



Selling Carbon Futures

Start-Ups and Carbon Dioxide Removal Credits

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Abstract:

In recent years, carbon dioxide removals have gained significant attention as a potential solution to address the climate crisis, and the IPCC considers it an important component of staying within 1.5 degrees of warming. Start-ups are actively working to translate theoretical approaches into tangible biophysical actions. Many of these start-ups offer their services as carbon credits, which allow companies to make claims about offsetting their emissions. In this thesis, I conducted interviews with such start-ups to explore their involvement with carbon credits and the associated markets. Given the uncertain potential of a large-scale implementation of carbon dioxide removal and its potential to delay necessary emission reductions, this study analyzes whether there are indicators of such risks within the carbon removal credit system.

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List of Abbreviations

BECCS - Bioenergy with Carbon Capture and Storage

CDR - Carbon Dioxide Removal

DAC - Direct Air Capture

EU ETS – European Union Emissions Trading System

GGR – Greenhouse Gas Removal

IAM – Integrated Assessment Model

IPCC – Intergovernmental Panel on Climate Change

NDCs – Nationally Determined Contributions

NETs – Negative Emission Technologies

SBTi – Science Based Target Initiative

STFs – Spatio-Temporal Fixes

1 Introduction

According to the World Health Organization, the climate crisis is the greatest health threat facing humanity (WHO 2021). Yet, despite the urgent need for action, we are continuing with business as usual, making the Paris Agreement's goal of limiting warming to 1.5 degrees Celsius seem unattainable (Engels et al. 2023). The Intergovernmental Panel on Climate Change (IPCC) bases the climate scenarios for different degrees of warming, such as 1.5 or 2 degrees, on so-called integrated assessment models (IAMs). However, some researchers have raised concerns about the underlying assumptions of these models (Ackerman et al. 2009; Pindyck 2013). For example, they are based on neoclassical economics and the restrictive conditions of a growth economy. The IAMs also use a discount rate that assumes climate mitigation will be cheaper in the future – suggesting less mitigation in the short term (Rubiano Rivadeneira and Carton 2022, 4).

To make these models work despite these assumptions, the IPCC has begun to incorporate carbon dioxide removal (CDR). CDR has already become an integral part of the IAMs that form the basis of scenarios for temperature projections below 2 degrees by 2100 (Masson-Delmotte et al. 2018, 342–43), although its potential for large-scale implementation is currently unclear at best (Carton 2019, 758). The IPCC is a highly influential institution that is referenced by public institutions such as the EU (Geden, Scott, and Palmer 2018; Tamme and Beck 2021; Erbach and Victoria 2021). This makes it relevant to examine CDR, both the more technological stage of development, as well as the political, economic, and social dimensions and their interrelationships.

As a result of the political legitimization of the necessity and feasibility of CDR, private capital has become increasingly interested in the potential of CDR as a business opportunity (Malm and Carton 2021). The era of climate change denial is giving way to a green capitalism that understands the climate crisis as a business opportunity and the commodification of carbon is the logical next step (Buller 2022, 88). The start-up scene is increasingly interested in CDR and is becoming a key factor in the attempt to make carbon removals work (Sifted 2022). The IPCC and other public actors merely provide the necessary legitimacy in the political discourse, while the start-ups are working on the actual implementation of CDR.

In general, two types of CDR are distinguished: nature-based and technological approaches. (Erbach and Victoria 2021). Nature-based solutions rely on the use of non-human nature to implement their projects, the most common being reforestation and afforestation, i.e. planting trees in some form (Fuss et al. 2018, 14–16) as well as soil carbon projects, which seek to replenish the carbon content of the topsoil that has been removed by human interference such as agriculture. This can be done through regenerative agriculture (Newton et al. 2020) or biochar that is spread on the soil (Fawzy et al. 2021). There are three main technological approaches (Erbach and Victoria 2021). These are direct air capture (DAC), which sucks the carbon out of the air (Sanz-Pérez et al. 2016), enhanced weathering, which spreads minerals on the soil to increase the rate of the natural carbon sequestration (Hartmann et al. 2013), and bioenergy with carbon capture and storage (BECCS), which involves planting biomass and burning it to produce energy and capture some of the carbon (Creutzig et al. 2015).

Whatever the approach, the start-ups lack a product in the traditional sense. There is some consideration of using carbon as a material for shoes, diamonds, and other consumer goods (Malm and Carton 2021, 18). It is also already being used in beverages such as soft drinks (Johnston 2021) and for enhanced oil recovery (Edwards and Celia 2018). However, if the carbon is utilized after it has been removed from the atmosphere, the question arises as to how to ensure that it does not return to the atmosphere. It makes sense that CDR can only be framed as climate action if the carbon is permanently stored (Malm and Carton 2021, 20–21). If it is used to make carbonated water, it will get back into the atmosphere in no time. But since that storing the carbon permanently is a service that benefits the planet as a whole rather than anyone individually, it is hard to see any kind of financial incentive to do so. So why would anyone want to do this in a capitalist system?

The solution to this lack of financial incentive seems to have been found in carbon credits. These have been popular in the past, but mainly as avoidance credits. A company could buy these credits and claim that otherwise a forest would have been cleared and the carbon released into the atmosphere. This practice has been widely criticized because no one can really say what would have happened to the forest if it was not for the credit (Buller 2022, 82–84; Fischer and Knuth 2023). Now, instead of selling credits to stop carbon from being released into the atmosphere, start-ups are removing the carbon and selling the certification that a

certain amount of carbon has been removed from the atmosphere to a company that can then claim to have offset a certain amount of its own emissions (Muff 2020). These carbon removal credits are at the heart of the business models of most start-ups¹. As many have pointed out, CDRs run the risk of being instrumentalized to justify a lack of more rapid decarbonization efforts (Markusson, McLaren, and Tyfield 2018; Carton 2019; McLaren et al. 2021). In this context, I want to critically analyze the credits and how they are related to the start-ups.

In this context, I will try to answer the following research questions:

1. *How do carbon dioxide removal start-ups relate to carbon removal credits?*
2. *How do these relationships reveal the potential of carbon removal credits to act as mitigation deterrence?*

Given the growing importance of CDR in the climate crisis discourse, it seems highly relevant to look at the start-ups that provide these technologies and (promise to) make carbon removal a physical reality. While they themselves are highly dependent on policy developments and regulation for CDR, they could to some extent shape how the markets develop in the future, as they have the power to decide to whom they sell their credits.

As a result, the study will be helpful in providing the basis for a further analysis to assess the role that start-ups play in the larger CDR discourse. In a first round of interviews, it became clear that many of them have an interest in maintaining a good reputation, as this is a significant factor in who companies are willing to buy the credits from. This could influence how CDR can be used to justify postponing reductions in fossil fuel use, or how it could even be understood as a permanent solution to keep a destructive system in place for the long term.

Finally, CDR start-ups and their relationship to carbon markets have not been studied before. Accordingly, the data obtained could guide the development of future research questions or theories. In addition, the study deepens the

¹ This is the result of an initial analysis of the sample of start-ups I chose to contact for this study.

understanding of what expectations exist regarding future policy regulations, and thus could be useful for decision-making by public actors.

2 Background

The definition of a start-up varies, and there is no universal one (Cockayne 2019). For the purpose of this study, I have employed a simple definition of a start-up as an early-stage company that provides a service or a product that did not previously exist. This is associated with innovation and sometimes a vision to change the world (Baldrige and Curry 2022).

I focused my study on start-ups in the carbon removal space not primarily for analytical convenience, but rather because start-ups dominate this industry. Their prevalence reflects the youthful nature of the market. The dominance of early-stage companies in this space is also noteworthy because, as a report on premature scaling of start-ups found a high failure rate of 90% among the 3200 start-ups examined in the study, mostly located in North America or Europe (Marmer et al. 2012, 4).

The main business model of most of the start-ups I analyzed is to sell the carbon removal as a credit to a buying company. There are two types of markets in which this transaction can take place: the voluntary market and the compliance (mandatory) market. *Compliance markets* are domestically regulated, part of reduction schemes, and have a geographical limitation (for example, California or the EU) (Broekhoff et al. 2019, 8–9). Anything traded outside of these markets is considered to be part of the *voluntary market*, although there may be some overlap. These credits are not used to comply with any regulation and can be used for any purpose, including, as the World Bank puts it, to comply “with voluntary mitigation commitments” (The World Bank 2022, 35). Also, while there are certain standards set by private actors, there is no regulatory framework for what defines a carbon credit and what the quality standards are (Buller 2022, 78).

An example of a compliance market that is particularly relevant to this study, because the start-ups are located in the EU and because it is explicitly mentioned by my interviewees, is the EU ETS. Framed as a key measure of the EU to address the climate crisis, it is a cap-and-trade system, meaning that there is an upper limit for the total amount of emissions, and if a company emits even less than

this cap suggests, it can sell the excess as credits (European Commission n.d.). However, carbon removal credits are currently not included in the EU ETS (Rickels et al. 2021, 1), and I could not find any signs indicating that this might change in the near future. Consequently, the start-ups I interviewed sell the credits on the voluntary carbon market. This is not to be understood as a single structured marketplace where all of the transactions take place, but rather as a combination of smaller organized marketplaces and direct interactions between the sellers and buyers of the credits.

3 Theoretical Framework

As a general approach, I use an ecological Marxist lens (building on O'Connor 1998) to examine carbon removal credits in the context of the climate crisis. This approach is particularly suitable for examining market-based mitigation strategies for the climate crisis. Within this framework, I draw on concepts such as spatio-temporal fixes (STFs) and mitigation deterrence that align well with the broader theoretical perspective.

3.1 Spatio-temporal and Socioecological Fixes to Crises of Capitalism

Capitalism has a tendency to overaccumulate, resulting in surpluses of capital and labor. Harvey introduces the concept of the spatio-temporal fix, which is “a metaphor for solutions to capitalist crises through temporal deferment and geographical expansion” (Harvey 2017, 65). Through these fixes, surpluses are shifted either spatially or temporally. The former is done by opening up markets in a geographical region different from the one where the overaccumulation is taking place. The latter is “investment in long-term capital projects or social expenditures (such as education and research) that defer the re-entry of current excess capital values into circulation well into the future” (Harvey 2017, 64). The two can also occur simultaneously.

Ekers and Prudham extend the concept to what they call a socioecological fix. They argue that “fixed capital is deeply ideological; it is produced from within and through political and cultural struggles between particular social classes and institutions, including states, and in the context of the pursuit of hegemony” (Ekers and Prudham 2018, 30). In addition to fixed capital, fixes to the crises of capitalism

also have an environmental component that requires fixing beyond technological solutions.

Developing notions of the ways in which capitalist crises are offset materially and ideologically by new configurations of produced socionatures provides us with analytical and political tools to interrogate the political ecology of capitalist accumulation and crises thereof as they articulate with the broader politics of environmental change and everyday life. (Ekers and Prudham 2018, 31)

3.2 Mitigation Deterrence

The temporal aspect of Harvey's concept of fixes to the crisis of capitalism is given less attention. Often the spatial dimension is considered first and foremost, "with crisis deferral often treated as the logical consequence of spatial restructuring, rather than a strategy in itself" (Carton 2019, 756). When it comes to the climate crisis and CDR in particular, it becomes increasingly conceptually useful to also consider the *spatial* aspect of the fixes more carefully. However, as the theory of the socioecological fix shows, it can be useful to think of fixes as something that can take place outside the sphere of capital accumulation altogether.

For capital, and especially fossil capital, the climate crisis is currently not a biophysical crisis. "The direct 'threat' comes from increasing social demands for mitigation and the political drive towards regulation rather than from increasing temperatures or rising sea levels" (Carton 2019, 758). The fossil fuel industry has a large amount of fixed capital² in infrastructure, such as pipelines or refineries. The crisis of legitimacy that fossil capital faces due to the climate crisis could potentially result in much of this infrastructure becoming stranded assets. Their main priority is to make profits, and the longer these structures remain in place, the more money they make (Malm 2016, 358).

In this light, the delay of emissions reduction would lead to greater profits. Such a delay in decarbonization is conceptualized under the term mitigation deterrence when it is "resulting from the introduction or consideration of another climate intervention" (Markusson, McLaren, and Tyfield 2018, 1). This is not to say that it must necessarily be a strategy pursued by a particular actor. Rather, "the

² Fixed capital refers to capital that has been invested in physical infrastructure that is intended to remain in place and operate over an extended period to generate value through production (Harvey 1999, 204–7)

term ‘deterrence’ is here used generically to include both intentional and emergent effects” (Markusson, McLaren, and Tyfield 2018, 1). Nevertheless, the power relations and economic interests that shape mitigation deterrence must be taken into account when engaging with the concept. CDR is an example of a technological promise that could lead to mitigation deterrence (McLaren et al. 2021). Despite the fact that the technologies are fraught with a number of social and environmental problems, and the potential for a large-scale implementation is uncertain at best, it is being used in climate models such as the IAMs on which the IPCC bases its temperature projections for 1.5 and 2 degrees of warming (Carton 2019, 758–59). “The introduction of NETs³ in cost-optimizing mitigation scenarios reduces the costs of long-term mitigation” (Minx et al. 2018, 13; footnote added), where “discounting of future costs and benefits, and overall financial cost-optimisation come together in ways that give integrated assessment models a strong preference for any potential future technological fix over near-term emissions cuts” (Markusson et al. 2022, 5). Because CDR does not (yet) largely exist as a physical reality, Markusson et al. theorize it more specifically as a *defensive* spatio-temporal fix. These “do not rely on material realisation but exist primarily as discursive, cultural phenomena. The mere promise of NETs is enough to defer a legitimacy crisis for fossil interests” (Markusson et al. 2022, 3).

Some voices see a danger in the concept of mitigation deterrence. Jebari et al. argue that policymakers could simultaneously incentivize both decarbonization efforts *and* carbon removals, while using the concept of mitigation deterrence would lead policymakers and the public to understand CDR as a substitute for decarbonization efforts. In this sense, mitigation deterrence as a concept could lead to mitigation deterrence in practice (Jebari et al. 2021). I think this argument has merit in pointing out the potential risk of the concept itself. However, I disagree with the notion that it is *only* the concept itself that could lead policymakers and civil society to think of the two as substitutes. In fact, the scenarios modeled by the IPCC are already being translated into the real world. Shell, for example, uses them to justify future oil extraction (Carton 2019, 759–61). Moreover, the temperature

³ NETs are negative emissions technologies, which basically means the same as CDR, but in theory includes greenhouse gases other than carbon. In practice, the two terms are generally used synonymously (see for example National Academies of Sciences, Engineering, and Medicine 2019).

projections are widely used in the political sphere, where CDR is already being instrumentalized to justify a lack of climate action that would otherwise be inconsistent with the goals of the Paris Agreement (Gordon 2021).

3.3 Sociotechnical Imaginaries

The theory of sociotechnical imaginaries is also relevant to the study of CDR. Jasanoff and Kim define sociotechnical imaginaries “as collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology” (Jasanoff and Kim 2015, 4). These imaginaries can be promoted by various groups such as nation-states, “corporations, social movements, and professional societies. Though collectively held, sociotechnical imaginaries can originate in the visions of single individuals or small collectives, gaining traction through blatant exercises of power or sustained acts of coalition building” (Jasanoff and Kim 2015, 4).

Similar to McLaren and Markusson, who emphasize the importance of considering the social, political, and economic contexts in which technologies are developed and deployed (McLaren and Markusson 2020), Jasanoff describes knowledge, and technology in particular, as both a product and a constituent of social life. “It both embeds and is embedded in social practices, identities, norms, conventions, discourses, instruments and institutions – in short, in all the building blocks of what we term the *social*” (Jasanoff 2004, 2–3; emphasis in original). According to this theory, the imaginaries also have a normative function. They “encode not only visions of what is attainable through science and technology but also of how life ought, or ought not, to be lived; in this respect they express a society’s shared understandings of good and evil” (Jasanoff and Kim 2015, 4). “NETs may be seen as a set of technological promises [...] not merely as a response to the climate issue, but specifically as a response of capitalist societies, as the scientific and political climate change problem is translated into a problem for capital and responses shaped accordingly” (Markusson et al. 2022, 3).

3.4 Greenwashing

One concept that came up a lot in my interviews is greenwashing. I did not necessarily want to include this concept in my study, and I did not use the word in

any of my questions, because I find that mitigation deterrence is a more precise theory for understanding problems with the use of carbon removal credits. But it came up so often (without being clearly defined by any of my interviewees) that I need to address it. As I understand greenwashing in the contexts in which it was used in the interviews, I would describe it as making something (be it a product or a company as a whole) look more environmentally friendly, or rather less environmentally unfriendly to the public eye than it actually is (drawing on Delmas and Burbano 2011, 65).

4 Methods and Methodology

4.1 Philosophy of Science

Critical realism is a philosophy of science that provides a clear distinction between ontology and epistemology. It divides reality into three categories: (1) the ‘real’ is what exists, (2) the ‘actual’ is what is theoretically observable, and (3) the ‘empirical’ is what has already been observed. Knowledge of the ‘real’ can be gained through the ‘empirical,’ but it is open to correction, never absolute, and caught up in discourses (Sayer 2000, 11–12). Given that this study seeks to integrate knowledge of the biophysical reality of carbon dioxide removal with the start-ups' understanding of carbon removal credits and carbon markets, critical realism is the appropriate philosophy. This is especially relevant for the theoretical framework of spatio-temporal fixes to the climate crisis, where the difference between the biophysical reality of carbon dioxide removal and its use as a discursive tool for political and economic agendas is at the core.

Because CDR sits at the intersection of the environment, politics, and capitalism, I use a political ecology approach. The startups' understanding of carbon credits and markets must be contextualized within their biophysical approach to carbon dioxide removal. Conducting semi-structured interviews to gain insight into their perspectives allows for a bridge between the two domains. The study is also informed by other disciplines, such as political economy, as the data is analyzed through the lens of the spatiotemporal fix to capitalism's crises and mitigation deterrence. This approach is relevant for understanding the underlying political and economic mechanisms at play.

4.2 Study Design

A company's public communications are designed to put itself in a good light. To explore the relationship of CDR startups to carbon credits and markets, I decided that interviews with them, where they could potentially speak anonymously, would be the best approach to gather data that goes beyond PR phrases and opens up a space for something that comes closer to a conversation.

4.3 Sampling

During an initial literature review, I learned about the Carbon Removal ClimAccelerator program of the Climate-KIC, which is co-funded by the EU. They have a list of start-ups that they have supported in the past. I decided to use this list as a sample of start-ups I wanted to contact. The selection ensured a diversity of start-ups based on their approach to CDR, including technological or nature-based solutions and providing the technology or operating a marketplace. For example, one would help farmers to sequester carbon through their agricultural practices, while another would develop a new technology to put DAC in cooling towers, and a third would provide an online marketplace where forest credits could be traded. A full list of the start-ups I interviewed can be found in the Appendix. Since I lack the knowledge to decide which start-ups are promising based on the technology they plan to use, it was a convenient way to have this pre-selection available. Also, as I planned to conduct the interviews in person, I wanted to focus on start-ups in my geographical proximity, so it was useful that only companies located in the EU were supported.

After an initial analysis of six interviews, I realized that I needed more data to adequately answer my research question. Fortunately, the accelerator program had just added a new batch of start-ups, so I contacted them. I ended up conducting six more interviews.

4.4 Interviews

I decided that semi-structured interviews would be the best approach for my purposes. I had questions in my mind based on my literature review and my research questions, but because of the exploratory nature of my research, I also hoped that new themes would emerge during my interviews that might require further exploration. Because my interviewees were themselves knowledgeable in

the field, they often brought up topics for which I had planned questions in the later stages of the interviews. In this respect, the flexibility of the semi-structured interviews was a great asset (Brinkmann, Kvale, and Flick 2018, 70–71).

I wanted to do the interviews in person, but ended up doing them all online because that was the preference of all my interviewees. With one exception, I interviewed a single person, in most cases with a founder of the start-up. Most of the interviews lasted about 30 minutes, with the longest one lasting an hour. I began by reiterating the purpose of the interviews (which I had already informed them of in my initial email) and asking questions to ensure the ethics of my research and to let me know if there was anything still unclear or that they wanted to know. In the beginning, I asked one or two questions that were more technical in nature to make sure that I understood what exactly they were doing before moving on to the part that was more directly relevant to my research questions.⁴

4.5 Analysis

For the first two interviews, I made verbatim transcriptions, thinking that my interviewees' reactions might allow me to draw psychological conclusions that would be valuable to the analysis. However, once I started the analysis, I realized that the fillers added no value and were mostly distracting, so I opted for intelligent transcriptions instead. Starting with the transcriptions and the analysis while still doing the analysis allowed me to reflect on and improve my approach to interviewing for my later interviews. I also made some minor adjustments to my interview guide, adding a sub-question after the first half when I found a topic I wanted to explore further. If there was anything unclear during the transcription, acoustically or in terms of content, I contacted them for clarification.

Immediately after the interviews, I took notes on aspects that seemed interesting and relevant to me. As I transcribed, I began to highlight sections that stood out and make analytical memos that might be useful during the coding and analysis. As a result, I already had some ideas about what aspects might be worth exploring when I began with my initial coding phase.

Since there was no data or research specifically on CDR start-ups, I decided to use a mostly inductive approach to analyze the interviews. However,

⁴ The basic interview questions can be found in the Appendix. However, the guide was slightly modified before the respective interviews based on research on start-ups.

inductive and deductive “approaches are the ends of a spectrum. Many analyses will start with some theory and perhaps some ideas for themes but then be led by the data” (Fugard and Potts 2020, 4). I designed my interview with some ideas and theories in mind, based on a literature review and some prior knowledge of the topic. Evidently, this carried over into my analysis, as “the researcher is positioned as active in the research process; themes do not just ‘emerge’” (Braun and Clarke 2006, 80).

To analyze the transcribed interviews, I decided to use a descriptive coding approach. I used the coding software NVivo. Descriptive coding, also referred to as topic coding, “summarizes in a word or short phrase – most often as a noun – the basic topic of a passage of qualitative data” (Saldaña 2013, 88). Thanks to the notes I took and my interview questions, I already had inspiration for topics that would be useful for the coding, and some I developed during the process. The topics were broad (e.g., *Carbon credit buyers’ behavior* or *EU policy*) in order to group sections into categories for the further analysis and to already get an idea of what information might be related.⁵

For some codes, I tweaked it a bit and used something that comes closer to structural coding, a question-based coding method, which makes it suitable for interview data (Saldaña 2013, 84–87). For example, one of the questions was *Do carbon credits undermine decarbonization efforts?*, which I had already used in a similar way in the interviews, but is still similar to a theme (or just a different way of describing the theme).

In a second phase of coding, I looked at the sections that I had included in each category and paraphrased them as keywords or short phrases (e.g., *Buyers value quality offsets* or *Time constraints*), sometimes also already with some interpretive elements (e.g., *Market growth is a priority over ethics*). I used a mix of coding methods that seemed appropriate, such as in-vivo, process coding, and values coding according to a coding manual (Saldaña 2013, 91–100, 110–15). I had one very broad topic from the descriptive coding called *Assessment of carbon markets* because I did not know what narrower categories I wanted. I broke this down into more categories after the second phase of coding. I kept revisiting my

⁵ See the Appendix for a complete list of codes.

codes and changing them as I had new inspiration, even well into the writing process.

Finally, I also looked at the frequency with which the different codes appeared. This gave me an idea of how common certain notions were among the start-ups. However, this does not mean that I would undervalue codes that did not appear as often.

4.6 Limitation

Because I used someone else's preselection of what start-ups they thought were promising, my sample is biased. While this is certainly a major limitation, as I described earlier, it is also an asset because I lack the knowledge and skills to judge whether a start-up has a promising future both technologically and as a business. My sample is also biased by who decided to take the time to answer my emails and to do the interviews with me. A random sample would have been a better option, but was not feasible. However, I am glad that enough people were willing to take the time to form a sample large enough for me to be able to answer my research questions.

Social desirability bias is common in interviews. In some cases, my interviewees may have given me answers that they thought I expected or wanted to hear (Bergen and Labonté 2020). I cannot say whether or how much this influenced the interviewees, but our very different ideological backgrounds and the online nature of the interviews avoided this to some extent. It is also possible that interviewees were reluctant to share certain information with me for various reasons, mainly because it might reflect negatively on their company. Since this was my first time conducting interviews as part of a research project, I tried to improve my interview technique with each interview I conducted. I later realized that some of the follow-up questions I had to come up with on the spot could have been leading.

The scientific discourse on carbon removal takes place and is shaped by scientists from the Global North (Biermann and Möller 2019), and this is reflected in the IPCC scenarios that suggest these technologies as solutions (Corbera et al. 2016). This study is also guilty of looking only at start-ups in Europe. But it also seems that so far CDR start-ups are mainly a phenomenon of the Global North. This makes it all the more important to critically engage with them, as a large-scale

deployment could negatively impact marginalized groups due to its massive demand for land, energy, and other resources (Dooley et al. 2022; Fuss et al. 2018, 17–18; P. Smith et al. 2016). However, as these material consequences of a large-scale implementation of CDR have been critically analyzed in the aforementioned literature. This thesis focuses instead on the non-material (or rather, not immediately material) consequences of carbon removal technologies.

4.7 Positionality

I conducted this research as a Human Ecology student and as part of a research group that is generally critical of CDR. I am generally skeptical of market-based approaches to address the environmental injustices that such markets have created in the first place, and my ideological background strongly influenced how I designed my study and how I analyzed my interviews. Some may see this as a limitation of my research, but in my opinion all research is subjective, so I consider this an asset.

4.8 Ethical Considerations

According to Lund University's research ethics standards (Lund University n.d.), all participants were informed before and again at the beginning of the interview about the research project I was working on and how the data from my interviews would be used. I did not explicitly mention my own positionality unless asked by my interviewees, in which case I honestly gave them my perspective on the topic. I offered anonymity to all of my interviewees, both for them individually and for their companies. At their request, I anonymized the quotes for some of them. I also sent the quotes to my interviewees beforehand to make sure that I was presenting their arguments correctly. I was asked to make minor changes to some of the quotes that did not change the meaning in any way.

5 Findings and Discussion

In analyzing my interview data, I identified four themes that are relevant to the research question: greenwashing, undelivered credits, time conceptualized in the credits, and the certification process. After introducing the themes and analyzing how they render carbon credits problematic, I want to discuss how this relates to

temporal fixes and mitigation deterrence. Finally, I will critically discuss the solutions proposed by the interviewees.

5.1 The “Weak Market of Voluntary Action That Looks Nice” and Greenwashing

One theme that almost all of the interviewees explicitly or implicitly mention is greenwashing. They understand it as a possible consequence of carbon credits in general, but also of carbon removal credits in particular. “I think one of the big threats which is out there at the moment is greenwashing” (Felix Harteneck, Co-Founder and CEO of Inplanet). Most of the start-ups also have a strong desire not to be instrumentalized for greenwashing purposes. This may be partly for ethical reasons, but it also became clear that a good reputation is an asset in a market, which is based solely on promises. This is especially true for start-ups working with nature-based solutions.

You don’t want to be associated with a negative reputation. And that’s also something that the projects ask from us, that the capital doesn’t come from greenwashing sources. Because they also don’t want to be implicated in a greenwashing setup. And of course, the companies ask as well. So it really is a reputation-driven business. (Tim Duehrkoop, Co-Founder and CEO of Xilva)

Some of the participants extend this thinking to a larger scale. Not only do they individually “not want to be used for greenwashing purposes. We also think it would be bad for carbon removal as a whole” (Mike Carpenter, Co-Founder and CEO of InheritCS).

The fact that voluntary carbon trading is described as a reputation-driven business brings to the fore the main problem with the voluntary carbon market. One of my interviewees describes it as a “weak market of voluntary action that looks nice” (Informant 1) but does not lead to real climate action. The voluntary nature of the market makes any participation in it an act of marketing. For-profit companies would not simply buy a credit if they did not believe that they could potentially benefit from it. Taking this a step further, one interviewee stated that when

operating in the voluntary trading market, I think calling them credits is a misnomer. It has an element of greenwashing. [...] You can't have a company that is not really involved in the ETS sticking in 2,000, 3,000€ as a cursory marketing spend and stating they've purchased carbon credits, because they have not. That is not the legal and regulatory definition of them. (Stephen Milburn, Founder and CEO of Nellie)

In his view, the term carbon *credit* should be reserved for the compliance market; calling it a credit on the voluntary market would already be an act of greenwashing. The 'credits' as they currently exist are not used to actually reduce a company's net-emissions to zero, he argued. Instead, they offset insignificant amounts of their total emissions, especially as long as decarbonization is not intensified. In fact, the volume of carbon removal credits that would make this possible does not even exist today. "It's just that those numbers are not there yet. The actual supply is just so short of the existing demand, but also the expected demand. So a lot more growth is needed" (Informant 2).

One interviewee argued that it is not the companies that are engaged that should be criticized for greenwashing. Instead, the focus should be on companies that "are actually not even engaging in offsetting of climate-relevant activities" (Stephanie Bischof, Managing Director of Airfix). Companies that offset some of their emissions would already have a degree of transparency about their emissions.

Some also believe that greenwashing should not be a problem in the future because it "is something that consumers will punish – the court of public opinion will punish eventually" (Tim Duehrkoop, Co-Founder and CEO of Xilva). This is not surprising since the start-up community is largely positive about markets. This assumption can be questioned as avoidance credits have been and continue to be used for greenwashing purposes, and claims of carbon neutral products do not seem to have had a negative impact on consumer behavior. In fact, the market for avoidance credits is growing despite negative media attention (Fischer and Knuth 2023; Monbiot 2022).

5.2 "When Is a Carbon Credit?"

So far, the supply of carbon removal credits is small. At the moment, it is mostly nature-based solutions that are actually doing the removal (CDR.fyi 2022b).

For many of these nature-based removals, it is debatable to what extent it makes sense to frame them primarily as carbon removal projects. For example, the start-ups working on such projects often point to their co-benefits for biodiversity, soil regeneration, and local communities: “Our forests have a really large number of ecosystem benefits and local social benefits” (Olivier de Montety, Co-Founder and Non-Executive Partner of Treeseve). In my view, it would be healthier to understand the carbon removal as a co-benefit of a reforestation project. But according to my interviewees, that is not where the money is. Regenerative agriculture and rewilding are positive practices in their own right, but “where do you get the funding” (Informant 3)?

Focusing on carbon alone, however, would risk promoting projects that may be efficient at removing carbon from the atmosphere in the short term, but have negative environmental impacts as a result. “If we wanted to maximize carbon capture, we would go into a tropical country and plant eucalyptus. That would be the best way to maximize carbon capture in a nature-based solution. But that would be an absolute ecological catastrophe” (Olivier de Montety, Co-Founder and Non-Executive Partner of Treeseve).

Most respondents understand nature-based CDR approaches as short-term solutions. And “we do know that we have to shift. We have to eventually get to a point where everything we do is highly durable, highly permanent” (Informant 1). This is where technological CDR solutions would have to come in. However, according to most interviewees, technological CDR is not developed to the point where it would make sense to implement the technology. Its only right of existence at the moment is that it needs time to reach a stage of development where a large-scale implementation is theoretically feasible and practical. And if that stage is ever to be reached, that development must begin now:

If we wait for companies to reduce by 90%, we will not have the financing and the maturity within the supply of carbon removal credits to then actually deliver in time – which is between 2040 and 2050, they say, when CDR is actually going to be needed the most. But if we only start to prepare for it then, it will be far too late. So if we only work with businesses that say, “We will reduce by 90% now, and then we will be in touch with you to buy some carbon

credits for those last 10%,” then the other argument is that there wouldn’t be enough time. (Informant 2)

To make this development possible in a timely manner, funding would be needed now. However, since the product that the technology start-ups want to sell – carbon removal – is not yet ready, they have to find other ways to finance themselves. One way is through pre-purchases:

What we need to do is work with the buyers of these carbon removal credits now to actually frontload the finance, the capital that we need to make that supply. And that is where you get these pre-purchase and off-take agreements that are becoming more popular. Although I think they are getting quite a lot of airtime and actually there are still quite few and far between. But the idea of them is “Let’s work towards this supply now because it is needed in 15 or 20 years.” But the suppliers need to get going with it now. And then the buyers, as a result, get a secure price for those carbon removal credits. (Informant 2)

My interviewee believes that this frontloading of finance is not the common practice. However, a tracker of all carbon removal credit purchases tells a different story. As of December 2022, only 7% of the credits purchased had been 'delivered' (meaning that the carbon had actually been removed), which is remarkably low (CDR.fyi 2022a). Of those delivered carbon removals, biochar accounted for 87%, which is also being the approach used by 8 out of the 10 companies that have actually removed more than 1,000 tons to date (CDR.fyi 2022b). In this sense, the numbers also clearly support the notion that near-term removals are primarily provided by nature-based approaches.

Related to this, most of the start-ups make huge claims about how much carbon they plan to remove from the atmosphere, which often seems unjustifiably large, given what is feasible in terms of available land and energy (Dooley et al. 2022; Minx et al. 2018). Part of this can be explained by the positivity around and belief in technological development of the start-ups. Accordingly, “some big companies are going to appear and some technologies are going to emerge, as it happened with the solar panels” (Informant 4). The innovation needed to make this

vision a reality will come from private actors, as “governments very rarely lead innovation” (Olivier de Montety, Co-Founder and Non-Executive Partner of Treeseve).

However, another factor may influence how start-ups come up with their numbers:

From the investor side of things and some of these large corporate’s frontiers, for example [...] when they want to support carbon removal projects and start-ups like us, they are looking for half a gigaton of carbon removal as a number. And so when we are speaking to investors, we do our calculations to that and say, “Look, it would take us ten years or twenty years to get to that 0.5 gigatons”. (Informant 2)

This is another example of how the promise of a bright future for CDR comes about. Investors expect start-ups to make gigaton-scale promises, even if they may not be realistic. Many have yet to deploy a single unit of their technology, so even if the claims are based on some theoretical calculations, there is reasonable doubt that it will ever be implemented at that scale.

Given this uncertainty, the claims themselves, as well as the pre-purchases, can be understood as small temporal fixes to the hope that carbon removals will significantly mitigate the climate crisis. On a larger scale, this could enable further mitigation deterrence. People may point to these numbers to justify further climate inaction. If we can remove 100 gigatons by 2050, why bother with decarbonization now? Now, 100 gigatons is a completely made-up, exaggerated number that probably not even the boldest advocates of CDR would dare to use. But just looking at all the start-ups I interviewed including only those that explicitly mention numbers on their website or the interviews, they would result in a total of more than 4 gigatons of carbon removals⁶. What’s more, the US company Noya, which installs DAC engines on cooling towers, “estimates that there is a potential for its technology to remove more than 10 Gt of CO₂ per year” (Shefrin 2022). This is “only” based on the “2 million cooling towers in the U.S.” (Shefrin 2022). In contrast, a study that analyzes the removal potential of different CDR approaches

⁶ They have different timeframes for when they plan to achieve them, but none of them are later than 2050.

based on supply chains, energy and land-use suggests that the potential for DAC is between 0.5 and 5 Gt of removal by 2050 (Fuss et al. 2018, 20). It is clear how these promises could be used to delay more concrete climate action, especially if these undelivered credits are used for greenwashing. “At present, there are no NETs deployed at scale. [...] NETs at scale is a promise, not (yet) a reality, but it already has impacts as a promise [...] on policy and decision-making. Thus NETs actually serve as imagined future STFs and so could help defend the legitimacy of fossil capital, and defer the crisis for capital” (Markusson et al. 2022, 3). Even one of my interviewees, who (to reiterate) works for a carbon removal start-up, told me that they “do not think that either carbon credits or carbon removal credits are the way out of the climate crisis” (Informant 2).

5.3 What Permanence?

Once the carbon is removed from the air, the question becomes how and where to store it. This is where things get even more complicated. For the nature-based solutions, the carbon is already stored in said nature (with the exception of BECCS). For technological removals, it has to be transported to a place where it can be sequestered. As many interviewees point out, the transport and the storage are entirely dependent on the expertise and existing infrastructure of the fossil fuel industry. Apart from the fact that this could be seen as a major conflict of interest, any kind of removal also raises the question of how long the carbon can be stored. For nature-based solutions, this number can only be roughly estimated, and in any case it is impossible to say how long an entire ecosystem or even a single tree will exist⁷, as it could be affected by the climate crisis or other environmental catastrophes (Wong and Dutschke 2003, 1).

But even if there was an unambiguous number for permanence that could be applied to any credit, there are some unclear implications. If we talk about permanence as a quality that a credit either has or does not have, there is a gradation that is lost that leads to a conflation of quality and quantity embedded in the credit. If there is no guarantee that the carbon from a credit will be stored in the ground for more than 20 years, should that credit still be valid after that period expires?

⁷ It is not even possible to say how much carbon an ecosystem removes in the first place (Sierra et al. 2021).

One interviewee made this lack of conceptualization of time in the carbon credits explicit. He proposed to standardize the credits by their permanence. “I think that is a really good way of creating stronger climate impact today with a market. The market should try to emerge so that it standardizes around a fifty-year credit or a hundred-year credit, and really nothing less” (Informant 1). As an example: If the reference period was fifty years and a credit had a permanence of ten years, a company would have to buy five of them as the equivalent of a standard credit; either stacking them horizontally, meaning that the five credits would be bought at the same time, or vertically, buying such a credit every ten years for those fifty years. My interviewee would not stop there, but would also require a company to declare which emissions it is offsetting, so that a calculation can be made of the additional warming that those emissions would have caused if they had not been removed immediately. For a historical emission from 10 years ago, they would have to compensate for the additional damage it has caused over that period. He believes this would encourage companies to reduce their emissions more quickly because they would not want to be responsible for removing so many additional emissions by 2050 or 2100.

At first glance, this may seem like a negligible point when it is unclear whether CDR technologies will ever remove significant amounts of carbon from the air. However, Microsoft has set a goal of becoming carbon negative by 2030, which means removing more carbon from the atmosphere than the company emits. In doing so, they promise to remove *all* of their historical emissions by 2050 (B. Smith 2020). In less than 30 years, the amount of carbon in the atmosphere would be the same as if the company had never existed. Again, we could argue about how likely this scenario is to become reality, and what the consequences would be in terms of land-use and energy consumption, as they plan to achieve their goals through BECCS and DAC. But setting aside all of the other environmental and social consequences of the CDR, even if we accept the premise that Microsoft would have offset all of its historical emissions by 2050, it does not mean that it has not already done significant damage to the planet. 1.5 degrees of warming, which is not unlikely to be reached by 2030 and to which Microsoft would certainly have contributed to, could trigger irreversible climate tipping points (Armstrong McKay et al. 2022), some with feedback effects that could themselves release carbon dioxide into the atmosphere (Lenton et al. 2019). In this sense, while the concept of

when an emission that is offset has occurred may not seem particularly noteworthy at the moment, it should not be completely ignored. Claims like Microsoft's have consequences for the present because they are part of a marketing strategy. But they also have implications for the future if Microsoft's approach is used as a precedent for future removals of historical emissions.

The concept of time embedded in the credits is also relevant to the practice of selling credits that have not yet materialized. How can companies claim to be offsetting current emissions if the physical offset has not yet occurred? Are they using these offsets only for future emissions, or are they making claims in the purchases with these purchases?

It is questionable how likely it is that a system like the one described by my interviewee will be implemented. It also follows the overshoot logic that warming can simply be reversed 1:1 without considering tipping points, etc., and abstracting complex systems into numbers. However, the proposal illustrates another problem with carbon credits as they exist today. Not only do they have a dangerous discursive component when carbon credits are sold today that we cannot even say with certainty will ever be removed from the atmosphere. It is also conceptually dishonest not to explicitly state which emissions are being offset and to monitor how long that carbon is being stored. This further illustrates the problems with voluntary carbon markets: the point of these markets is not for an offset to perfectly compensate for an emission.

5.4 A "Jungle" of Certifiers

Many carbon removal credits sold on the carbon market are accredited by private certifiers such as Verra and Gold Standard (Broekhoff et al. 2019). Some marketplaces, such as Puro.earth, have their own certification methodology (Puro.earth n.d.). Among my interviewees, there is a general dissatisfaction with the way certifications are currently done. There are many reasons for this:

Existing certification programs are expensive and discourage small-scale removal projects. "A lot of voluntary carbon credits like Verra or Gold Standard are quite expensive. Like a few hundred thousand US dollars to acquire. So if you focus on small dense reforestation projects, particularly in Europe, where there is not so much land available, it becomes harder to find a project on such a large scale

to make that project worth the certification” (Olivier de Montety, Co-Founder and Non-Executive Partner of Treeseve).

The programs are unregulated and rely on trust. This adds to the aforementioned greenwashing aspect, as no public actor ensures the quality of control of the credits: “It is an unregulated market, so you have to choose from a certifier. And that certifier is not regulated by anybody. People just trust this certification institution” (Informant 5).

Even the certification programs with the supposedly highest quality standards have bad projects in them. “The current certifications are a joke. I mean, some of the projects that I have seen that have been certified are based on absolutely nothing” (Informant 3).

Certifiers do not have an appropriate methodology for all types of removals. “The Gold Standard is not really very good for the type of projects that we do. So the most popular one for what we do would be Verra, but they didn’t have their biochar methodology out” (Informant 2). By now, Verra does have a methodology for biochar and this problem cannot be blamed solely on the certifiers, as there are countless new methods of CDR coming up, all of which would require a somewhat unique certification process. Nevertheless, it is a problem that the start-ups are facing.

Many certifiers require the physical carbon removal to occur before certification, while many marketplaces want removals to be certified before they will accept them. “Several certification institutions want to see you remove carbon before you get certified. And a lot of marketplaces say that you should get certified first and then you can remove carbon, which makes no sense to me” (Informant 5).

The certification process should ensure the quality control of the carbon removal credits. Because of the problems mentioned by my interviewees, the actors who could to some extent prevent greenwashing, the distribution of undelivered credits, and the lack of clarity about permanence are unable or unwilling to do so and may even exacerbate these problems.

5.5 Carbon Credits as Mitigation Deterrence

Carton considers it “useful to distinguish between (1) negative emissions as material practice, as in the implementation of specific NETs, and (2) the discursive construction of negative emissions as a modelled, future solution to

climate change” (Carton 2019, 752). Carbon removal start-ups straddle the line of this distinction. On the one hand, they are one of the main drivers in the attempt to actually materialize removals, as they provide the physical basis for realizing CDR. In doing so, the start-ups are taking the mitigation deterrence out of models like the IAMs. They sell a concrete promise of how much carbon they will remove in the future, rather than a theoretical promise of what will supposedly be needed. However, unlike other actors in CDR, the start-ups are not only involved in selling the metaphorical dream of a carbon negative future. They are also literally selling the commodified carbon removal, reintegrating carbon removal into the sphere of capital accumulation. This is still embedded in a social dimension, as the discourse around the climate crisis is the reason why companies would find it beneficial to buy carbon credits on the voluntary market in the first place. But for a carbon removal start-up itself, this is first and foremost a business opportunity that it can capitalize on. On the other hand, they also shape the discourse by providing hypothetical numbers for future removals and representing a high level of confidence in their technology that can be used as a reference by other stakeholders involved when discussing carbon removals.

If we understand the overblown promises for future removals and the portrayed high confidence in the technology as a means to legitimize CDR as an essential tool for mitigating the climate crisis by temporarily fixing its current ineffectiveness, this is first and foremost a fix for a business model that is not (yet) working. The start-ups need funding immediately, but since most of them do not have a real product yet, they depend on other means to finance themselves. In that sense, this is more of an old-school fix in the sphere of capital accumulation.

However, since CDR in itself is a socio-ecological fix rather than a purely spatio-temporal fix, so this practice cannot be looked at in isolation; it is also embedded in and permeates into the larger discourse on CDR. “This is a conundrum that cannot be understood merely by focusing on the “fixing” that occurs within the immediate circuit of capital accumulation. It also requires scrutiny of the scientific and political work that enables such fixes to occur, work that is therefore co-constitutive of efforts to prevent widespread capital devaluation” (Carton 2019, 761). In this sense, the start-ups play an interesting role if we understand CDR as a fix to the crisis of legitimacy of fossil capital.

Firstly, the interconnectedness with the larger discourse is manifested in the promise of massive amounts of removals in the future. The start-ups allow policymakers to potentially rely on these numbers to justify climate inaction, thus, to some extent, fixing the socio-political crisis of legitimacy of capital in relation to the climate catastrophe. “To be useful as a carbon budget item, NETs have to be seen, at least provisionally, as a black-boxed ‘thing’ that can be planned—i.e. predicted and managed. The thinner and simpler the framing of the techniques, the more likely they are to seem predictable and manageable” (Markusson et al. 2022, 5). And providing plain numbers that make the removal nothing more than a quantity of carbon that will be removed from the atmosphere is perhaps the simplest way to frame it. The likelihood of these numbers to be achieved is secondary, the “exaggeration about GGR⁸ cannot be rationally dispelled in ‘real-time’, because GGR acts as a ‘time-machine’ in climate policy, being able to promise future reversal of current and past emissions, and thus becoming a ‘temporal’ socio-ecological fix” (McLaren et al. 2021, 16). In this sense, the temporal aspect of the removal credits is directly related to mitigation deterrence. By making promises about how much carbon they could remove in 30 years, start-ups are contributing to the construction of sociotechnical imaginaries that could actively shape how decarbonization is approached today. McLaren et al. call this the “*Exaggeration and the power of promises*” and warn that these promises are powerful “regardless of material viability” (McLaren et al. 2021, 8; emphasis in original).

Secondly, companies are using pre-purchases for marketing purposes, all the more so because they are buying them on the voluntary carbon market. This is exacerbated by the lack of clarity about which emissions are being offset and how permanent the corresponding removals will be. In this sense, the practice of trading of carbon removal credits (which have not been physically manifested) on the voluntary carbon market must be understood as small instances of mitigation deterrence in practice. Companies that engage in this practice may delay emission reductions, and consumers may get the impression that carbon neutral or net-zero products are part of the solution. Because these practices could backfire on the start-ups, mainly in terms of bad press, I encountered a mantra-like repetition that

⁸ GGR is an abbreviation for greenhouse gas removals, a synonym for NETs (Matthews et al. 2021)

reductions must come before removals. This is coupled with a high level of confidence that the Science Based Targets initiative⁹ (SBTi) will ensure that this is the way companies prioritize on their path to ‘net-zero’. “I would expect that such an organization like Science Based Targets sets the standard which enforces that a company really reduces its emissions” (Informant 5).

All of this could result in a cycle of legitimization (similarly described by Markusson et al. 2022). The IPCC legitimizes CDR by claiming that the technology is necessary to stay below 1.5 degrees of warming, or to get back to 1.5 degrees if we so happen to go beyond that. Because the IPCC is highly influential, these claims are then adopted by political institutions. Private capital sees this circumstance as an emerging market and a business opportunity and makes claims about how much CDR will be possible. These claims can then again be used by policymakers to prove that their plans are feasible and to justify a lack of real political climate action. This also allows for more funding for scientific research into CDR technologies.

I understand the current state of the certification processes as a part of this phenomenon. Certified removals do not meet the standards that most of the start-ups interviewed would consider necessary. This is a consequence of the fact that the carbon credits on the voluntary market are not supposed to be real climate actions. The low-bar certification process enables a system in which as many cheap credits as possible are available, while the certifiers have a strong interest in certifying as many projects as possible, as this is their source of income. Both the relationship between researchers, policymakers, and start-ups, as well as the relationship between certifiers, start-ups, and buyers of credits must be understood as mutually beneficial. It is in everyone’s interest to further legitimize CDRs for their own advantage. Everyone benefits except the people who suffer the consequences of the climate crisis.

5.6 The Neoliberal Institution That Wanted Regulation

There are several possible explanations as to what exactly motivates the start-ups’ to identify the problems associated with carbon credits and markets. It could be ethical, as the climate crisis concerns and affects people on a personal

⁹ An organization assembled by the World Resource Institute, the United Nations Global Compact, the Carbon Disclosure Project and the World Wide Fund for Nature, working with companies to ensure that those align their reduction targets with the Paris Agreement and to reach those targets (Science Based Targets initiative n.d.).

level. However, there is also a clear self-interest in ensuring a bright future for CDR credits, which would lead to profits for the companies selling them. I would argue that this circumstance does not make their critique any less valid.

For the start-ups, all the problems they identified lead to a high degree of *uncertainty*, a theme that came up frequently in my data analysis. First, there is uncertainty about how the prices and the markets will evolve: “It is a changing market so that makes it difficult for companies and private organizations alike to make informed decisions. Because a lot of it is still to be determined” (Olivier de Montety, Co-Founder and Non-Executive Partner of Treeseve). Then there is the aforementioned uncertainty about certification methodologies and how they might change in the future. One of my respondents admitted that for him, there is even uncertainty about whether the removals will work: “They are buying, in a sense, future and promises about carbon capture and carbon offsets. But that can be a bit more for communication than anything else, because you don’t know if it’s actually going to work” (Informant 4).

My analysis has shown that there is one uncertainty that precedes all others: the uncertainty of future regulations, which limits planning and hinders investment in CDR.

How things will end up jelling with the cap-and-trade system, NDCs¹⁰ and all these. I mean, that is still kind of to be seen and there is a bit of a risk in that and there is a bit of uncertainty around it. And it would be good to have clarity regardless of how exactly it is. [...] It is usually the uncertainty that makes it most difficult to mobilize investments which are sorely needed at the moment. (Informant 3)

However, this does not mean that the start-ups do not *want* more regulation. For all of the problems with voluntary carbon markets that my interviewees identified, the most commonly proposed solution is for policymakers to step in.

¹⁰ Nationally Determined Contributions, plans by nation states on how they want to mitigate climate change to meet the goals of the Paris Agreement (UNFCCC 2023).

And again, that is where regulation needs to come into play. So over time corporations will actually be obliged to set net-zero targets and have standards within them that have milestones that need to be achieved. Rather than it be in some places more of a marketing thing, just to look good. (Informant 2)

It is an interesting dynamic that it is start-ups – not actors usually known to be in favor of regulation – that are calling for the state to solve these problems. As Malm and Carton put it, “those who harbour hopes of a DAC-fuelled boom thereby find themselves in the awkward position of having to trust in the state as its catalyst” (Malm and Carton 2021, 37). The regulations they are explicitly asking for can shed some light on this atypical attitude.

There are several types of regulations that the start-ups consider useful or necessary. First, the start-ups want policymakers to provide a framework that standardizes the certification of carbon removal credits. “I think there needs to be more regulation, especially in the area of governance. It has to be clear that certain standards have to be met when you declare a CO₂ certificate” (Felix Harteneck, Co-Founder and CEO of Inplanet). Additionally, some are calling for more emitters to be included in the compliance markets. “I would like to see more businesses involved in compulsory ETS schemes” (Stephen Milburn, Founder and CEO of Nellie). And most importantly, the majority of the start-ups I interviewed would prefer to be part of the compliance market, namely the EU ETS, as most of them are located in the EU (or former EU, in the case of the UK). “Ideally, for us, it would be the integration of carbon credits into the EU ETS” (Olivier de Montety, Co-Founder and Non-Executive Partner of Treeseve).

Given these proposals, it is not surprising that the start-ups would like to see more regulation of the carbon removal market. The mentioned measures would ensure them a large demand for their product – the carbon credits – while simultaneously securing further investment. A standardized certification would also benefit them as long as they actually provide high quality carbon removals (which all of my interviewees claimed to do).

Most of my interviewees were also confident that regulation would happen eventually. However, it is unclear what this would entail and how quickly it will happen. There is also no consensus on how quickly it *should* happen. Some wanted the policy to be implemented much more quickly, while others expressed concern

that rushing the process could create new problems. “I am afraid that if regulations are made too quickly, it will create some mixed incentives that could create more problems than it solves [...]. It takes time to get good regulations in place” (Mike Carpenter, Co-Founder and CEO of InheritCS). Given the history of climate change policy (or rather the lack of it), I am not worried about a rush to regulation, but unfortunately, I am also doubtful that this will ensure the quality of the regulation that will be implemented.

5.7 The EU ETS – the Carbon Credit Panacea?

My interviewees were hopeful that the problems they identified would be solved in the compliance market. But this confidence deserves to be questioned, as I will show in this section. Since all of the start-ups I interviewed are located in the EU, most of them were talking about EU policy and specifically the EU ETS. Accordingly, most of the start-ups consider it a positive development that the EU is engaging more with CDR. “If the EU is bringing CDR on the agenda, then it can only be a good thing” (Informant 2).

While there are the aforementioned concerns about the lack of clarity on what future policy will look like, on a theoretical level, and especially from the perspective of the start-ups, relying on the EU for CDR regulations and integrating CDR certificates into the ETS seems logical. However, the EU might not be the best institution to turn to for climate change mitigation. Historically, the EU, and in particular its ETS, have not been known for effectively reducing emissions. The EU claims that the ETS resulted in an emissions reduction of about 41% from 2005 to 2020 (European Environment Agency 2021, 15). However, studies have found that these reductions are largely due to other reasons, mainly the promotion of renewable energy at the national policy level (Nicolas et al. 2014), improvements in energy efficiency and the economic crisis, meaning that “the price of carbon played a small role in the recorded fall in emissions” (Gloaguen and Alberola 2013, 29). A review of all studies on the EU ETS suggests that its annual reductions are “between 0% and 1.5%” (Green 2021, 9).

Recently, there have been some changes to the ETS that could make it more effective. In the last 6 months, as of this writing, the carbon price of the EU ETS has consistently stayed above 80€ and currently stands at 95€ (Trading Economics n.d.). Also, in December 2022, after the last interview took place, the

EU decided on some adjustments to its ETS. By 2030, the cap on carbon allowances is now supposed to be reduced faster than originally planned. Instead of 43%, it will be set at 62% of the 2005 level. In addition, the transport and buildings sectors will be included in the ETS from 2027, meaning that it will cover around 70% of the total emissions in the EU instead of the current 40%. However, allowances for these sectors will be kept separate, and more allowances will be added to the market if the price rises above 45€. Even those experts who trust in a cap-and-trade system say that this figure is too low. At least 100€ would be necessary for the measures to be effective, and it would have to rise to 180€ in the future. Furthermore, the EU will continue to distribute free allowances to energy-intensive industries until 2034, giving these industries little incentive to decarbonize faster (Wahnbaeck and Endres 2023). So while these minor improvements are being implemented, the ETS is still far from an ideal instrument given the EU's climate ambitions, and I doubt that this would change, if CDR credits were included.¹¹

Another common criticism of the ETS is that it acts as a ceiling for emissions reductions. This is because if a company reduces emissions beyond the required amount, it can sell its unused allowances, which can be purchased by other companies to offset their emissions. As a result, these companies may not reduce their emissions as much as they otherwise would have (Endt 2022). I believe that integrating carbon removal credits into the EU ETS would lead to a similar scenario. If the carbon is removed and used as an offset, it would only allow for a company to reduce its emissions more slowly and weaken the carbon price. Of course, the amount of removal credits is so marginal that in reality the effect would be insignificant at the moment. However, conceptually this still *is* the effect it would have. And if there ever is a large-scale implementation of CDR, decarbonization would be significantly slowed down.

This would undoubtedly still be an improvement over carbon credits being sold on the voluntary carbon market. And it could be argued that this would still have a positive effect in the long-term if it allows CDR to reach a stage of development where it can have a significant impact. In this respect, the inclusion of CDR in the ETS, if properly integrated and regulated, could improve the status quo

¹¹ One a sidenote, while carbon removal credits are not part of the ETS, carbon capture and storage (CCS) already is (Rickels et al. 2021). This is interesting, considering CCS is even more directly manifesting carbon infrastructure.

of CDR. Similarly, some participants in a workshop conducted as part of a study by McLaren et al. appealed “to rational economics, arguing that allowing GGR removals to trade in well-regulated carbon markets is a straightforward way of funding their development and deployment. But for many participants, carbon markets and the implied offsetting mechanisms involved are themselves the problem, and adding GGR to them would make for more prevarication and delay” (McLaren et al. 2021, 9). I agree with this assessment. After all, CDR does not address the root causes of the climate crisis. As long as carbon removals are understood and used to offset emissions, there is a risk that they will be misused.

Carbon removals can only be effective if they are solely aimed at removing carbon from the air, rather than being used as compensation for emissions. This requires “the formal separation of GGR incentives, targets and accounting from emissions reduction policy” (McLaren et al. 2021, 18). However, the only way this could be made possible in a capitalist system is through state investment. If the ultimate goal were to mitigate the climate crisis, this would be the logical approach. But as in many other areas, capitalist states rarely seem interested in providing measures to combat the climate crisis. Instead, they opt for benign market-based solutions that seek to maintain the status quo by any means necessary (Buller 2022). As Jasanoff argues, technology has a normative function that has implications for what kind of society is desirable and functions to maintain the status quo rather than change the underlying structures (Jasanoff and Kim 2015, 4). “GGR discourse can be understood as exemplary of how technological promises are enrolled in cultural, economic and political processes to enable prevarication and delay where significant change that is not purely technological and instrumental would threaten the dominant social order” (McLaren et al. 2021, 18).

The fact that we even need to talk about carbon removals, because a fast decarbonization has not already been underway for 30 years, makes this clear. Pure climate action does not work in the logic of capitalism, and carbon removal in itself is not profitable. CDR is a preferred solution because it does not require the quick abolition of the existing fossil infrastructure.

6 Conclusion

I wanted to find out how CDR start-ups relate to carbon removal credits. In general, the start-ups I interviewed have a positive attitude toward carbon removal credits and believe that they are the future of CDR. However, they also identified a number of problems that come with the credits as they currently exist. Most of my interviewees see a risk that CDR credits could be used for greenwashing, as companies purchase them for marketing purposes, sometimes even before they have been delivered. In this context, some of them note that it is often unclear which removal relates to which emission and for how long this removal will stay stored. The certification processes that should ensure quality control and prevent this are also lacking, according to my interviewees.

I then wanted to analyze how these dynamics described by the start-ups could pose a threat to act as a temporal fix and mitigation deterrence. The social imaginary of a technology that could remove massive amounts of carbon from the atmosphere in the future could lead to reduced decarbonization efforts in the present. Start-ups contribute to this dynamic by making promises that are unlikely to be met, underscored by the fact that some of the removals sold have yet to be delivered, and even those that have can be used for greenwashing purposes, rather than potentially mitigating the climate crisis. This effect can be further amplified by the actors involved in the carbon credit market and CDR discourse, including start-ups, political institutions, academia, and certifiers, who legitimize each other. While the start-ups interviewed believe that compliance markets, such as the EU ETS, can solve the problems they have identified, I disagree with this assessment. In my opinion, the concept of carbon credits and markets is the problem, not their implementation. As long as CDRs are used to offset emissions, decarbonization efforts may be slowed.

While I think it is unlikely that government investment in carbon removal will be for the sole purpose of removing carbon from the atmosphere as an end in itself, I believe that the only way to truly harness the potential of carbon removal is to do so in a way that is not driven by growth and profit. There is a body of literature that explores non-market-based approaches to carbon removal. Buck suggests that states could buy fossil fuel companies and reform them to do carbon removals and storage instead (Buck 2021, 230). Malm and Carton support this, adding that

governments could also take over the automobile industry and have it produce DAC units instead of cars (Malm and Carton 2021, 37). Similarly, Parenti argues for the nationalization of existing carbon removal technologies, comparing the climate crisis to a “massive military emergency” that requires rapid implementation of carbon removal (Parenti 2020, 130). While I appreciate his enthusiasm, it is important to consider how such implementation would affect marginalized communities. Whyte points out that carbon removal would benefit from the participation of indigenous communities (Whyte 2020, 75–77).

Overall, these proposals are intriguing but seem unlikely to be realized in practice. However, if carbon removal is to become a serious tool for mitigating the climate crisis, massive state intervention or a complete reorganization of society will be required. It is important to note that my study only examined the perspectives of start-ups. Further research could explore how their communication affects the larger discourse around carbon removal.

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Appendix A. List of interviewed start-ups

Name of the start-up	Date of the Interview	Product
Airfix	28.10.2022	Biomass carbon removal and storage
Inherit Carbon Solutions	02.11.2022	Carbon capture of biogas facilities
Inplanet	17.10.2022	Enhanced weathering on tropical soils
Nellie	02.11.2022	DAC and CCS using biotechnology
NeoCarbon	23.09.2022	DAC using existing cooling towers
Parallel Carbon	03.11.2022	Chemical DAC
Planboo	17.10.2022	Providing tools for biochar creation and measurements
<i>Anonymous</i>	02.11.2022	Enhanced weathering in walls build by robots
Ruumi	13.10.2022	Soil carbon sequestration and measuring on grazeland
Soilwatch	06.10.2022	Remote sensing to measure nature-based carbon sequestration
Treeseve (formerly TreesEverywhere)	26.10.2022	Reforestation projects in France with a focus on biodiversity
Xilva	12.10.2022	Marketplace for forest credits

Appendix B. Interview Questions

1. A question specific to the technology the company is employing/trying to employ → Potentially clarify what their product is (in case that this is unclear from the website)
2. What impact are you expecting your start-up to have long-term?
 - 2.1. Is a large-scale implementation of the technology/idea possible?
3. Is selling carbon credits your preferred and long-term business model?
4. How would you prefer to see carbon markets to be organized in the future?
 - 4.1. Do you prefer voluntary or mandatory (compliance) carbon markets? Why?
 - 4.2. What are your thoughts on the planned EU regulation for a standardized certification of CDR?
 - 4.3. There is a debate going on about which residual emissions are hard to abate and which can be seen as luxury emissions. In that regard: Do you think that markets should be regulated to establish which emissions can or cannot be offset?
 - 4.3.1. If yes: What kinds of emissions should people and companies be able to buy credits for? Which should they not be able to compensate?
 - 4.3.2. If no: How can a just transition be accomplished if those with the most purchasing power get to buy the carbon removal offsets?
 - 4.4. Let's say, a company is not actively trying to reduce its carbon footprint and thus exacerbating the climate crisis. If you had this choice, could you ever see yourself selling credits for a lower price to not support such a company?
 - 4.4.1. How much decision-making power about who the credits are sold to do you expect to have in the future?
 - 4.5. How do you predict carbon markets to be organized?
5. Do you think that carbon credits could undermine decarbonization efforts?
 - 5.1. If yes: What do you see as possible counteracts to this phenomenon?
6. Do you think that carbon markets are the future of carbon removals?
 - 6.1. Can you imagine a future with large-scale implementation of carbon removal technologies outside of carbon markets?
 - 6.2. How would this future look like? Try and depict it.

Appendix C. Codes

Name	Files	References
Assessment of carbon markets	0	0
Big numbers over small-scale approaches are an issue	1	1
Carbon CREDIT is a misnomer for the voluntary market	1	1
Carbon credits as internalization of externalized costs	3	4
Carbon credits lack transparency	1	1
Carbon finance enables new projects	2	2
Carbon finance for global justice, to redistribute global wealth	1	1
Carbon markets are an unstable environment	2	2
Carbon markets will solve the climate crisis	1	1
Carbon removals are necessary	0	0
IPCC	3	3
CDR credits are not the way out of the climate crisis	1	1
CDR needs capital now to be ready when it is needed	1	1
Prepurchases	1	1
Certification's methodologies did not fit	3	3
Changing focus on biodiversity and other benefits (nature-based)	1	2
Co-benefits of carbon finance	6	13
Commodification of nature	1	1
Compliance markets become relevant for CDR very slowly	1	1
Compliance markets will be important in the future	4	5
Confusing lack of standardized certification	1	2
Consumers will punish negative behaviors	3	3
Governments should not restrict claims	1	1
More awareness is necessary	1	1
Cultural change around climate change will affect business models	1	1
De facto standards are emerging in the	1	1

Name	Files	References
voluntary carbon markets		
Declare which (historical) emission you are removing	1	1
Demand is limited at the moment	1	1
Easier entry to carbon credits for the average person	1	1
Easier to sell on the voluntary market than to companies in the ETS	1	1
Few marketplaces in the future	1	1
Global regulation is unlikely	1	1
Governments might take shares of carbon credit sales	1	1
Greenwashing cannot be prevented globally	1	1
Growing incentives for carbon capture	1	1
Higher price leads to faster development and more technologies	1	1
Investors expect promises for certain numbers of removals	1	1
Market shakeup when both supply and demand increase	1	1
Markets must be simple	1	1
More regulation is necessary	7	13
More regulation will happen	4	5
MRV is the cornerstone of high integrity carbon credits	1	2
Nature based solutions will go down in the near future	2	2
Positivity around technological development	2	2
Preference for compliance markets	1	1
Compliance markets are more secure for start-ups	2	2
Price of carbon needs to be higher	2	2
Private actors are more proactive than public ones	2	2
Problems with existing certification programs	4	7
Profit must be the incentive for companies to do CDR voluntarily	1	1
Quality is not a deciding factor at the moment	1	1

Name	Files	References
Quality will be a more important factor in compliance markets	1	1
Regulation should not be rushed	2	2
Risk in focusing only on carbon (nature-based solutions)	2	3
Risk of bullshit coming into the market	1	1
Selling carbon credits is the main business model	1	1
Stacking credits; standardization around time	1	2
Substitute certificate for carbon credits	1	1
Supply could ramp up immediately	1	1
Supply is short of (expected) demand	1	1
Supply will increase	1	1
Technical removals are driven by philanthropy	1	1
The current state of the market is unacceptable	1	1
Timeline of low permanence CDR is not considered today	1	1
Transport options need to grow	1	1
Uncertainty around methodologies	1	3
Uncertainty around regulation hinders investments	1	1
Uncertainty around the future prices	3	3
Uncertainty around the markets	2	2
Uncertainty if removals will work	1	1
Voluntary market are a good first step	3	5
Voluntary market is where the demand is	1	1
Voluntary market needs to grow	1	1
Way more marketplaces than suppliers	1	1
Carbon credit buyers' behavior	0	0
Buyers are hard to regulate	2	2
Buyers should not be restricted	1	1
Buyers try to get a competitive advantage by being the first	1	1
Buyers value quality offsets	3	3
Buyers might look into quality control themselves	1	1

Name	Files	References
Buyers want removals	1	1
Demand will increase	1	1
Farmers should not have to offset their emissions	1	1
In the EU ETS, regulation for potential buyers is already happening	1	1
The price just needs to be right	6	10
There should be regulations for which emissions can be offset	1	2
Do carbon credits undermine decarbonization efforts?	0	0
Blockchain is a problem	1	1
Buying carbon credits is a PR exercise	2	4
Consumers punish offsets without reduction	1	1
Double counting can be a problem	1	1
Greenwashing is a problem	2	2
Greenwashing is an unfair market advantage	1	1
Improve market to prevent this	1	1
Most companies want to reduce	3	4
No because SBTI	3	3
Offsets mean transparency of existing emissions	1	1
Public regulation would help	3	4
Removals without reduction is a problem	1	1
Time conflict-CDR is necessary in the future but needs time to grow, even if it does damage short-term	1	2
Why focus on greenwashing instead of companies that do not engaged at all	1	1
EU policy	0	0
CDR credits should be included in the ETS	2	5
Cost of a credit would likely be fixed	1	1
EU is improving the ETS	2	2
EU policy will not have a strong impact short term	1	1
More companies or industries in ETS for higher prices	2	3

Name	Files	References
Most climate action just looks nice on paper but doesn't do anything	1	1
Power imbalances rather than reason decide policies (in the EU)	1	1
Reducing fossil fuel dependency too quickly would kill the economy	1	2
The EU should bring CDR on the agenda, it is good that they are	6	7
The regulations are late	3	3
Too many technologies to provide a standard for all of them	1	1
Uncertainty around future policies	3	3
Fossil fuel industry	0	0
Carbon capture is reliant on the fossil fuel industry	2	2
David vs. Goliath	2	2
Dilemma of having to work with them	1	1
Fossil fuel industry will lobby against changes	1	1
Fossil fuels will be used so might as well offset them	5	5
Oil will become less relevant in the coming years	1	1
Opportunity for different business model	1	1
Qualitative differences between oil companies	2	2
Reliance on cheap fossil fuels is unsustainable	1	1
Technology and infrastructure for carbon transport and storage	3	5
They have to slowly die	1	2
General climate politics	0	0
'Carbon tax is the best thing'	1	1
(Neoliberal) market positivity	1	3
Bottom-up approaches are key	1	1
Carbon credits is considered a dirty word by climate activists	1	1
Discourse about the climate crisis is too focused on GHGs	1	1
Lack of quality offsets implies a lack of interest in climate action	1	1

Name	Files	References
Regulation is unlikely in capitalism	1	1
Vilifying carbon is not helpful	1	1
We know what needs to be done	1	1
Removals without carbon markets	0	0
Accidental innovation will happen that is useful outside of CDR	1	1
CDR does not make sense without credits	3	3
CDR's potential to heal the planet	1	1
Desirable but not probable at the moment	1	1
Different revenue models will be possible, but additional	4	4
Governments don't have the capacity to scale projects	1	2
Hard to imagine	2	2
Time constraints	1	1
Use carbon credits only short term for a transition period	1	3
Utilization is not an option	1	1
Who do they sell to or work with	0	0
Market growth is a priority over ethics	2	2
It is complicated	1	1
No direct influence to reduce company's emissions	1	1
Not to everyone	7	10
Conscious businesses SBTI	4	4
Reputation is important	2	2
Companies care about reputation	2	2
Projects do not want capital from greenwashing	2	2
Reputation is not important	1	1
Success over moral standards	1	1
Suppliers should and will not have the responsibility	4	4
Understand how the credit is used	2	2
Other interesting statements	0	0
100 years permanence is not enough	1	1

Name	Files	References
Carbon credits are not profitable	1	1
Everyone benefits from carbon finance	1	1
Everyone would like to see massive carbon removal	1	1
It is the total amount of CO2 that matters	1	1
Lack of understanding of natural carbon sequestration	1	1
Skepticism towards other technologies and start-ups	3	4
The only way our business model stops working is if the climate crisis is solved	1	1
We can use one third of the earth crust exponential growth	1	1
We don't want to call them carbon credits as long as we are not certified	1	1