a carbon sink of 2.5-3 billion tonnes, the current rate of afforestation — 35 million tonnes per year carbon dioxide equivalent — is lower than what is needed to achieve the target. Similarly, as per data on GIM in the report to UNFCCC, India was supposed to plant trees on 142,000 ha of land between 2015 and 2020, but managed only 78% (112,000 ha). Furthermore, it was mentioned in 2019 by the Parliamentary Standing Committee on Science and Technology, Environment and Forests that the programmes such as GIM and NAP are under-funded (Down to Earth, 2019). - "Green Credits Scheme" an instrument to identify land to develop plantations, which will be taken over by the Government after three years. **CCS-based CDR** - No specific CDR regulations; with regard to CCS-related regulation: Regulatory and legal standards have not been well-established. Issues are usually discussed under CCU and/or CCS (Shaw and Mukherjee 2022; Vishal et al. 2021) - Relevant developments and support for CCUS in the context of innovation support, see section [E]; however, "lack of policy ecosystem" (Malyan and Chaturvedi 2021a)
C.2 Timing (sequential, immediately, long-term)	- LULUCF removals already established, including relevant governance structures - CCS-based removals: medium- to long-term; CDR-relevant but not specific infrastructure is emerging in pilot plans, but mostly CCU and CCS, no dedicated CDR projects yet
C.3 Major political struggles in public policy processes	- **Long and complex history of forestry politics**. Broadly speaking, key issues of contestation are carbon, capital, and community (Aggarwal 2011), always dealing with the question of what counts as forests and what are the objectives of restoration (Roy and Fleischman 2022) - **Public and policy debate about CCU, CCS and CDR in its infancy, no major political struggles yet**. Researchers expect there is marginal interest in domestic demonstration of the technology in India because of the concerns about the public's reaction to underground CO2 storage, poor geological CO2 storage data, and technical uncertainties associated with deploying CCS technologies at scale (Gupta and Paul 2019).
C.4 Relations to other policy instruments/targets)	- LULUCF-based CDR methods are key element of Indian mitigation strategy - CCS-based CDR is not yet part of mitigation strategies, especially avoidance of emissions in the context of the CCUS is expected to play a more relevant role in the near future. CDR-specific developments are not yet part of climate policy debate. –

D. Expert bodies and science	**India**

D.1 Role of expert bodies and science more generally (incl. national modelling)	- For LULUCF-based removals, large scientific community, complex technical papers and MRV infrastructures produced for the government - Less scientific work on CDR methods, but increasing attention for CCUS (Shaw and Mukherjee 2022; Vishal et al. 2021)
D.2 role of IPCC reports in shaping the debate	- IPCC reports have had limited impact on domestic debates on climate policy in India. At the international level, the growing recognition that there is very little carbon budget left to limit temperature rise to 1.5 degrees as a result of SR15 may have led to recent Indian demands that developed countries should go net-negative, in order to allow developing countries more carbon space.

E. Development in CDR niches	**India**
E.1 Developments in "protective spaces" that shield, nurture, empower	- LULUCF based CDR are already well established; in general, high attention to voluntary markets of carbon offsets, that were already established through REDD+ (see above) - CCS-based CDR: The Indian Government and industry has been part of several initiatives to support CCUS technologies, these initiatives are not CDR specific. **CCUS Initiatives:** - Carbon Sequestration Leadership Forum - In 2007, the Department of Science and Technology (DST), Government of India established the Indian CO2 Sequestration Applied Research (ICOSAR) Network (Viebahn et al. 2011) - Accelerating Carbon Capture, Utilisation, and Storage Technologies (Act4). The call for full proposals was supposed to culminate in March, 2021. The aim of this project is to encourage “translational funding” of projects aimed at CCUS. ACT is currently operating with 16 member countries/provinces/regions to fund research and development in the field. - Mission Innovation on CCUS (Government of India Department of Science and Technology 2022) - R&D on various CO2 sequestration has earlier been carried out through the DST’s CCS programme in 2007. Various R&D and academic institutes such as IIT Bombay have been engaged in CDR related activities, together with industry partnerships **CCUS research & demonstrations** - Several industries have started exploring CCUS as an option, especially for hard to abate sectors (Malyan and Chaturvedi, 2021). Examples are: - National Aluminium Company (NALCO) pilot-cum-demonstration CO2 sequestration plant. - The Oil and Natural Gas Corporation Limited (ONGC) and Indian Oil Corporation Limited (IOCL) are exploring CO2-based Enhanced Oil Recovery (EOR) by injecting CO2 captured from IOCL’s Koyali refinery. - The cement company Tamil Nadu Steel Tubes has announced the installation of a large-scale CCUS facility of capacity 0.5 MtCO2 per annum at one of its plants in Tamil Nadu, India and is working with Carbon Clean Solutions, UK, to adopt the latter’s patented technology, CDRMax (Plaza, Martínez, and Rubiera 2020; Malyan and Chaturvedi 2021a). - Tata Steel in 2021 commissioned a 5 tonnes per day (TPD) carbon capture plant at its Jamshedpur Works. It will adopt such a carbon capture technology that extracts CO2 directly from the Blast Furnace gas. Tata Steel will reuse the captured CO2 on site to promote the circular carbon economy. The facility uses amine-based technology and makes the captured carbon available for onsite reuse (Tata Steel 2021) - In 2012 India’s Second National Communication (SNC) mentioned demonstration project for CO2 capture and storage at one high concentration CO2 stream plant in India (Malyan and Chaturvedi 2021a). - Pilot-scale facilities have been established for algae-based CO2 fixation at Hazira, India, representing a distinct technological advancement. CO2 utilization potential in India may also benefit considerably in the next couple of years with the development of the methanol plant in Dankuni in eastern India by Coal India Limited - A CCU facility by Tuticorin Alkali Chemicals, partnered with Carbon Clean Solutions, UK - The National Institute for Oceanography participated in an ocean iron fertlisation experiment with the Alfred Wegener Institute more than a decade ago. There is work underway at the Indian Institute of Science (Prof. Ravindranath) and climate modelling work at IIT Delhi, which also has CDR relevance (Dr SK Mishra). The Department of Science and Technology has provided the funds. - Various institutes have also taken the onus to conduct in-depth research. For instance, Institute of Reservoir Studies is carrying out CO2 capture and EOR field studies in Gujarat, while National Geological Research Institute (NGRI) Hyderabad is testing the feasibility of storing CO2 in basalt formations (Gupta and Paul, 2019). - Two national centres of excellence (CoEs) in CCU, IIT Bombay and Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR)

E.2 Emerging business cases	- Afforestation as LULUCF-based CDR method is already a business case and part of complex politics (see above) - No clear CDR-specific business cases for CCS-based CDR; CCUS discussed as possible stranded assets avoidance strategy (Vishal et al. 2021)
E.3 New actors that demand change in incumbent climate regime	- Some industry actors, esp. from hard-to-abate sectors but also fossil fuel industry are actively exploring CCUS (see Dalmia Cement and Tata Steel above)

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Chapter 11

		Research questions and key findings of chapters		
Chapter	**Publication**	**How – through which strategies, mechanisms, and struggles – does IPCC expertise become policy-relevant in climate policymaking processes?**	**How have SR15 and related knowledge production and validation processes been strategically mobilized and contested in climate science, policy, and politics?**	**What are patterns of CDR governance and policymaking and what role did IPCC's SR15 have in the domestic climate policymaking?**
3	Schenuit (2022): Staging Science Dramaturgical Politics of the IPCC's Special Report on 1.5 °C Global Warming	- Strategies: Putting IPCC on stage to (de-)legitimize policy positions and governance structures; simultaneously mobilized for different, sometimes contradictory political purposes; strategically mobilized to keep up momentum. - Mechanisms: Procedural embeddedness and alignment of the IPCC's SR15 in climate regime in transition; involvement of governments in assessment production processes; IPCC-SBSTA cooperation through special events plus providing IPCC with a pavilion for self-staging. - Struggles: Invitation to provide a special report on a genuinely political target caused political struggles both within the IPCC and UNFCCC processes. Fierce criticism of those concerned with weakening the report led to substantial public debate and struggles at COP24, eventually increasing the visibility of the report.	- Based on an analytical framework for dramaturgical analysis that helps studying who is putting IPCC on stage in front of what audiences. - Three main scripts are being identified: (1) SR15 as a tool and rhetorical device to feed momentum for urgency of climate action, (2) a politically contested element of hard politics and soft coordination under the UNFCCC, (3) policy relevance but not policy-prescriptive resource for evidence-based climate governance. - Dramaturgical politics of SR15 reveal that its production and publication were embedded in broader struggles about climate ambition, the role of the IPCC, and climate mitigation in particular. It shows that the production and performance of SR15 haven been inextricably linked. - The IPCC is facing different sets of expectations and its reports are being used for numerous political causes – with limited control for the IPCC over how it is being used to legitimize certain political positions. While it has strategies to address some of the challenges, it lacks capacity to deal with misrepresentation and spill-over of political struggles into IPCC processes	
4	Aykut et al. (2022): It's a performance not an Orchestra! Rethinking Soft Coordination in Global Climate Governance, Global Environmental Politics	- Strategies: soft modes of coordination are a key mode of governance in the implementation phase of the Paris Agreement; the article explores the dramaturgical repertoire of soft coordination, through which the UNFCCC Secretariat exerts considerable influence beyond its formal mandate. Scientific reports like the SR15 are resources for these efforts building on symbolic and discourse elements (see chapter 3 for details on how it played out in practice for the SR15). - Mechanisms: At COPs as mega-events, Presidencies and UNFCCC secretariat have considerable leeway to select, schedule, and sequencing events, both in official negotiations and side-events. They can provide visibility	- Dramaturgical analysis of post-Paris climate governance through collective event ethnography provides insights on the political context in UN climate governance. - Studying the transition toward and implementation of the hybrid architecture of the Paris Agreement with a specific focus on actual performances helps to contextualize the dramaturgical practices and mobilization strategies identified in chapter 3 and how they have been used to create momentum in a phase of institutional insecurity of UNFCCC in 2018/19. - Insights on the role of UNFCCC Secretariat and COP Presidencies, esp. their capacity to shape the settings and	

		to specific issues, frames, and agents – which they also did for putting IPCC's SR15 prominently esp. at COP24 on a variety of different stages (detailed observation on how and where this occurred see chapter 3). - Struggles: The chapter identifies "counter-scripting" as a practice at COPs and observes that actors interpret or circumvent scripts, improvise on established roles, and use the attention provided by climate conferences to advance their own agendas. These practices have also been identified in the context of SR15, as chapter 3 (and Aykut et al. 2020) show empirically.	intended dramaturgies; observation of a "grand accounting theater", where rather than "name and shame" the interactions are shaped by "claim and shine". - Identifies typical narrative arc for speeches at COP25 and related illustrative roles. (1) Alarming picture of the climate emergency (admonisher), (2) the second highlights efforts to gather and assess data on climate policy (accountant), (3) the third depicts growing momentum for climate action in society (animator). - This broader context is important for analyzing IPCC's new role in the changing climate regime and for interpreting and contextualizing relevance-making practices identified in chapter 3.	
5	Schenuit et al. (2020): Markets for Public Attention at the Interface of Climate Science and Policy Making + case study on the "Global Tree Restoration Potential"	- Strategies: Incentives for and visible efforts of scientist at science-policy-politics interface to provide to engage in research that receives substantial public attention and qualifies as being policy-relevant. Scientists are incentivized to use the leeway for subjective choice in order to justify results that are, e.g. in line with a certain carbon budget. Furthermore, strategies for public relation efforts linked to publications or research projects can be observed. - Mechanisms: Importance of metrics such as citations and media appearances for funding possibilities leads to a dilemma for scientist; potential to either negatively affect the quality of their research, or for scientists avoiding lead to a situation in which scientific findings and perspectives might remain unnoticed while being important for the public debate; increasingly difficult to attract attention and policy relevance to well-balanced scientific assessments leading to a risk of "market for lemons". - Struggles: Case study on the paper "Global Tree Restoration Potentials" shows that very prominent do receive push-back in the scientific community, but their influence on policy initiatives – in this case on nature-based solutions – can be significant and that scientific push-back remains unnoticed in policy context.	- The chapter and added case study point to social practices and incentive structures within knowledge production and validation processes in climate science. By pointing to the example of the carbon budget for the SR15 it shows that the strategic mobilization of the IPCC (see chapter 3) also affects knowledge production processes. - In these strategical mobilized setting, dynamics described through the analogy of Akerlof's "Market for Lemons" points to trade-offs in knowledge production processes between public attention through straightforward results and balanced assessments. In the context of the carbon budget, the chapter states that by failing to clearly specify the assumptions behind a certain carbon budget, for example, that generating the global temperature increase target, different studies appear to arrive at contradictory results and that scientist are incentivized to use the leeway for subjective choice in order to justify a particularly high or low number to satisfy proponents of either position.	- Raises the issue of reliance in many IAM mitigation pathways on large amounts of yet technologically unproven CDR methods to achieve negative emissions and achieve the 1.5 °C temperature target after a period of overshoot; specifically points to a key study behind the carbon budget calculations in SR15. - The publication the case study refers to explicitly builds on the IPCC's numbers and assessed wether the numbers related to afforestation in the report are achievable. It shows that the SR15 is not only policy relevance, but also science-relevant and shapes knowledge production prior to and after the report.
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6	Schenuit et al. (2021): Carbon Dioxide Removal Policy in the Making: Assessing Develop-	- Strategies: The SR15 findings were a key element for policy initiatives and debates related to establishing a net-zero targets in many of the cases studied here. The article finds that net-zero emerged as an organizing principle of climate policy in the aftermath of the report. This	- SR15 thus developed into one knowledge resource used as a key reference to justify the need for CDR policymaking. SR15 led many actors, including think tanks, NGOs and policymakers to start dealing with CDR. At the same time, in some countries the issue has been publicly ignored by the	- Provides insights on 9 OECD cases on CDR governance and policymaking including empirical observation an analysis of the political economy, path dependencies, and policy designs related to the varieties of integrating CDR into climate policy

	ments in 9 OECD Cases. Frontiers in Climate, 3	led to more attention for the issue of CDR since one of the key and influential framings here was that CDR will be required to counterbalance hard-to-abate residual emissions. Especially in those countries that did not address CDR explicitly before, - Mechanisms: While in some countries, parliamentary hearings and exchange between national IPCC authors and representatives from the administration were organized, these efforts could not be tracked systematically - Struggles: In the context of the omnipresent debate about net-zero target, the timing of the target has been discussed in some of the countries, sometimes with links to discussions about global equity in mitigation efforts. With regard to CDR, struggles about whether CDR is a 'legitimate' mitigation option or not in some countries. Furthermore, discussions about the definition of CDR methods, esp. the framings of "nature-based" vs. "technological/engineered" methods.	administration.	- Based on the comparative cases and a synthesis of the commonalities and differences, a conceptual distinction between three idealized types was proposoed: (1) incremental modification, (2) early integration and full fungibility, (3) proactive CDR policy-entrepreneur - The systematic synthesis is based on five key dimensions, one of them "expert bodies and science", of CDR policymaking and continua of observed manifestations, - The role of SR15 differs across countries. In those countries that did not have CDR as an issue of the climate policy agenda, SR15-related discussions initiated a process of CDR climbing up the agenda. However, national advisory bodies and modelling efforts also played a key role. In some countries, debates on CDR are older, especially with regard to CDR in the LULUCF sector.
7	Schenuit et al. (manuscript): Taking Stock of Carbon Dioxide Removal Governance in Emerging Economies: Developments in Brazil, China, and India	- Strategies: The case studies on CDR suggest that SR15 played a significantly less prominent role in these three countries; the net-zero pledge by these countries did not substantially affect the CDR policymaking in these countries because they already have well-established governance structures for land-based CDR. There are, however, efforts to extend these policies and repurpose existing programs to align it bettwen with the need for scaling up CDR, e.g. through trading carbon removal credits. - Mechanisms: No clear mechanisms could be identified in these countries - Struggles: While there are numerous domestic struggles about the land-based CDR methods, the most prominent struggle with regard to SR15 relates to the issue of net-zero and the timing of net-zero in these countries. India in particular has raised the issue that net-zero by 2050 as identified by SR15 would mean that high-income countries would need to become net-negative before and that emerging economies like India can emit after 2050.		- Further develops the analytical framework developed in chapter 6 with a specific focus on comparing the level of regulation and developments in niches, key dimensions in a rapidly emerging policy field - Extend the set of empirical case studies to emerging economies Brazil, China, and India to provide the first empirical case study on CDR policymaking in these countries and reduce the bias towards OECD countries in CDR governance literature - The chapter finds that in addition the the three idealized types of CDR governance and policymaking identified in chapter 6, the synthesis of these three case studies show that "repurposing policies" should be included as a fourth idealized type - Brazil, China and India already have well established policies that address land-based CDR, esp. afforestation, which have been regulated and contested since the beginning of mitigation efforts in these countries. Therefore, dynmics observable in these countries are mostly the repurposing and extending existing policies. - The case studies also show that they will gain more prominence in the context of the national net-zero targets. The case studies also show that equity will be a contested issue with regard to CDR.

8	Schenuit and Geden (2022): Carbon Dioxide Removal: Climbing up the EU Climate Policy Agenda. In: Rayner, T.; Szulecki, C.; Jordan, A.; Oberthür, S. (eds.): Handbook on European Union Climate Change Policy and Politics. Edward Elgar Publishing Ltd	- Strategies: The European Commission as a policy-entrepreneur in CDR policymaking mobilized the SR15 to justify the need for CDR. The SR15 is explicitly mentioned in the EU Climate Law that codified the net-zero GHG 2050 target, and has informed the target formulation of net-zero by 2050 and net-negative emissions thereafter - Mechanisms: The EU proclaims an evidence-based approach in climate policymaking and therefore the IPCC and its products is mentioned in the legislation as a key knowledge resource. - Struggles: While the covers 27 Member States each with very specific debates and policymaking in environment and climate policymaking, struggles existed about the definition of net-zero, some countries proclaimed to need more time and asked for a Union-wide target so that other countries could counterbalance their emissions in 2050 with CDR. Secondly, in the context of the 2030 target, that had reformed from a gross emissions into a net emissions target, allowing to account for a limited amount of removals to achieve the target, discussion about how emission reduction and carbon removal should interact in climate policy and whether they should be interchangeably	- In the EU, SR15 has been, together with own modelling efforts, a key resource to put CDR on the agenda of the European Green Deal and related legislative procedures.	- The European Commission positioned itself as a policy entrepreneur and used the SR15 explicitly to justify this step. - Tracing the CDR in EU climate and energy policy allows to identify path-dependencies for CDR policymaking in the context of LULUCF Regulation and show how the European Green Deal facilitated the shift from implicit governance of LULUCF-based removals to explicit governance of a broad portfolio of CDR methods. - Tracing the positions of key institutions in legislative procedures allows to identify key elements of the emerging political economy CDR policymaking, including the distributional impacts across different Member States and sectors through the notion of “geographies of net-zero”. - It shows that while the EU had been one of the key critics of including carbon removal into the Kyoto Protocol, the now established net-zero target facilitated the normalization of CDR as a key element of mitigation strategies to achieve the target.

14 Declarations

Hiermit erkläre ich, Felix Schenuit, dass ich keine kommerzielle Promotionsberatung in Anspruch genommen habe. Die Arbeit wurde nicht schon einmal in einem früheren Promotionsverfahren angenommen oder als ungenügend beurteilt.

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Eidesstattliche Versicherung

Ich, Felix Schenuit, versichere an Eides statt, dass ich die Dissertation mit dem Titel:

„Bounded Policy Relevance: Knowledge Politics of the IPCC Special Report on 1.5 °C and Carbon Dioxide Removal“

selbst und bei einer Zusammenarbeit mit anderen Wissenschaftlerinnen oder Wissenschaftlern gemäß den beigefügten Darlegungen nach § 6 Abs. 3 der Promotionsordnung der Fakultät für Wirtschafts- und Sozialwissenschaften vom 18. Januar 2017 verfasst habe. Andere als die angegebenen Hilfsmittel habe ich nicht benutzt.

_____ _____

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