Pandora's Jar has opened: now what?

An explorative study to the navigation of key decisions and trade-offs in carbon removal policy in California and the Netherlands

Master's Thesis

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“Carbon dioxide removal is like a perfect prism for refracting all of climate politics into its factional squabbles.”

~ *respondent CA1b*

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Abstract

This thesis studies the navigation of trade-offs and key decisions in carbon removal scale-up policy. It does so by means of an explorative case study comparing two nations with emerging carbon removal policy: California and the Netherlands.
Starting from a literature review in which key elements were identified, this thesis then proceeds to analyse data from semi-structured expert interviews and from relevant policy documents.

This thesis finds that several intertemporal trade-offs arise in carbon removal policy: coupled with large degrees of uncertainty, these preclude informed decision-making by market parties. Market mechanisms are inherently limited in what they can achieve: a compensation market cannot provide net negative emissions, due to the latter being a public good. A large role for government in realizing carbon removals follows from this reasoning. Further, the alleged corporate capture of the powerful Californian regulator stresses the necessity of democratic decision-making in this field, since decisions made now produce significant lock-in effects for future generations.

This thesis contributes to economic theory by the understanding of net negative emissions as a public good. Further, it lays bare the threat of increasing democratic deficit during the development of carbon removal policy. This thesis marks a first step at economic-governance theoretical understanding of carbon removals.

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Introduction

Reducing global warming to 1.5 °C requires extensive deployment of carbon removals (Meyer-Ohlendorf et al., 2023). In fact, all climate models that plot a pathway to reducing global warming to 1.5°C assume that carbon will be removed from the atmosphere (Meyer-Ohlendorf et al., 2023). Furthermore, the European Climate Law requires “balance between greenhouse gas emissions and removals by 2050”. The EU further aims at net negative emissions in the second half of the century (Meyer-Ohlendorf et al., 2023).

Carbon removals are to be used for three goals: to counterbalance hard-to-abate emissions, to compensate for climate overshoot, and to accelerate the attainment of climate goals (Smith et al., 2023). Carbon emissions can be thought of as a carbon flow to the atmosphere, carbon concentration in the atmosphere being the stock. Conversely, carbon removals are a carbon flow out of the atmosphere. The first goal is thus to balance out the flows, the second is to make the outward flow greater than the inward flow so as to decrease the stock, and the third concerns the speed at which the net difference between the flows changes.

Carbon removal is however not without its problems: there is no free lunch. Carbon removals are all costly, consuming either large amounts of energy, land, water; having negative impacts on biodiversity, or combinations thereof (Anderson & Peters, 2016; Carton et al., 2020; Fuss et al., 2014; Markusson et al., 2018; D. McLaren, 2020). Increasing the flow of carbon removals from the atmosphere thus has costs involved, although these may not always be clear or expressed in money (e.g. biodiversity).

Emission reduction is also increasingly expensive, since marginal costs of abatement rise with more abatement realized. The low-hanging fruit of emissions reductions has mostly been plucked, and companies now face high marginal abatement costs (Gillingham & Stock, 2018). Some emissions may be considered hard-to-abate or residual emissions and thus not have to be abated, being balanced by carbon removals instead. A selection can be made based on cost of abatement, but perhaps also on societal or political grounds.

There is thus a trade-off between the level of emission reductions, and the volume of carbon removals used to counterbalance the residual emissions. Allowing high levels of residual emissions relieves financial pressure on emitters, but requires high volumes of costly carbon removals in return. Furthermore, the size of emissions flow into the atmosphere directly influences the potential for net negative emissions. The volume of carbon removals can thus be divided in two parts: those that counterbalance emissions, and those that reduce the stock of carbon in the atmosphere.

A risk that is related to this trade-off is mitigation deterrence: “the prospect of reduced or delayed mitigation resulting from the introduction or consideration of another climate intervention” (Markusson et al., 2018). McLaren (2020) has defined three types of mitigation deterrence with regard to carbon removals. Type 1 is when emission reductions are formally substituted for carbon removal in climate plans, and the latter fails to materialize. Type 2 happens if carbon removal technology produces additional emissions as side effects, for instance due to energy or land use. Type 3 mitigation deterrence is when emission reductions are delayed or foregone because of anticipated or imagined potential of carbon removal. Mitigation deterrence thus describes the risk that one side of the trade-off does not deliver: in essence, mitigation deterrence conceptualizes the uncertainty at one side of the trade-off. The risk is at making the outcome of a choice doubly negative: emissions are not reduced and not removed. Permanence and reversibility concerns are also risks that increase when moving towards carbon removals in the trade-off. If carbon is removed, but not stored permanently, the carbon removal is reversed and the carbon reemitted to the atmosphere. Furthermore, higher volumes of carbon removal have higher risks of harming policy goals in other areas, such as carbon capture and storage (CCS), energy, biodiversity and land use. Carbon removals are thus more uncertain than emissions reductions.

Carbon removals are needed to be able to compensate for overshoot of carbon budgets, complimentary to the trade-off in reduction versus removal, (Smith et al., 2023). The European Climate Law prescribes that net negative should be reached in the second half of the century (Meyer-Ohlendorf et al., 2023). Furthermore, discussion on historic responsibility for the stock of carbon may lead to increased ambition or obligation for Western countries (Burke & Gambhir, 2022). Carbon removal techniques thus need to be scaled up, even in the (hypothetical) scenario where all emissions would be abated.

Carbon removal has characteristics of both a market good and a public good, depending on its use for counterbalance or net negative. Carbon removal as counterbalance can take away (parts of) emission externalities and thus generate demand. However, carbon removal as net negative behaves as a public good: removing carbon from the stock in the atmosphere is non-rivalrous and non-exclusive. This raises questions about the role of governments in scaling up and procuring carbon removals: what role should government play, and what role can be left to markets? More specifically, there is the question how as a government to efficiently facilitate scale-up using market mechanisms via compensation of emissions, but be able to procure carbon removals once there is too little demand from private companies to achieve net negative emissions.

Accelerating the attainment of climate goals, the third use of carbon removals, calls attention to the time dimension (Smith et al., 2023). The European target is net zero by 2050, but the Paris Agreement calls for limiting warming to 1.5 degrees Celsius by 2100. Carbon budgets (the concentration of carbon in the atmosphere that will cause this warming) will however likely be exceeded in the coming years. Not only is net negative needed to remove overshoot, it is needed fast to avoid climactic feedback loops (Miner et al., 2022). Some of these feedback loops have the potential to cause additional carbon emissions to the atmosphere, increasing the global warming problem. To avoid these tipping points, volumes of carbon emissions and removals thus also need to be balanced dynamically, not only statically in 2050.

The societal consequences of inadequate climate mitigation (both removals and reductions) are immense, leading to extreme weather, starvation and sea level rise. However, the potential impact of carbon removals, even if they do assist in mitigating climate change, extends towards large swaths of land used for biomass production, water shortages, biodiversity loss and energy poverty.

Developing carbon removal policy requires navigating these trade-offs and barriers. Carbon removals are a complex economic good, the role of government is unclear and the urgency of deployment is high. The social values of timely climate mitigation, economic welfare, and the impacts on other social welfare determinants such as biodiversity need to be balanced in carbon removal policy. The trade-offs are often interlinked: navigating one has consequences for the other.

Some countries have started to think about carbon removal policy. In 2022, the state of California for the first time entered carbon removal into law, in its climate targets for 2045 (California Air Resources Board, 2024). Since then, it has been expanding legislation on the policy measures implemented to achieve these targets. Most relevant among these is the obligation for emitting entities to purchase carbon removal credits to counterbalance their emissions (Lebling & Riedl, 2023). The European Commission is due to publish a report on the implementation of emissions trading for carbon removal in 2026 (Carbon Gap, 2024). The Dutch government has started work on a carbon removal roadmap, outlining ways to support and stimulate carbon removal technologies without creating a carbon lock-in (Motie Erkens & Bontenbal, 2023).

In both these cases, there is a supranational governance dimension, which is expected to influence the room for manoeuvre in drafting national policy. The impact of the EU in the Dutch case, and the impact of the federal US government in the Californian case will be analysed in this case, to examine how these entities behave towards this new policy field.

This research seeks to contribute to finding a way towards development paths for carbon removal that balance societal interests and succeed in combating climate change. It will compare the Dutch and Californian experiences with carbon removal policy. The goal is to identify key decisions and trade-offs that only arise once policymakers seek to translate scientific concerns about carbon removal into actual policy that should mitigate these concerns. More specifically, this research will contribute by sketching how navigating the emission reduction-carbon removal trade-off is interlinked to other trade-offs and decisions. The comparison between the Dutch and Californian cases has as its goal to develop theoretical insights about carbon removals and their position within national and supranational climate policy.

To attain this research goal, the following research question has been formulated:

> *How does the navigation of trade-offs and key decision points in carbon removal development policies and strategy compare between California and the Netherlands?*

This research question has been divided into four subquestions:

> *Subquestion 1: what trade-offs and key decision points arise from Dutch carbon removal development strategy and policy?*
>
> *Subquestion 2: how does EU policy influence Dutch carbon removal policy?*
>
> *Subquestion 3: what key decision points and trade-offs and key decision points arise from Californian carbon removal development strategy and policy?*
>
> *Subquestion 4: how does US federal policy influence California's carbon removal policy?*

The choice for California and the Netherlands as units of analysis has been made because both are front-runners in the developing of carbon removal policy. Both are also involved in multi-level governance systems, which may influence the policy process. A comparison of the two is expected to yield insight as to which barriers are country-specific or path-dependent, and which may be more universal in developing carbon removal policy. Furthermore, because it is expected that California and the Netherlands may pursue different goals in the scale-up of carbon removals, it is plausible that barriers and trade-offs or their navigation may be different.

This report will continue first with a theoretical section, further analysing the problem and coming up with sensitizing concepts to serve as interview guide. In the following methodology section, the research design will be set out and justified. The report will continue with the empirics, presenting the data from the desk research and interviews conducted, together with the data analysis. A brief conclusion will mark the end of the report.

Literature review

The purpose of this literature review is first to further describe the problems surrounding carbon removal scale-up, and second to gather relevant adjacent theoretical insights in order to come to sensitizing concepts. These sensitizing concepts will serve as a basis for the interview guide.

Choice of literature

For this study, an interdisciplinary approach featuring both economic and governance literature has been chosen. This section will justify this approach.

Scaling up innovative techniques is an integral part of economic theory. The necessity to scale up carbon removals and the policies needed to do so cannot be properly understood without applying an economic lens: factors like cost, potential of supply, and the general behaviour of carbon removal as an economic good play important roles in drafting policies to stimulate scale-up.

However, carbon removals produce significant effects beyond the realm of climate mitigation, negative and positive, many of which can be hard to quantify and thus use within economic models. Examples are energy use, threats to biodiversity, water use and land use. These, combined with the role which carbon removals need to play in addressing climate change and the scale on which their deployment is needed, mean that applying an economic perspective alone cannot provide sufficient insight into scale-up policies.

A shift towards governance theory is needed to analyse how interests (specifically non-internalized interests) are transformed into policy (Stone, 2012). Choices made in economic policy often carry deep societal consequences: trade-offs apparent in economic theory may take on an entirely different form when non-quantifiable effects are considered. Furthermore, the different governance structures in the two cases merit the inclusion of this perspective. Governance and economics are not necessarily binary: the discipline can mutually reinforce in understanding the problem.

Taking an interdisciplinary approach, however, is more than taking a multidisciplinary approach (Menken & Keestra, 2016). Carbon removals as a subject of study warrants an interdisciplinary approach: economic and governance factors are inextricably linked. For instance, thinking about societally optimal outcomes involves matters of cost and benefit, but also (more so than in other goods) intergenerational equity and environmental concerns. As another testament to the need for interdisciplinarity in this case, Mazzucato's (2019) idea of 'grand challenges' implies that in the societal transitions of today, governments (should) define the goals and set the direction of change, while economic policy should be oriented to help achieve these goals. Therefore, picking isolated economic or governance theoretical lenses will highlight only part of this dynamic: to grasp the totality, both are needed and must be made to speak with each other (Menken & Keestra, 2016). The goal is thus to find common ground in the findings from both governance and economic perspectives and preferably to come up with some integrated theoretical concepts.

Purposes of carbon removals

The problem of global warming is caused by high concentrations of carbon in the atmosphere. This stock of carbon is caused by an increased flux of carbon emissions from the geosphere into the atmosphere, due to human activity in the industrial era. Carbon removals are human activities that remove carbon from the atmosphere stock and store it durably, either in the biosphere or in the lithosphere (Fankhauser et al., 2022). The biosphere concerns carbon stored in living ecosystems (mainly trees and animals), while the lithosphere is a term indicating geological reservoirs, from which fossil fuels are taken and in which CO^2 can be sequestered.

Carbon removals can be used for three purposes: to counterbalance residual emissions, to prevent overshoot of carbon budgets by reducing net emissions, and to achieve net negative emissions (Smith et al., 2023). In the first purpose, the flux of carbon from the atmosphere should be as big as the flux of carbon continuing to flow into the atmosphere. In this way, the atmospheric carbon stock is stabilized. The second purpose revolves around keeping net emissions as low as possible, to prevent overshooting carbon budgets. For the third purpose, achieving net negative emissions, the flux from the atmosphere should be greater than the flux into the atmosphere.

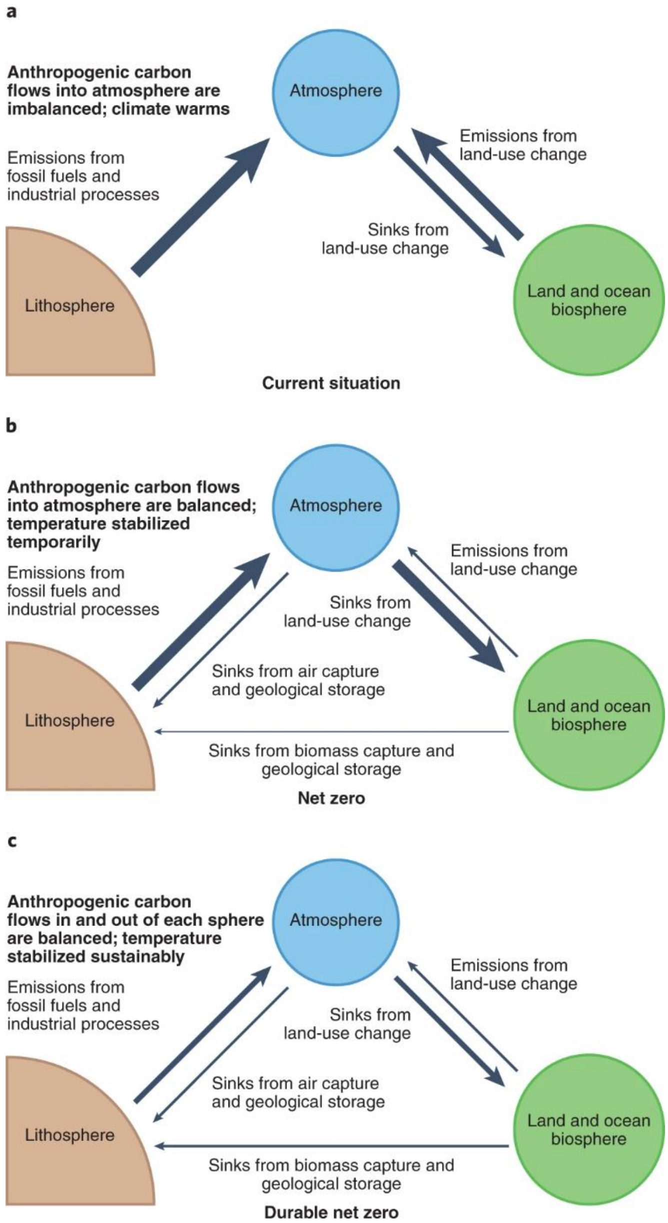


Figure 1: Carbon removals & durable net zero (Fankhauser et al., 2022)

For the first purpose, the net flux of carbon to and from the atmosphere should be zero; this is what the EU Climate Law prescribes as climate neutrality (McLaren et al., 2019). As figure 1 shows, carbon removals can flow into the lithosphere or the biosphere. Fankhauser (2022) states that in order to achieve *durable* net zero, the net fluxes out of the lithosphere should be zero. This concept seeks to avoid relying on an ever-increasing biosphere to compensate for continued fossil carbon emissions. Although the concept of durable net zero has not been mentioned explicitly in the EU Climate Law, it is conceivable that it will be a part of the legally required "balance between emissions and removals" (McLaren et al., 2019)

Mitigation deterrence, as outlined earlier, describes the moral hazard associated with the trade-off between emissions reduction and carbon removals (Markusson et al., 2018). While some volume of residual emissions is likely to remain, every exchange of emission reduction for carbon removal is problematic, especially when done intertemporally (D. P. McLaren et al., 2019). The question for governments and climate policymakers is how to overcome this dichotomy. There appears to be some grey area in the literature here, where the purpose of carbon removals as compensation for residual emissions is recognized as a legitimate goal for their deployment in the short to medium term, but at the same time seems to classify as mitigation deterrence and thus unwanted, especially if in the medium to long term these emissions escape reduction pressures.

The following sensitizing concept has been derived from this section:

SC1: Mitigation deterrence and emission reduction-carbon removal relationship

Definition of carbon removals

To define what counts as a carbon removal, Smith (2023) introduced two principles: carbon removals must capture CO^2 from the atmosphere, and subsequently durably store it. Thus, both the source and sink of the carbon matter for the qualification as carbon removal. Carbon Capture and Storage (CCS) is often confused with carbon removals: in principle, CCS is not carbon removal since it prevents emissions from going into the atmosphere. Only when biogenic emissions are captured and stored can CCS qualify as carbon removals (see figure 2).

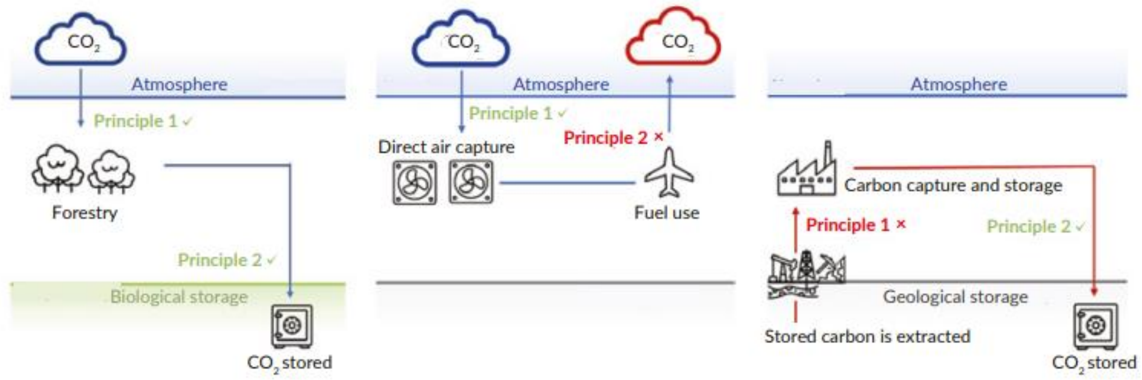


Figure 2: Two principles for Carbon Removal Qualification. Principle 1: carbon removals must capture CO^2 from the atmosphere. Principle 2: carbon removals must subsequently durably store carbon. From left to right: Carbon removal (CDR), Carbon Capture and Utilization (CCU), Carbon Capture and Storage (CCS) on fossil origin.(Smith et al., 2023)

Carbon Capture and Utilization intends to convert CO^2 into tradeable products. Converted CO^2 can be used for a number of products: to make fuels, plastics, carbonated drinks or for enhanced oil recovery (Smith et al., 2023). However, CCU as a category does not inherently conform to the two principles. Most commonly, CCU does not conform to the durable storage principle: for example when CO^2 -based fuels are burned, or a carbonated drink is opened, carbon is re-emitted to the atmosphere, and no carbon removal has happened. Furthermore, most CCU sources its carbon from fossil emissions, in which case principle 1 is violated.

While principle 1 (capture of CO^2 from atmosphere) is a more or less binary criterium, the durable storage criterium moves on a spectrum. While storage in fuels or carbonated drinks are commonly not recognized as carbon removals, the EU Carbon Removal Certification Framework regulation (CRCF) recognises storage in products with a duration of more than 35 years as carbon storage (European Commission, 2022).

Carbon removal techniques differ in their storage permanence (figure 3). Since CO^2 emissions have climate damage effects in the range of centuries, carbon removals used for counterbalance (purpose 1) must match these timescales in order to be effective (Anderson & Peters, 2016). Otherwise, carbon leaking from storage creates greater emission fluxes into the atmosphere in subsequent years.

Removal and storage pathway	Storage duration *(half-life)*
Bioenergy with carbon capture and storage	millennia
Enhanced weathering	centuries
Forestry techniques & wood products	decades to centuries
Single family home	*100*
Furniture, residential upkeep and improvement	*30*
Paper	*2*
Soil carbon sequestration techniques	years to decades
Biochar	years to decades

Figure 3: Storage duration of carbon removal techniques (Kalkuhl et al., 2022)

One of the most durable storage techniques for carbon is underground geological storage: old fossil fuel reservoirs and saline aquifers (geological formations containing salt water) that are able to store CO^2 (IOGP, 2019). These storage reservoirs are at this moment being developed to materialize capacity for CCS, and are thus often financed by the fossil companies owning these fields (Kampman et al., 2023). However, this geological storage capacity is scarce and its eventual volume unknown. Both CCS from fossil origin (classifying as emission reduction) and carbon removals using CCS (BECCS & DACCS, see below) will need to utilize this capacity, and are thus rivalrous. A trade-off is thus expected between CCS and geological carbon removals.

A single CO^2 market will likely arise, in which tonnes of CO^2 will be traded via pipelines between capture, storage and utilization plants (European Commission, 2024e). It can thus be expected that those companies demanding CO^2 for CCU purposes will have a willingness to pay for the CO^2 (since they use it as a resource), while the storage facilities will want reimbursement for their service of storage. The expectation can thus be made that suppliers of CO^2 from both atmospheric and lithospheric origin will – in an unregulated market – be inclined to supply CO^2 to utilization instead of storage demanding parties, adding no climate benefit or even doing climactic harm.

The following sensitizing concept has been derived from this section:

SC2: Relationship between carbon removal and CCS&CCU.

Non-permanent removals

A crucial question is thus what value non-permanent carbon removal (such as CCU, but also some land-based carbon removal) can have for attaining climate targets. Kalkuhl (2022) states that the degree of permanence influences an intertemporal trade-off: a less permanent removals portfolio has short-term benefits but long-term costs. Optimal pathways for carbon removals thus differ with storage permanence, as do carbon prices and fossil energy use.

Future costs of non-permanent carbon removals are currently not sufficiently internalized in their price signals on the voluntary carbon market (Burke & Schenuit, 2023). To integrate non-permanent removals into climate policy, a division needs to be made between which carbon removal is fungible with emissions reductions and which carbon removal is not, and how to use the latter in a sensible manner given that it cannot counterbalance emissions (Burke & Schenuit, 2023).

Treating non-permanent and permanent carbon removals as the same (i.e. completely fungible) product in a market has a high likelihood of inducing adverse selection. Lower-quality carbon removals (non-permanent) do not reflect long term costs and are thus artificially cheaper than high-quality removals (Burke & Gambhir, 2022). If fully fungible, these low-quality removals will force out high quality removals in the market for emissions compensation (Edenhofer et al., 2023). This resembles a form of adverse selection, where a good product is forced out by a bad product because it is difficult for buyers to distinguish between them (Akerlof, 1970). Akerlof predicts the market to then dry up, since only bad quality products are for sale. In this analogy, only low-quality removals would be sold on the market, with no demand for high-quality removals.

The voluntary carbon market in place at the moment has solved this problem by issuing different types of carbon certificates that check the quality of carbon removals, opting to reduce the information asymmetry between buyer and seller. Currently, on the voluntary carbon market both emissions reductions and carbon removals are sold to buyers who on a voluntary basis want some form of compensation. However, this market has too little volume and too low prices to stimulate more high-quality carbon removals (Smith et al., 2023). This may be a sign that the information asymmetry may not be reduced enough, or that high-quality removals will not be produced by private markets without government step-in.

A compliance carbon market is recognized as a policy option for the roll-out of carbon removals (Meyer-Ohlendorf et al., 2023). Emitting parties would be legally required to obtain carbon removal credits to compensate for their emissions. If however in the creation of this market non-permanent removals are made fungible with permanent removals, the same problem of adverse selection apparent in the voluntary market may return. As a result, the market would be flooded with non-permanent removals that may be cheap now, but may incur significant costs later.

Integrating non-permanent removals in a market for emissions compensation thus seems counterproductive: their positive effects need to be stimulated via other mechanisms (Simone, 2023). While these warnings have been uttered in the literature, a solid economic problem definition is lacking to back them up.

With regard to non-permanent carbon removals, the following sensitizing concepts have been distilled:

SC3: Definitions of permanent versus non-permanent carbon removal
SC4: The role of non-permanent carbon removals in climate policy
SC5: Informational solutions for non-permanent carbon removals

Developing permanent carbon removals

On the other hand, permanent (>100y) carbon removals are recognized to have a role in compensating residual emissions (Meyer-Ohlendorf et al., 2023). Storing CO^2 in geological reservoirs has a high (but not full) certainty of permanent storage and is thus more suited to serve as compensation for carbon emissions (purpose 1). However, permanent removals are also needed for purpose 2: net negative emissions. There is a trade-off between the two; carbon removals used to counterbalance residual emissions cannot be used for achieving net negative (D. P. McLaren et al., 2019).

In general, permanent carbon removal techniques are characterized by low technological readiness level (TRL) (Smith et al., 2023). TRL is a metric that classifies technologies by its readiness: ranging from 1-9, TRL scores indicate developments from theoretical functioning (TRL 1) through demonstrations in laboratory, relevant environment, prototypes up to full (commercial) deployment at TRL 9 (Mankins, 1995).

Carbon removal technique	Technological Readiness Level (TRL)	Cost at scale (\$/tCO^2)	Potential GtCO^2/y)
Direct Air Capture and Storage (DACCS)	6	100-300	5-40
Enhanced Rock Weathering (EW)	3-4	50-200	2-4
Bioenergy with Carbon Capture and Storage (BECCS)	5-6	15-400	0.5-11

Table 1: Technological Readiness Level, cost at scale and potential for permanent carbon removal techniques. Adapted from Smith et al., 2023.

The need for innovation to develop permanent carbon removals is evident, since permanent carbon removals are needed on large scales for climate neutrality pathways. There is a dichotomy in innovation literature between factors that influence supply for innovation and those that influence demand for innovation (Di Stefano et al., 2012; Nemet & Brandt, 2011). On the supply side, matters like cost and performance of technology matter, while on the demand side the technology use, the market in which the technology competes and public acceptance are considered (Nemet et al., 2018). Although descriptions and delimitations vary (Anadon et al., 2016; Grubler & Wilson, 2014), different stages of innovation can be distinguished within the supply and demand categories (figure 4) (Nemet et al., 2018).

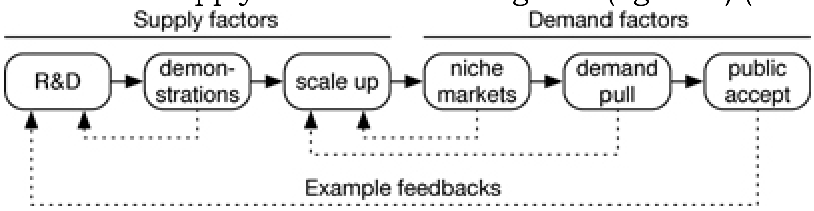


Figure 4: stages of innovation. Arrows show flows of knowledge. (Nemet et al.. 2018)

Nemet (2018) states that the supply "push" category of innovation with regard to carbon removal technology has been extensively researched, but that demand side "pull" factors have remained underrepresented in scientific literature. This hiatus signifies the risk of deploying carbon removals without proper consideration of the uses and users of these technologies (Nemet et al., 2018). This research will thus focus on the demand side of carbon removals innovation.

The demand side of innovation includes niche markets, demand pull, and public acceptance (Nemet et al., 2018). Niche markets in case of carbon removals concern for instance CCU markets, which help derisk investments for carbon removal plants but do not actually provide climatic benefits themselves (von der Assen et al., 2013). Public acceptance of carbon removals, both at adopter and at societal scale is an important factor in successful rollout. However, both these aspects will fall outside the scope of this study. The focus will be on demand pull, on the markets on which carbon removals will compete, and the way governments seek to structure those markets. The choice for this focus has been made because literature on this subject, especially from the economic perspective, seems lacking.

The sensitizing concept *SC6: Demand pull for innovation through markets* has been derived from this chapter.

Carbon removal markets

As mentioned earlier, the voluntary carbon market in place currently undersupplies high-quality permanent carbon removals, since low-quality removals and emissions reductions force them out of the market in a process of adverse selection. An effective distinction between permanent and non-permanent removals helps, but willingness to pay for high-quality carbon removals needs to be created by regulation. Only if willingness to pay for high quality removals is guaranteed by regulation, can markets execute demand pull for these innovative high quality techniques. As of yet, there is only demand for low-quality, low-price removals, which does not provide any prospect of a business case for developers of high-quality removals.

The dual purposes of carbon removals make it different from normal economic goods. Assuming permanent removals are more or less fungible with emissions, a removal could take away part of the externality of an emission. This means that under a cap-and-trade system, theoretically an emitter should be able to choose between reducing his emissions or compensating them with carbon removal (purpose 1). Compensation, for instance via certificate trading, makes carbon removal for this purpose a normal good: it is both excludable (only one emitter can use the compensation) and rivalrous (one emitters' use of the compensation precludes other people's use). The condition here is that it is clear who emits: property rights of the emissions are assigned to the emitter.

However, the second purpose of net negative emissions suggests that the exact same carbon removals behave as a public good once used for net negative emissions. Carbon removals are of their nature non-excludable and non-rivalrous (clean air is accessible to all, and one's enjoyment of it does not preclude another's). Since no property rights have been assigned regarding the stock of carbon in the atmosphere, certificate bartering is out of the question, since nobody would buy these certificates (except perhaps for moral reasons [Lambert, 2017]). This notion of net negative as public good is - to the best of the authors' knowledge – not explicit in existing scientific literature. Furthermore, net negative only appears in a handful of publications, whereas net zero is almost ubiquitous.

Assigning responsibility for historic emissions is difficult, since carbon emissions have not always been monitored in the past, and even if the knowledge is available, global intergovernmental decision-making (like in the UNFCCC) operates on a consensual basis. Therefore, it is hard to imagine (but not impossible) to see a division of historical emissions and corresponding carbon removal obligations (Fridahl, 2013).

This lack of assigned property rights for historical emissions (sometimes labelled scope-0 emissions) and net negative emissions thus being a public good uncovers oversights in methods to calculate the optimal mix for the deployment of carbon removals. For instance, Kalkuhl (2022) introduces an analytical framework for optimal permanent and non-permanent carbon removal deployment which is geared towards achieving net zero emissions. Edenhofer (2023) builds upon this framework, proposing a model to internalize costs of non-permanent carbon storage and assign liability for the carbon re-released. However, due to net negative emissions being a pure public good, it seems these models will only render outcomes that can at best achieve net zero.

These models consider the social cost of carbon (SCC) which is subdivided into the SCC-E (social cost of carbon emissions) and SCC-R (social cost of non-permanent carbon removal) (Kalkuhl et al., 2022). What these models try to achieve is an efficient deployment of carbon removals versus level of residual emissions, by pricing in uncertainty and reversal of storage. It is unclear from the model whether external effects of carbon removals (such as energy use, biodiversity, etc.) are or can be sufficiently internalized in the SCC-R, but even if so, it appears this model still could not provide net negative.

If carbon removal is treated as an offset, the opportunity cost of the carbon removal (amounting to roughly the negative value of the SCC-E) is ignored. The carbon removal could provide this negative SCC-E value to society if no emission was there to be counterbalanced. There thus seems a tendency to overconsume carbon removal offsets (D. P. McLaren & Carver, 2023).

Multiple net zero equilibria are possible. After all, net zero depends on the fluxes in and out of the atmosphere being equal, but does not imply anything on their size (Fankhauser et al., 2022). Overconsuming carbon removal offsets is thus likely to lead to an outcome that is societally less efficient than optimal consumption of offsets and an optimal public consumption of net negative carbon removals.

Considering the above, there appears to be a trade-off. Assuming that the upper limit of carbon removal techniques is independent of the volume of residual emissions, any compensation of residual emissions directly reduces the potential for net negative emissions (Buck et al., 2023; D. P. McLaren et al., 2019). This trade-off seems underrepresented in the literature, especially the literature that proposes operable instruments, which mainly focuses on instituting demand pull and ensuring financing by offset markets (Edenhofer et al., 2023; Kalkuhl et al., 2022; Meyer-Ohlendorf et al., 2023; Nemet et al., 2017).

This raises questions on the role of government. The previous section has highlighted the need for government to stimulate innovation and derisk investments so that the market can produce the good, while this section identifies carbon removals for net negative as a pure public good, that is underproduced by private markets, thus warranting public stimulation or provision (Lambert, 2017). The question arises how a government should then proceed with stimulating carbon removals, while at the same time also limiting the use for compensating, not wanting to exhaust the capacity of carbon removals and restrict potential for net negative. This question has not yet been addressed in literature.

The following sensitizing concepts have been derived from this section:

SC7: How to achieve net negative?

SC8: The role of government; stimulating and delimiting the use of carbon removals

SC9: The size of the residual emissions compensation market towards 2050

SC10: Consumption of carbon removals as emissions offset versus public net negative

Residual emissions

Conceptually, the most direct way for a government to steer towards a societally optimal balance between emissions and removals and to safeguard net negative potential is to define the volume of residual emissions in the net-zero year, and then determine the volume of carbon removals separately (D. P. McLaren et al., 2019). This is called the separate targets approach, in which there remain two 'gross' targets for emission reduction and carbon removals, instead of one explicit 'net' target. However, due to concerns around lock-in, countries are currently not explicit about the volume and sectoral origins of net-zero residual emissions (Buck et al., 2023) Also, desired net volumes of carbon emitted before the net-zero year are not explicitly stated in national climate policy (Buylova et al., 2021). To provide a clear commitment signal to carbon removal developers – granting them a future business case – and current emitters – providing clarity of payoff of mitigation measures – alike, countries should be more explicit in net-zero pathways. However, clear ways and timeframes to provide this clarity and what factors should be weighed in designating residual emissions seem lacking in the literature, or are at least not systematically presented.

The following sensitizing concept has been derived from this section:

SC11: Definition of residual emissions volumes

Multi-level governance

Hooghe and Marks (2021) have identified the concept of multi-level governance as an adaptation to scale diversity in the provision of public goods. Different public goods have different optimal provision scales, determined by scale advantages and heterogeneity of regional preference, and authority to provide these goods moves along government levels to correspond (Hooghe & Marks, 2021). This neofunctionalist approach to the development of multi-level governance in a process of regional integration relies on the concept of spillovers (van Meurs, 2018). Two dimensions of spillover seem most relevant to this study; functional spillover, in which supranational integration of one sector or commodity creates pressure to integrate in another sector or commodity, and political spillover, in which national actors increasingly see the supranational arena as better serving their interests, creating pressure for additional integration (van Meurs, 2018).

The delegation of authority from national governments to supranational institutions is explained by the strand of historical institutionalism theory. In short, this theory states that rational sovereign states delegate authority to institutions to facilitate intergovernmental agreements and credibly commit to these agreements (Pierson, 1996). This theory aligns with neofunctionalism in that functional spillovers can provide the pressures to achieve intergovernmental agreement, while the delegation of authority to a supranational institution is the method in which this agreement is facilitated (van Meurs, 2018).

An important tenet of historical institutionalism is path dependency: previous decisions (and transfers of authority) restrict future outcomes by means of increasing returns and sunk costs. A choice for one institutional arrangement disincentivizes other pathways (Pierson, 1996). Institutionalist theory has helped explain the stability of EU climate policy (Dupont et al., 2024). With the scramble to develop carbon removal policy and find a place for it within supranational climate frameworks, it is expected that elements of these theories can be traced within our Californian and Dutch cases.

The following sensitizing concept has been derived from this section:

SC12: Dynamics of multilevel governance

Methodology

This section will outline and justify the research aim, and the methodological choices taken in data collection and analysis. Furthermore, it will reflect on the impact of those choices on reliability and validity.

Research aim & approach

This study seeks to explore the interlinkage and the navigation of trade-offs in carbon removal demand pull policy in the Netherlands and California. This exploratory aim of research is justified, because although some limited theoretical knowledge on the characteristics of carbon removals is available, almost nothing is known about the way these characteristics are translated into policymaking in these countries and what choices policymakers face in this translation. As seen in the theoretical chapter, there appears to be some disconnect between the limited theoretical analysis of carbon removals available and the reality of policymaking. It is this gap that this research tries to fill.

This problem warrants an inductive approach to research. In inductive research, the researcher observes the real world, describes a problem, and seeks to derive generalized statements from this problem about cause or characteristics.

Inductive research is especially relevant for situations in which little is known about the subject, for instance when the subject is newly relevant (Van Thiel, 2022).

Adjacent theory, as identified in the literature review in this report, serves inductive research by identifying so-called sensitizing concepts. These sensitizing concepts guide the research, by describing issues that raise questions, are contradictory, under-researched or absent from adjacent literature (Van Thiel, 2022). The theory identified in the literature review is thus adjacent to the field of carbon removals, and serves to guide the research towards hiatuses.

Since explorative research can be hard to delimitate, it needs clarity on the scope of the research. This research tries to identify problems surrounding carbon removals, and how countries seek to navigate these problems. This research thus is not policy analysis, but a scientific problem analysis.

Research strategy

There are different ways to execute research and fulfil the research aim. For this research, a case study strategy has been chosen. This choice is warranted by the subject of study (carbon removal policy) being new and still barely implemented worldwide. Furthermore, the applied nature of this research and the subject being a concrete societal problem that will be addressed by policy makes a case study a suitable choice (Van Thiel, 2022). The aim of this research is theoretical generalization: to derive theory from these case at hand, that can be replicated in other cases (Yin, 2002).

Since case study research focuses on wealthy in-depth description of a case, instead of broad generalization capability, it is often difficult to develop theory from a single case. Yin (2002) states that having multiple cases allows for replication logic: in theoretical replication, cases can be chosen because of a theoretical expectation that outcomes will differ. By describing two contrasting cases, broader implications for other cases can be formulated based on either contrasts or similarities. This theoretical replication logic lies at the base of this research: it is the reason that this study uses a comparative case study design. Additionally, the delimitation of unit of study (carbon removal demand pull policy) and case (the respective countries) is more clear. Furthermore, it allows to make more fundamental theoretical claims, since these are based in two cases instead of one.

The case study design chosen is a holistic multi-case design, meaning that one unit of analysis (problems in carbon removal policy) will be investigated across two different cases within two different contexts: the Californian and Dutch case (Yin, 2002). Multiple cases can be homogeneous (i.e. expected to yield the same results) or heterogeneous/contrasting. In inductive research, it can be difficult to identify beforehand whether cases are contrasting or homogeneous (Van Thiel, 2022).

However, the internship done within the context of one of the cases (i.e. the Dutch climate ministry) helps with prior empirical knowledge, therefore giving some guidance on the case selection. The risk here is that embeddedness of the researcher in one of the cases may lead to bias.

Case justification

The cases chosen to compare the problem analysis of carbon removal policy are the California and the Netherlands. For selecting these cases, purposive sampling has been used (Van Thiel, 2022). The selection was influenced by some theoretical deliberations, but practical matters also played a role.

The first theoretical argument for choosing these cases is that both of these countries are frontrunners in developing carbon removal policy. Therefore, there is likely a lot to be learnt from their pioneering efforts, more so than countries who will follow suit. Of course, this argument can at this point in time also be read as a practical justification: countries not developing carbon removal policy yet cannot serve as case for its examination.

Second, California and the Netherlands are both in supranational (con)federations. While the governance characteristics, dynamics and division of competences of the US and EU differ, the common ground is that both supranational organizations have their own climate policy frameworks. This means that the countries themselves are bound within international commitments, which will influence the scope and form of their own carbon removal policy. For theoretical purposes, this is interesting, since a new policy field like carbon removals can bring along conflict over the division of competences between national and supranational governments, as well as a battle over national and supranational subject-specific preferences.

Research method

Within the case study as research approach, two different research methods have been chosen to collect data (Van Thiel, 2022). First, there is content analysis of documents, and second, expert interviews.

Both these methods yield qualitative data. The choice for this type of data has been made because the research problem (carbon removal policy) is small in number: both the population of carbon removal policymakers and researchers as well as policy documents are small. Therefore, the choice for a qualitative approach has been made: it was judged to fit better with the data available.

Content analysis of documents has been chosen because it is an easily accessible manner of exploring the cases at hand, and can be done in an iterative process to prepare for and reflect after the interviews, which can only be done at one point in time. The documents to be analysed can be policy documents themselves, but also surrounding documents like news articles and governmental press releases. These documents are suitable, because governments communicate via these channels about their problem analysis, seeking societal approval for implementing policies. Thus, analysing them yields insight in the manner government identifies the societal problem. From the content analysis of these documents, qualitative codes will be developed, for use in the analysis later.

Interviews will also be used as a method of data collection. The main benefit of interviewing in these cases is that because carbon removal policy is often still in development, there may be limitations to data collection, because of a lack of (accessible) documents. Interviews provide a more flexible method of data collection, in which anonymity may reduce the threshold for respondents to cooperate and share insights (Van Thiel, 2022). The interviews will take a semi-structured form; an interview guide will be prepared and followed throughout the interview, but there is room for respondents to introduce or expand upon their own inputs. Chiefly, the interviews are used to gather non-factual information: factual information can be taken from the content analysis executed beforehand, and interviews provide an opportunity to delve deeper (Van Thiel, 2022).

The selection of respondents has been made purposely, but has been limited by considerations of accessibility. Because the researcher was himself involved in Dutch policymaking, for the Dutch case policymakers have been found willing to cooperate in interviews. Complimentary, independent experts in the form of other researchers familiar with the topic will be interviewed. For the Californian case, access to policymakers was expected to be harder: there is thus probably a heavier reliance on second-hand knowledge. This may hurt the reliability of the research, however, triangulating findings via the analysis of documents will still produce reliable results. Further, by use of the snowball method, more respondents may be found.

Interviewing policymakers and relevant scientists adds to the validity of the research, because these people are themselves involved in the problem analysis phase of policymaking, and can thus provide data from the first hand. Of course, ease of access considerations were also relevant in making the choice of respondents: the personal network of the researcher made these respondents relatively easy to approach and more likely to cooperate.

The interviews will be transcribed and coded in a similar way to the content analysis of documents. In this way, triangulation in data source and resource method is possible, thereby helping the reliability and validity of the results. Especially if few inside respondents are accessible in the Californian case, triangulation may help in identify accurate and valid data (Van Thiel, 2022).

Data analysis

After the data has been transcribed, the first step consists of data reduction. Guided by the sensitizing concepts, data not deemed relevant will be excluded from analysis. This step of data reduction was done sparingly, since in inductive research, all data may prove valuable at a later point. Afterwards, codes will be used to delimitate data and facilitate comparison. Because this study is inductive, this will be done in a process of open coding, meaning gradual and iterative comparison to develop codes (Flick, 2022). Once a saturated coding scheme has been established, meaning no more additional codes can sensibly be assigned, axial coding will begin. At this stage, codes will be compared and contrasted, with the goal of integrating data; cause-effect relations, trade-offs, and other interconnections can be the result of axial coding (Van Thiel, 2022). In other words, codes will be used to develop axioms, out of which the theory development will take place.

Validity & reliability

Case study research can have an uneasy relationship with theory, and reliability and validity concerns are often greater in this type of research than in others (Van Thiel, 2022). Especially the small number of units of study, or cases, can hurt the validity and reliability of the research.

Addressing the validity concern of small-n case study research has been done in this study by use of method and data source triangulation. Combining data collection via different methods from different data sources (i.e. interviews with involved experts and content analysis of documents) benefits internal validity: errors or biases in one method can be identified and offset by the other. This way, it is more likely that the method actually measures what it intends to measure.

External validity (the possibility of generalizing from the cases to broader reality) is hampered by this study only being a two-case study. However, since the object of study (carbon removal policy) is new, less possible cases are available, and it is more difficult to gather data than in policy fields that are more established. This, together with time constraints has influenced the choice for a two-case design. In such a design, it is still possible to make some claims to external validity, since comparison between the cases will yield insight in the functioning of the developed theory (Van Thiel, 2022).

The reliability in this case study is helped by documenting the process of data collection and analysis. Thus, the interview guide is annexed to this report, and a log of choices made in data selection, coding and analysis as well.

One often-heard concern with regard to qualitative data analysis is the risk of researcher bias: the analysis may be too subjective because it is based on the researchers own interpretation (Van Thiel, 2022). This is an important risk in doing any qualitative research. As mentioned above, triangulation helps in mitigating this risk. Furthermore, keeping a case study protocol can help with the comprehensibility of the analysis, and thus allow reproduction or falsification to improve reliability.

Another common concern is that the external validity is scarce within qualitative, small-N research, since data analysis methods do not provide enough power to generalize among different cases. This is true, but the impact of this concern is limited because of the place of this study along the empirical cycle: its aim is to explore this case and develop theory, thus being inductive. Testing theory belongs to the deductive part of the empirical cycle (Van Thiel, 2022). Thus, it can be justified that these small-N qualitative data are used to develop theory.

Obstacles in this study & how they were solved

Perhaps the biggest obstacle identified beforehand was access to information and respondents in the Californian case. Due to an internship in the Dutch ministry of Economic Affairs & Climate, the researcher had personal connections with many policymakers and scientists relevant for the Dutch and EU case. Before reaching out, however, it was uncertain whether any of these connections were either knowledgeable about the Californian carbon removal context, or knew people who were. In the worst case scenario, therefore, it could be that no respondents for this case were found willing to cooperate.

It did not turn out to be so bad, however. Via the snowball technique starting with the EU respondents, several contacts were provided, one of which proved very willing to help – sending a case overview with relevant policies and providing a great start for the research in this case. Due to average response times of respondents, and the fact that reaching out to potential respondents for the Californian case could only start after talking to EU respondents, by the time the snowball really started to roll, there was not enough time anymore to hold and process interviews. This means that the analysis of the Californian case is based on one interview respondent – a Californian independent carbon removal policy researcher and advisor – although the data gathered from this respondent is around three times more than the average EU respondent.

Another obstacle was also related to the Californian case, although this one was unexpected. In the analysis of the Dutch case, an economic perspective was mostly applied to the data; seeking to understand the problems and trade-offs and developing theory on the basis of them

However, when data on the Californian case came in, it became apparent that this substantive analysis of carbon removal policy and the trade-off navigation was not feasible for that case. A policy discussion about the themes identified as part of the literature review was almost completely lacking. This lack of policy and visions about the trade-offs meant that it was hard to make an economic analysis.

In the face of this problem, and guided by the data from the interviews, a shift was made towards governance theory, to explain why this absence is present. Although governance theory was a part of this thesis from the start, it was expected to be of secondary importance: now, it suddenly became the only viable way to make a comparison. The focus of this research thus shifted from "how does the content of carbon removal policy reflect the navigation of key decisions and trade-offs?", more towards "how does the form of carbon removal policy, and the way it is established politically, influence the possible navigation of key decisions and trade-offs?".

However, this meant that governance analysis of the Dutch case needed to happen retroactively. This was not necessarily a problem, but if this problem was known beforehand, the interviews could have been geared more towards this dimension.

Reflection on limitations of execution & validity/reliability

This section will outline some reliability concerns and limitations, and argue why this research has credibility, even if it is not perfect.

The small number of respondents, especially for the Californian case, is arguably a weak point in this research. However, by use of triangulation with policy documents, the internal validity of this research was improved. It can furthermore be argued that because this research was inductive, aimed at developing theory, the small dataset does not necessarily present a problem: testing theoretical hypotheses is a part of deductive research, in which case larger datasets are needed.

Only having one interview respondent for the Californian case is however less than ideal. A further interview with this respondent about the subject, not conducted by this researcher but freely available online, was therefore analysed. This move helped limit researcher bias, but of course made the potential for respondent bias greater.

However, as a result of the knowledge gathered from the Dutch case, the position of this respondent, their incentives and their potential biases could be better understood. This has helped to prevent respondent bias from seeping into the report.

The use of a case study protocol has improved the reliability of this research: the interview guide, and other choices impacting the case study have been documented there. Further, the data and interview transcripts are stored, and readily available for replication research.

Overall, this research has sought to theorize on the problems and trade-offs in carbon removal policy, in cases with a supranational entity with climate frameworks. In further cases that have a supranational component, the conclusions from this research may be applicable, or serve as building blocks for the further development of theory. Additionally, the economic analysis as distilled mostly from the Dutch case can be added to the theoretical understanding of the problem of carbon removals governance. This economic part as resulting from the answer to subquestion 1, however, has due to the lack of policy in California only superficially been replicated among the cases. Further research may use these contributions to theory to subject them more to replication more intensely.

Case contextualization

Dutch climate governance

The Netherlands has a two-house legislature, with members of the second chamber able to initiate and amend legislation, while the first chamber formally can only accept or reject legislation, but has some informal amendment powers. Both chambers control the executive power, although the second chamber is more (politically) active, while the first chamber ensures the coherence and feasibility of legislation . Although in theory the representatives in the second chamber can (but rarely do) initiate legislation, most legislative proposals are initiated by civil servants of a relevant ministry, discussed in Cabinet and only then voted upon in parliament (Tweede Kamer, 2018). This means that the separation of powers is somewhat diluted, with the executive also filling part of the role of the legislative power (Eerste Kamer, 2024).

Executive power in climate policy is chiefly delegated to the Ministry of Economic Affairs & Climate, with a subdivision for Climate & Energy. Furthermore, since 2021, the Netherlands has had a dedicated minister for Climate & Energy Policy (Houthoff, 2023).

Climate policy in the Netherlands has, especially in recent years, focussed around emission regulation (Ministerie van Economische Zaken en Klimaat, 2022; Pappas, 2024). Subsidies and liability measures are also implemented, often in policy mixes, but the political environment has permitted ambitious and effective first-best emission regulation (Pappas, 2024).

Often, Dutch climate policy serves two masters: national targets and EU targets. Since part of the EU climate policy is organised on an EU scale (see below), it does not count for the Dutch reduction goal as agreed within the EU, but does count towards Dutch achievements for the UNFCCC inventories. Furthermore, Dutch national targets are often stricter than the international commitments (Ministerie van Economische Zaken en Klimaat, 2022).

The EU is recognized as one of the global climate leaders within international negotiations (Oberthür & Dupont, 2021). Over the last decade, member states have increasingly transferred competence to the supranational EU level, in hopes of committing to more effective policy (Wettestad et al., 2012). Furthermore, negotiations at the EU supranational level have been seen to open windows of opportunity domestically, in which more ambitious national climate policy can be implemented (Kreienkamp et al., 2022).

Dutch & EU climate targets

The Dutch Climate Law, approved in 2019, instituted a 95% emission reduction target compared to 1990 levels for 2050, with an intermediate target of 49% reduction in 2030 (Klimaatwet, 2019).

In 2021, the European Climate Law came into force, implementing a net zero target for 2050 and a 55% reduction compared to 1990 levels for 2030, both for the EU as a whole (European Climate Law, 2021). As a response to this law, the Dutch government adapted the national Climate Law to include the same targets on a national level: 55% reduction by 2030 and net zero by 2050. Furthermore, the Dutch government has the (non-binding) ambition to achieve 60% reduction by 2030 (Rijksoverheid, 2024).

Currently, a 2040 climate target is under discussion in the European Union, with the Commission proposing a 90% net emissions reduction target compared to 1990 levels, including 400 $MtCO^2$ in carbon removals (European Commission, 2024a). This target does not have legal effect yet, but is awaiting negotiations (Kurmayer, 2024). However, it is the first time the EU explicitly mentions a carbon removal target.

Both the EU and the Netherlands are signatories to the UNFCCC Paris Agreement limiting warming to well below 2 degrees Celsius, preferably below 1.5 degrees: the EU submits the Nationally Detemined Contributions on behalf of itself and its member states.

Carbon removal policies in the Netherlands

Relevant policies for carbon removals in the Netherlands will be described in this section.

<u>The Climate Plan</u> is the key Dutch policy instrument to achieve its climate targets, which is adopted at least every 5 years and sets out the main lines of climate policy for the 10 years thereafter. Two years after the adoption of the Climate Plan, a progress report is published, with potential additional measures to achieve the existing targets (Ministerie van Economische Zaken en Klimaat, 2020). In the newest Climate Plan, a net target will for the first time be incorporated, which will shift attention toward carbon removals (Ministerie van Economische Zaken en Klimaat, 2022). The newest Climate Plan, which will be published in 2025, will thus indicate intended volumes for carbon removals between 2025-2035.

<u>Roadmap Carbon Removals:</u> as a result of a parliamentary motion, the Dutch Ministry of Economic Affairs & Climate will publish a comprehensive strategic plan for the deployment of carbon removals, describing policy instruments needed to support and develop carbon removals without creating a fossil lock-in effect (Motie Nr. 1243, 2023).

<u>CRCF:</u> the EU Carbon Removal Certification Framework created a framework laying down EU quality criteria for carbon removals, helping to define and identify high-quality permanent carbon removals. (European Commission, 2024b).

EU LULUCF: under the EU Land Use, Land Use Change & Forestry (LULUCF) regulation, the land sector counts towards climate targets, currently constituting a net negative target for 2030 of 310 $MtCO^2$. Under this regulation, non-permanent nature-based carbon removals are governed (LULUCF, 2018).

ETS/ESR: The EU Emission Trading Scheme (ETS) and the Effort Sharing Regulation (ESR) are the other two pillars below European Climate policy, next to the LULUCF. The EU ETS is a European-level emission trading scheme, under which polluting entities can buy an increasingly lower amount of emission allowances. The ESR divides the rest (i.e. non-ETS) of the emission reduction obligations among the member states. Both instruments have provisions for future inclusion of carbon removals, but at this moment, carbon removals cannot be used to comply with either ETS or ESR obligations (European Commission, 2024c, 2024d)

SDE++: the largest sustainable subsidy scheme in the Netherlands, giving out subsidies for renewable energy production or CO^2 reduction. Under this subsidy, CCS on waste incineration plants is subsidized, resulting in carbon removal. Furthermore, this category CCS was planned to be expanded to include BECCS (Rijksdienst voor Ondernemend Nederland, 2024b).

Other subsidies: other subsidies, both on the EU and national level, mainly finance the R&D and demonstration phases of carbon removals. These include the EU Innovation Fund, Horizon Europe, DEI+ and the MOOI. In the latter two, however, currently CCS is mostly financed, not CCS for carbon removal purposes specifically (Rijksdienst voor Ondernemend Nederland, 2024a)

CCS: the Dutch government takes a facilitating and supporting role in the development of Carbon Capture and Storage infrastructure, speeding up the permitting process and implementing policy on CCS (Noordzeeloket, 2024)

Californian climate governance

California has a two-house legislature, with members of the Senate and the Assembly both able to draft bills, which will be heard in committee meetings and, if approved by the House of origin, goes to the second House (not the House of origin). If approved by both, it can be signed by the governor: a governors' veto can be overturned by a two-thirds majority in both houses. Currently, the Democratic Party holds veto-proof majorities in both houses (CLEE, 2024). The legislature has the power to implement legally binding legislation, including the setting of climate targets.

Executive power in climate policy is for a large part concentrated in the California Air Resources Board (CARB), as a result of Assembly Bill 32 (CLEE, 2024). CARB is free to implement any regulatory measures in order to attain legally binding climate targets. To this end, CARB wrote and periodically updates California's Climate Change Scoping Plan; a document that sets out the strategy and sectoral targets for meeting emission reduction targets.

CARB is embedded in the Californian Environmental Protection Agency, which is comparable to a ministry and reports to the governor. The members of the Governing Board of CARB are appointed by the governor. Thus, CARB is situated within the executive branch of Californian government.

As a whole, California is among the most active US states in emission regulation(Pappas, 2024; Plumer, 2019). These active states implement their own emission regulations, and seek judicial action against federal inaction on climate issues (Pappas, 2024).

The power to implement emission regulation on the US federal level is mainly concentrated in the executive branch: however, federal legislatures have over the last years been caught in *inaction*, while the competences of the executive to go beyond the legislature's ambitions have been restricted by the Supreme Court (Pappas, 2024). In the past, the Obama and Biden executive administrations have succeeded in nudging federal emission policy to more active regulation paths, but real control over these policies often remains gridlocked in the legislative US Congress.

Pappas (2024) identifies that while first-best emission regulation policies thus do not seem realistic in current federal dynamics, policies previously conceived as second- or third-best in terms of effectiveness, like subsidies or liability measures, have more political potential to address climate change (Pappas, 2024).

With a lack of federal leadership, some individual states have taken ambitious measures in mitigating climate change. In this federal-state dynamic, these leader states have set examples, but are bound by small budgets and limited legal competences (Stokes & Breetz, 2020). Importantly, these states on their own cannot invest unilaterally in developing new technologies.

Californian & US climate targets

Relevant policies for carbon removals in California will be described in this section.

First, there is the legally binding climate target for 2020, as set out in AB 32 (Global Warming Solutions Act of 2006), which set targeted a return to 1990 emissions levels by 2020. Authority was delegated to CARB to implement regulations to achieve this target. Under AB 32, CARB was instructed to write and regularly update a Scoping Plan to indicate the strategy for achieving the targets (AB-32, 2006)

SB 32 expanded upon this act in 2016, setting a reduction target of 40% below 1990 emission levels by 2030. SB 32 was accompanied by AB-197, which increased legislative control over CARB by appointing two legislative members to its board, and requiring CARB to publish greenhouse gas inventories (AB-197, 2016; SB-32, 2016).

A series of executive orders by Californian governors set directives for climate targets. These executive orders are subject to legislative and judicial review, but have the power to direct government agencies towards achieving certain goals, especially when different goals overlap (Nichols, 2009). In these executive orders, the following climate targets were set out: a return to 2000 emission levels by 2010, return to 1990 levels by 2020, 40% below 1990 levels by 2030, 80% below 1990 levels by 2050, and statewide carbon neutrality by 2045 (CLEE, 2024).

Most recently, AB 1279 instituted a legally binding 85% emission reduction target by 2045 (the net zero year) (AB 1279, 2022). This bill was implemented in parallel to the most recent Scoping Plan, which incorporated carbon removals for the first time. This scoping plan called for the full remainder of emissions (i.e. 15% of 1990 emissions) to be compensated by carbon removals (Lopez, 2022).

The federal US emission reduction targets amount to 50-52% below 2005 levels by 2030, and net zero in 2050 (White House, 2021). The US ratified the 2015 UNFCCC Paris Agreement, committing to keep global warming well below 2.0 degrees Celsius above pre-industrial levels, preferably below 1.5 degrees. However, under the Trump administration the US withdrew from this agreement. Almost immediately after the election of president Biden, the US re-entered the Paris Agreement (Kemp, 2017; Merica, 2021). This means the US is committed to submit a Nationally Determined Contribution, which needs to be “an ambitious effort” and “represent progress over time” (UNFCCC, 2016).

Carbon removal policies in California

Carbon removal-relevant policies effective in California that aim to achieve the above targets are the following five (Lebling & Riedl, 2023):

SB 905 (Carbon Sequestration Carbon Capture, Removal, Utilization, and Storage Program), a Californian law implementing a regulatory basis for the development of geological carbon storage projects, including guidelines on environmental safety and the protection of nearby communities, but also instating monitoring requirements and liability (SB 905, 2022).

SB 27 (Carbon sequestration: state goals: natural and working lands: registry of projects), implementing a register for temporary nature- and land-based carbon removal projects, and gathering emission data from these projects (SB-27, 2021)

SB 308 (Carbon Dioxide Removal Market Development Act), an act that would oblige large emitting entities to purchase increasing percentages of carbon removals to compensate their emissions, starting with 1% in 2030 and ranging up to 100% of their emissions in 2045. This bill has been on hold for over a year after passing the senate, and thus does not have legislative effect (yet) (SB-308, 2023). On the 5th of June, 2024, the bill was amended in the Assembly (where it was held up) and re-sent to its legislative committee. In this amendment, the focus of the bill shifted from obliging individual companies to compensate for their emissions towards a state-level obligation to ensure minimal amounts of carbon removals per year as a percentage of that calendar years' emissions, beginning with 1% in 2030. Furthermore, it seeks to define carbon removals as removal of carbon dioxide from the atmosphere (not just avoidance or reduction of emissions), and places requirements on the longevity of storage and the sourcing of biomass used (SB-308, 2023). Even after this amendment, however, this bill still does not have legally binding value.

Bipartisan Infrastructure Law: as a part of this federal act, the US Department of Energy subsidizes research and development, as well as deployment, of DACCS hubs: concentrated areas where DACCS installations will be developed and deployed. As a part of this act, $3.5 billion will be given out to 4 DACCS hubs across the US, and in the first round of funding, some feasibility and engineering studies were allocated funds from this act (Bipartisan Infrastructure Law, 2021)

Bipartisan Budget Act: this federal act implements a tax credit (called 45Q after its place in the US Tax Code) in which companies that store CO^2 underground get access to a tax credit, and even direct payment, based on the amount of CO2 sequestered underground. Any entity storing CO^2 is eligible for this credit, regardless of the origin (atmospheric, biogenic, or fossil) of the CO^2 stored. This tax credit at this moment is one of the primary drivers behind the development of carbon management infrastructure (Bipartisan Budget Act, 2018; Carbon Capture Coalition, 2023).

The existing legislation on carbon removals in California thus can be characterized by facilitating on the state (Californian) level, ensuring project development does not cause negative effects on the direct surroundings of the project. Additionally, some federal subsidies are available to finance R&D and commercial deployment. However, as Lin (2020) has indicated, significant concerns – such as technological lock in, moral hazard, and coordination of research – are unaddressed by existing law. SB 308 in its amended version somewhat tries to address this gap, but is still not signed into law.

Empirics

This chapter will outline the relevant empirical data gathered during the research, and seek to perform preliminary analysis, building up for the conclusion. The data has been ordered along the lines of the literature review: every section contains the data from both cases as relevant to the sensitizing concept discussed.

Mitigation deterrence/trade-off carbon removals-emission reductions

In the literature review, the tension between the concept of mitigation deterrence and the conceptual trade-off between emission reductions and carbon removals was described: on the one hand, mitigation deterrence should be avoided by keeping the focus on emission reductions, but on the other hand, there is recognition in the

literature that carbon removals can be used to compensate or balance residual emissions.
Relevant Sensitizing Concept:
SC1: Mitigation deterrence and emission reduction-carbon removal relationship

In the interview, the following question was asked:

> *How do you perceive the relationship between emission reduction and carbon removals in government policy, especially with regard to mitigation deterrence?*

<u>Netherlands:</u>

An interesting distinction could be identified in the answers to the question above as to who would "commit" mitigation deterrence. Two levels can be identified: company-level mitigation deterrence and state-level mitigation deterrence.
EU1 and EU2 were, without explicitly mentioning the division, mostly concerned with company-level mitigation deterrence. Thus, their perception was that government policymakers should implement guardrails to prevent mitigation deterrence from happening. For instance, EU1 indicated that:

> ***EU1:*** *so once you kind of create that firewall and you prohibit the claimed neutralisation of fossil fuel emissions with land sink or biosphere carbon removals, you've already eliminated most of mitigation deterrence.*

EU2 also pleaded for a firewall, albeit a different one. In his view, governments should make clear that emission reductions and carbon removals are not to be traded off:

> ***EU2:*** *How do we keep a very tight firewall between emissions and removals, and I've seen that being tempered with, both by removal developers needing money who see the ETS as a source, and by polluting industry who see removals as a way to not have to do too much emission reduction.*

NL1 proposed another pragmatic safeguard: a 1:2 volume compensation exchange rate for emissions and removals. That way, he stated, the fundamental pressure of mitigation deterrence is not solved, but a compromise could be reached, wherein some room exists for emissions to continue, but there is also more climate ambition than net zero.

All suggestions above revolve around governments designing robust policy to prevent mitigation deterrence from happening in the domain that is regulated: be that the industry under EU ETS or other fields.

However, another dimension to mitigation deterrence can be identified from our data. NL1, NL2 and NL3 implied a struggle with mitigation deterrence at state level. NL3 characterized this struggle in regard to high pressure on emission reductions in the face of carbon removal availability as:

> ***NL3:*** *once the economy starts pushing, it may be hard to keep resisting [for climate benefit].*

At state level, NL1 indicated, it may make sense from a societal benefit perspective to allow some more residual emissions to continue in the face of high volumes of carbon removals. From the side of industry and emitters, government is under continuous pressure to allow more residual emissions. Therefore, states themselves may also "commit" mitigation deterrence by making the explicit choice to allow more emissions to continue, or a more implicit choice in selecting and attributing importance to different climate policy instruments.

<u>California</u>
Except for targets which include carbon removals, and some federal-level stimuli, California does not have carbon removal policy, nor is there a dedicated policy discussion ongoing, according to CA1a. Thus, it is difficult to talk about policy-induced company-level mitigation deterrence. However, on the state level, respondents characterized the state of carbon removals in California as follows:

> ***CA1a:*** *This is one of the best examples in the real world of how just a complete […] smokescreen around "let's do carbon removal right", is not actually encouraging a strategic vision for carbon removal that's realistic, but is being used to deploy point source CCS, in ways [of which] we don't know exactly how it's all going to play out, but it very much could go in the wrong direction because there is no comprehensive framework in the state or at the federal level.*
>
> ***CA1b:*** *So if I told you that a big important player had put out a plan that relies, pretty substantially, for almost a quarter of its net zero goal, on a sort of speculative set of technologies with no detail on what they are, how to deploy them, and was taking no near-term action and deferring this conversation on the basis of some incomplete modelling, you'd say, "that sounds like an oil company."*

Thus, the reliance on carbon removals without proper planning or action for their deployment can also be classified as mitigation deterrence on the state level. In the Californian case of state-level mitigation deterrence, two elements seem to be at play: first, at a state level, CARB explicitly plans for 25% of emissions to not be reduced, but be compensated by carbon removals, and second, CARB thus far has undertaken no effort to realize carbon removals.

<u>Conclusion:</u>
Respondents in the Dutch case seem most preoccupied with preventing mitigation deterrence within their policy design: a policy should not incur less emission reduction because of carbon removals. However, there is some implicit recognition that a state can make the choice to allow some emissions to continue, because carbon removals are available; thereby committing mitigation deterrence on a state level. The Californian case provides another example of state-level mitigation deterrence. California setting a target in which carbon removals are included, but not implementing policy to develop those removals, seems a case of type-1 mitigation deterrence: substituting removals for emission reduction, with the former failing to materialize.

Carbon removals and their relationship to CCS & CCU

In the literature review, the relationship between carbon removals, CCS & CCU was explored. From that section, the hypothesis arose that due to the two principles for carbon removals, it is easy to distinguish between carbon removals, CCS on fossil emissions, and CCU. Furthermore, the expectation arose that a universal CO^2 transport market would arise, in which CCS, CCU, and carbon removal players would operate. In such a market, the expectation exists that carbon from fossil origin would compete with carbon from atmospheric origin for storage; and that storage operators (CCS & carbon removals) would compete with utilization buyers (CCU) for carbon.
Relevant Sensitizing Concept:
SC2: Tradeoff between carbon removal and CCS&CCU

In the interviews, the following question was asked:

How do you see the relationship between CDR & CCS/CCU?

Netherlands:
A Dutch parliamentary majority requested the minister to push for European definitions of CCS, CCU and carbon removals, and to push for regulation of these techniques from a specific climate angle (Motie Kröger-Teunissen). On the European level, the Commission announced the initiative of the Industrial Carbon Management Strategy, in which CCS, CCU & carbon removals are treated as three inherent pillars. However, at this point, a clear framework (for instance using the two principles) that can distinguish between the three technological categories is absent. Their inclusion into one strategy, however, was defended by respondent NL3: he sees them as related technologies, utilizing the same carbon infrastructure and thus united in need of developing that infrastructure.

All relevant respondents envisioned a future CO^2 transport market, in which supply and demand of CO^2 meet for storage or utilization purposes. Where NL3 disagreed with NL1 & NL2, however, was his perception of the potential competition between CCS/CCU and carbon removals. NL3 saw the development of storage potential by fossil industry as necessary and pragmatic in the need for quick development: he called the cooperation of these companies logical, since they own the assets (pipelines, storage reservoirs) that are needed to inject CO^2 into the ground. He saw the cooperation of these companies as their chance to contribute to the solution of the climate problem, and did not foresee a lock-in effect. He did not necessarily see the ownership of CO^2-infrastructure as a barrier to carbon removal scale-up, since Third Party Access is guaranteed in European legislation. However, he also mentioned receiving signals of market power by infrastructure owners and exclusion on technical specifications of CO^2, which may yet constitute barriers to the access of atmospheric CO^2 into CO^2 transport infrastructure.

However, NL1 and NL2 identified more problems. NL2 stressed the scarcity of underground injection storage and the fact that the envisioned CO^2 will be traded on a European single market, precluding or limiting state control. The scarcity of storage thus meant that currently, overreliance on CCS may be occur, hindering the ability of the Netherlands to realize net negative emissions after net zero as a result of international obligations. NL1 added to this by mentioning that currently, the price of storage does not reflect its long-term societal value: he mentioned that a ton atmospheric CO^2 stored in 2045 may produce far more societal value than a ton fossil (easy to mitigate) CO^2 stored now. A trade-off can thus be identified over time: allowing fossil CCS now precludes using the same storage for storing atmospheric CO^2, or even CO^2 from more hard-to-abate emissions later.

Navigating this trade-off efficiently requires information on the volume and price of future storage. NL1 indicated that since reservoirs nearby the coast are now developed and demand for storage expected to rise, the price of geological storage may yet rise drastically, while NL3 expected technological scale-up to do its work and result in lower prices for carbon storage: he also pointed towards large reservoirs fit for carbon storage in Norway and the UK. Depending on the perception of the future availability of storage, different levels of government regulation of the carbon transport market may be necessary: the Dutch government previously treated the carbon transport market as business-to-business, but is prepared for more stringent demands coming from the EU level (Ministerie van Economische Zaken en Klimaat, 2024).

NL3 further indicated that for his part, carbon removal discussions originated in international discussion fora geared towards CCS. In these discussions, first CCU was brought up, and a couple years later (he indicates around 2021) carbon removals came into the picture. He added that in the beginning years, the motives to develop CCU were not as clear as those for CCS and carbon removals.

California:

In California, at the time of writing, there is no clear legal definition distinguishing carbon removals from CCS & CCU on a basis of climate benefit or the two principles. California prohibits the injection of CO^2 into geological reservoirs for the purpose of Enhanced Oil Recovery (a CCU technique which injects CO^2 to extract more oil) under Senate Bill 905. This bill also regulates the construction of geological injection plants in terms of their monitoring, construction and the pollution of their immediate environment (SB 905, 2022). Furthermore, respondent CA1a indicated that the injection of CO2 into Class II wells (oil & gas reservoirs) is forbidden under SB 905, in an attempt to detach carbon injection (for CCS/carbon removals) from the fossil industry.

The federal government, under the 45Q tax credit, stimulates geological carbon injection. CA1a indicates that this implies CO^2 from any source; fossil CCS and carbon removals are treated in the same way. This federal incentive scheme stimulates the development of carbon infrastructure. From a climate perspective, however, this incentive scheme treats emission reduction and carbon removal the same, not imposing any guidance on desired volumes among the two, even though they compete for the same – scarce – storage volume.

CA1a states that under the premise of this 45Q tax credit, and the assistance in permitting by both California and the federal government, a lot of injection capability is being developed, providing supply of storage. However, the respondent states that the discussion in the policy environment on what origin the stored carbon should have (fossil or atmospheric) is not being held, or only superficially:

> ***CA1a:*** *And so arguably, what's going on here is under cover of* carbon removal is good and we need to scale it *[…] a lot of development is occurring where it is not possible to answer the question:* ***is this actually resulting in a reduction in emissions?*** *Because you could build and many of these projects involve new gas infrastructure being built where the emissions will be captured. Some of it will probably include biomass BECCS plants. Which, at least from my perspective, does lead to some net carbon removal, […] but those projects are happening and so there is some carbon removal happening, but the broader question of what kinds of carbon capture and carbon removal in underground sequestration projects do we want to have there is no coherent guidance to that.*

Only steering on the development of storage capacity has little certainty of climate benefit if the origin of carbon stored is unclear. Building new gas plants to capture carbon from has questionable climate effect. CA1a even mentioned that CARB seeks to reach its minimal emission reduction goal by planning for new gas infrastructure with CCS in 2045: the volume of carbon captured from these new power plants would technically qualify as emission reduction, but both its value for the electricity sector as well as its climate benefits are - respondent CA1a says - by that time highly dubious, given a decarbonized electricity grid. Building a new fossil fuel plant with CCS to reach emission reduction targets does not seem within the spirit of climate mitigation.

There thus is ambiguity because of a lack of regulatory clarity about what types of carbon storage actually provide climatic benefit. CA1a characterized the situation as:

> **CA1a:** But just saying it's missing doesn't really solve the problem because it's not missing because somebody just overlooked it. I would argue it's missing because politically sufficient consensus with industry has been reached that

> certain kinds of projects are good and those political interests are not necessarily interested in asking those broader questions.

Further, the respondent indicated distress over the capture of the regulatory agenda by industry interests.

An amendment to Senate Bill 308, proposed on the 5th of June 2024, seeks to distinguish between carbon removals, CCS and CCU for the first time in Californian legislation (SB-308, 2023):

> ***SB-308:*** *(8) CDR that is intended to balance out continued emissions of greenhouse gases in order to achieve net zero GHG emissions by 2045 should therefore result in long-lasting reductions in carbon dioxide in the atmosphere on a similar time scale to that of the released carbon dioxide.*
> *[..]*
> *(11) In order to be counted for the purpose of balancing continued residual emissions of greenhouse gases, CDR processes must be quantifiable and must include scientifically rigorous approaches to monitor and verify the sequestration of removed carbon in order to ensure that the reduction in atmospheric carbon dioxide is maintained over long periods of time.*
> *(12) CDR that is intended to balance the impact of residual emissions of greenhouse gases in order to achieve net zero GHG emissions by 2045 should represent true removals of carbon dioxide from the atmosphere and not just the avoidance of emissions that might otherwise have occurred, as is sometimes allowed in carbon offset programs.*

Crucially, this amendment seeks to restrict use of carbon removals for the purpose of balancing of residual emissions to *true removals*, having the effect of long-lasting reductions of atmospheric carbon. Although this bill and this amendment have not been passed and thus do not possess legally binding value (yet), this amendment marks a clear effort by the legislature to provide clarity and retain or regain control over outcomes of the deployment of CCS, CCU and carbon removals.

Conclusion:
Geological storage is a scarce good, of which we do not know the total potential yet. However, because the infrastructure needs to be developed, both the Dutch and US stimulate the storage of fossil-origin CO^2, both as of yet without a broader strategic vision about their volumes in 2050. Both carbon removals and fossil CCS compete for the same – scarce – geological storage capacity. Since the future societal value of CCS and carbon removals is unknown, but already has an existing business model, this intertemporal trade-off may be locked in through short-term interests. A ton of 2024 fossil CO^2 may now take up the space of a ton of 2045 atmospheric CO^2, while the latter may more valuable. Because of this uncertainty, a government strategy is desired. As of yet, however, these visions are absent, and only financial stimuli to develop the infrastructure exist in both California and the Netherlands.

The first step in developing such a strategy is the identification and distinction between climate-beneficial technologies and others. The Dutch push for an EU definition, while California tries to anchor this in national legislation, in the face of a non-discriminatory federal incentive for CO^2 injection.

Non-permanent & open-system removals

In the literature review, non-permanent removals were viewed through the perspective of Akerlof's market for lemons. Within this analogy, the market is expected to dry up because high-quality options are forced out of the market, since buyers cannot distinguish between high and low-quality products. On the voluntary market for compensation, a similar dynamic is at play: high-quality carbon removals are often not produced, since their quality cannot be adequately distinguished from low-quality removals or even emission reductions. According to Akerlof, the solution is in informing the buyer, so that he will be able to make an accurate choice about the type of product.

Relevant Sensitizing Concepts:
SC4: The role of non-permanent carbon removals in climate policy
SC5: Informational solutions for non-permanent carbon removals

In the interviews, the following question was asked:

> *What role should governments assign to non-permanent and open-system removals in climate policy? Can they be used for compensation?*

Netherlands:
The perceived underlying problem with both non-permanent and open-system removals is that the climate benefit is hard, if not currently impossible, to quantify, especially over time. Permanence and openness of systems, although facing similar quantifying difficulties, have been identified as two different spectra with regard to carbon removals:

> ***EU1****: Certainty of climate benefit, the verification confidence level, the precision with which we can constrain the climate benefit. That's its own spectrum, completely independent of the durability spectrum.*

Two important distinctions can be made here: first, that although both permanence and system openness revolve around the added climate benefit, they are on different axes; and second, that both are spectra, meaning that permanence and system openness aren't binary, but have "a 1000 shades of grey".

The problems facing the measurement and quantification of both open-system and non-permanent removals can according to one respondent reasonably be expected to be alleviated during the coming years:

> ***NL3:*** *but well, there's assumptions in that, so it's more uncertain. Dedicated MRV is not available, so […] in 10 or 20 years, we could add this.*

Thus, more precise methods for MRV (monitoring, reporting and verification) may be expected, and thus more information can be disclosed about the added climate benefits of these technologies by that point.

At this time, however, the same respondent (NL3) also mentioned that these techniques "are less to be trusted" in providing climate benefit, a position that all respondents shared. Furthermore, there were no dissenting voices in that (some of) these techniques *are* able to provide climate benefit (if regulated well), and that they should be incentivized.

Perceived ways in which these non-permanent and open-system carbon removals should be incentivized or incorporated within (climate) policy, however, differed quite substantially among respondents.

Respondent NL3 held the view that it was preferable to defer the discussion of integrating non-permanent and open-system removals into climate policy until a later date. He indicated that talks about the inclusion of these less reliable options muddy the waters of policy discussion about the scale-up of more permanent, geological removals, and action is desperately needed in that arena. He called for a "first-things-first" plan for the scale-up of carbon infrastructure, needed for the more permanent carbon removals (but also CCS & CCU) that will be most relevant towards 2050. Therefore he did see the importance of including non-permanent and open-system carbon removals in the scope of R&D policies, but preferred their exclusion of in current carbon removal scale-up policy. Respondent NL1 agreed, but did not think this politically viable.

Both respondent EU1 & EU2 called for a 'firewall' between carbon removals storing carbon in the biosphere and in the lithosphere. In line with the concept of durable net zero, this firewall would entail only allowing fossil emissions to be balanced by lithospheric carbon removal. EU1 thought of nature-based temporary carbon removal as:

> ***EU1:*** *simply restoring carbon that we stole from that sink tens, hundreds, or even thousands of years ago. In other words, there's no headroom to use those removals to cover up for fossil fuel emissions, so that's an important distinction to draw.*

Within this view, on a state or even global level, all fossil emissions remaining should be balanced by geological carbon removal. This means excluding non-permanent and open-system removals with carbon storage in the biosphere (the majority of this category) from being used for the first purpose of carbon removals: counterbalancing hard to abate emissions. It does not preclude the use of these removals for the other purposes, nor does it ignore climatic benefits.

The carbon removed from the atmosphere via these removals should, in the opinion of EU1 & EU2 be thought of as a co-benefit coming from other, non-climate policy. They pointed towards the necessity to reform agriculture and the use of land anyway: carbon sequestered in these sectors could help mitigate climate change, but activities like afforestation should not be done "from a carbon tunnel vision" (EU2).

NL1 however mentioned that even if non-permanent carbon removal is done as a side-effect of other policy, the carbon sequestered will then "be thrown upon the pile" in the UNFCCC inventories. Therefore, if nature-based solutions temporarily store carbon, a country will be seen to be doing better in reaching net zero, meaning that political ambition to reduce emissions will likely be subsequently lower. Therefore, as long as the UNFCCC accounting is not adapted, non-permanent carbon removals – even if done for non-climate motivation and kept separate in national accounting– will likely have mitigation deterring effect.

Additional to this expectation of political mitigation deterrence, NL1 also judged that while he thought using non-permanent removals for compensation was risky, he thought it was ultimately a political decision whether to use them for this purpose or not. In the process of making these removals market-fit (putting a price on them), too much information is lost about their future upkeep and actual climate benefit, meaning that in his view, this risk must be evaluated democratically.

<u>California:</u>

Respondent CA1a indicated that California was hit by a severe drought in the 2000s, and by wildfires in 2021 and 2022, meaning that in the state, much land-based carbon removal died off or went up in flames. He indicated that while CARB devoted much attention to forest-based carbon offsets, these events pushed it to consider the land sector as a net source of emissions, rather than a net sink. In his opinion, CARB deserves credit for this recognition of the uncertainty surrounding non-permanent removals. Further, CA1a states that while there is much rhetoric emphasis on carbon removal in the land sector, CARB relied mostly on industrial techniques like DACCS in their Scoping Plan: he estimates the reflection of the land sector as responsible.

The amended, but not yet approved SB308 includes a section stating:

__SB-308:__ (10) CDR approaches that can reduce atmospheric carbon dioxide for shorter periods of time can also provide valuable services in reducing climate change, but they eventually must be coupled with more durable sequestration of carbon in order to truly balance the impact of residual emissions of greenhouse gases.

By using non-permanent removals in this capacity for compensation, they can be used to 'buy time' to develop permanent carbon removals. Carbon is thus temporarily stored by a non-permanent technique, and by the time of its release back into the atmosphere, a permanent technique will capture and store it. Although this is a paper truth, it may help with hastening the roll-out of carbon removal obligations (since an alternative is available almost immediately, independent of CCS infrastructure). However, this provision does rely on permanent carbon removal being readily available by the time of release of carbon to the atmosphere.

<u>Conclusion:</u>
Returning to Akerlof, we find that information may not be available (yet) on the climatic benefit of non-permanent or open-system removals. Therefore, these types of removal make a bad climate product: not enough information is available for a market to function efficiently in trading climate benefit. If a market for compensation (allowing emitters to buy removals) would be instituted, it should contain removals of which the climatic value is clear: only then can it function efficiently. All relevant respondents therefore disagree with using these non-permanent, open-system with (as of yet) uncertain value for compensation of residual emissions. Non-permanent and open-system removals should be treated as co-benefits of other policy, and preferably kept out of compensation accounting. Whether taking the risk of using these removals in some form for compensation is acceptable, should be a democratic decision.

In California, catastrophic weather events (drought, fires) demonstrated the risk behind non-permanent removals: the regulator adapted its views on their use accordingly. In the EU, however, non-permanent removals are still relied upon for a large chunk of climate neutrality.

Developing permanent removals

In the literature review, the role of demand pull coming from markets was discussed as a stimulus for innovation. No explicit expectation was formulated, but the focus was laid upon demand pull with regard to the market on which carbon removals would operate, including the position of government in relation to this market.
Relevant Sensitizing Concept:
SC6: Demand pull for innovation through markets

In the interviews, the following questions were asked:

There is a need to scale up carbon removals; what role should governments play in that?

What ways are there to scale up carbon removal? Who has a role? What are their advantages and drawbacks?

<u>Netherlands</u>:
For the development of carbon removals, a distinction could indeed be made between the different stages of innovation and the role of government within these stages. Mostly, there was agreement that carbon removals should be supported every step of the way; through R&D subsidies and co-financing of demonstration projects. When it came to the scale-up phase, opinions differed; respondent NL3 stated that that

phase could be done by the voluntary carbon market, while NL2 and NL1 noted that this voluntary market does not provide enough certainty of investment. They outlined the necessity for a fitting instrument that helped desired carbon removals with a speedy scale-up phase. In NL1's view, this policy instrument should have a broader evaluation scope than mere €/Mton CO^2 cost effectiveness criteria.

For the next innovation phase (demand pull) the overall agreement among the respondents of the Dutch case was that the government should help in providing a business model to developers of carbon removals, thus providing demand pull. However, some slight differences in attitude towards the way in which to provide this business model could be identified. EU2 indicated that a tender for a limited amount of different carbon removal techniques could already have been set out on a European scale. EU1 distinguished between providing a deployment incentive (i.e. some form of co-financing), and government tenders, which he indicated may be especially relevant for non-permanent or open-system removal types. Both EU1 & EU2 implicitly indicate a preference for a steering role for government in scaling, essentially "picking winners".

NL3 stated that a government should, after the R&D and demonstration phases, essentially "keep out of the way", letting the market decide on what carbon removal techniques are implemented where. Presumably, with "market", he means market for compensating emissions by buying carbon removals (compensation market). The market and the business case should be facilitated by government, but NL3 indicates that the government should afterwards not hinder developments, and let the market decide its outcomes.

<u>California:</u>
In California, respondent CA1a indicated with regard to the need to scale up carbon removals:

> ***CA1a:*** *there's a blank piece of paper in that process where the word removals is written and not a lot of detail. So I think a lot of people are assuming one or more policy frameworks is going to sort of figure out the mechanics and then we can sort of grow and build from there.*

His summary of the situation is that while emission reduction and carbon removal targets are being discussed, no policy discussion is taking place about the way there: the need to scale up removals and the role government should play in that process.

The old, unamended version of SB 308 proposed a mechanism that could have a demand pull effect, with emitting entities being obliged to purchase increasing amounts of carbon removals from 2030 onwards (SB-308, 2023). However, this bill did not pass the legislature yet, meaning that currently, no policy aimed at achieving demand pull is active, nor is there (according to our sources) an ongoing conversation about providing this, except SB-308. However, CA1b mentioned that a high carbon removal target does imply some demand pull for less developed techniques, since such volumes could not be achieved by already available carbon removal techniques.

<u>Conclusion:</u>
Demand pull for innovation is recognized as an effective way to scale up carbon removals. This demand pull is achieved by giving carbon removal developers the prospect of a business case. Providing this prospect can be done in multiple ways; by instituting a compensation market, by government procurement, or by obligating parties to purchase carbon removals (as proposed in California). A compensation market, although often mentioned, arguably provides less effective demand pull than government procurement could, since a market is only focused on cost effectiveness. In the Netherlands, the policy discussion about scaling up carbon removals is in full

swing, while in California, no serious discussion is taking place, despite high volumes planned for. Most respondents pleaded for a large role of government, supporting innovations along the whole way by R&D funding, demonstration co-finance and procurement. Demand pull is not a catch-all solution.

Compensation markets

The literature review identified a wide range of attention for carbon removals within a market for compensation, and a general underrepresentation for carbon removals for the purpose of net negative. Implicit in this division of attention are assumptions about the role government should play in the deployment of carbon removals. Proposed instruments and means to deploy carbon removals, as well as future visions for net-zero climate policy frameworks, can tell a lot about the importance an individual attributes to the three purposes for carbon removals.
Relevant Sensitizing Concepts:
SC7: How to achieve net negative?
SC8: The role of government; stimulating and delimiting the use of carbon removals
SC9: The size of the residual emissions compensation market towards 2050
SC10: Consumption of carbon removals as emissions offset/compensation versus public net negative

In the interviews, the following questions were asked:

> *Specifically about market mechanisms; what can and can't they achieve?*
>
> *How do you see the relationship between the purposes of carbon removals; specifically between offsetting and net negative?*
>
> *(For economists) How do you think of carbon removals an economic good?*
>
> *Is there an optimal size for the compensation market towards 2050? What factors influence that size? Can there be overconsumption?*
>
> *How can governments safeguard the use of carbon removals for net negative?*

<u>Netherlands:</u>
In short, the one thing most respondents for the Dutch case had in common was the word 'market'. However, their definitions and their visions of its use and place in future climate policy differed.
Most pointed to markets as something that government should top-down develop and facilitate, in order to give carbon removal developers a business case (demand pull, c.f. section *developing permanent removals*). Further, it was argued that a market should get certainty: the logic of allocative efficiency only holds true if market parties can make accurate assumptions about the future. Uncertainty, in this regard, can come from the technological capabilities of carbon removal techniques, or from government interference on the market or in policy areas adjacent.

But what should be traded on this market? Not all respondents elaborated on this element, but NL1 theorized that since an emission generates an externality, a carbon removal can take away this externality, and thus it may make sense to combine the two in a market. Emitters can in the face of climate targets then choose to reduce emissions, or buy carbon removal offset credits. A much-discussed example would be to let carbon removal plants supply allowances in the EU emissions trading scheme, which until this point only has emitters demanding allowances and the European Commission supplying.

Such a market could transform carbon removals from a public good (non-rivalrous and non-exclusive) to a normal good via the selling of allowances. The effects of carbon removals would still be non-exclusive (because no one can be excluded from less CO^2 in the atmosphere) and non-rivalrous (because no one's use of less CO^2 in the atmosphere precludes another's), but these certificates used for their financing could be traded like a more or less normal good: one's use of a credit to offset precludes another's use, and certificates are easily excludable.

The argument for instituting such a market quickly is to provide carbon removal suppliers with a business case, facilitating demand pull and helping quick scaling (NL2/NL3). However, NL1 indicated that a cap-and-trade scheme like ETS is intended to reduce the number of emissions over time. All the while, the scaling need for carbon removals is only likely to increase towards 2050. Thus, if both goals are to be attained, more and more carbon removals need financing, while less and less emitters are available in a market to fund them.

The ability of such a market mechanism to provide net negative emissions is questionable, according to respondents. NL3 indicated that government could be a demanding party on this market, buying up carbon removals. However, he admitted that government funding could then crowd out private purchasing of removals, because it would compete with emitters for the same removals. This would drive up the price, drawing in potentially more removals, but also forcing out emitters for whom removals are no longer profitable. This lays bare the more removals-less emitters tension of such a market. Furthermore, he thought it politically unviable for a government to compete with emitters in such a way. Additionally, a quick analysis learns that this type of government interference would increase uncertainty on the market and thus undermine the working of allocative efficiency.

NL3 indicated the problem that if climate policy works as normatively intended, in a compensation market, increasingly fewer emissions need to serve as demanding parties for ever more carbon removals. Figure 5 depicts this problem, modelled after the EU ETS, with its linear reduction factor, the zero emissions target in 2040, and a hypothetical inclusion of carbon removals as supply of allowances. These graphs assume carbon removals as limited by technical factors only, thus independent of price. If the cost of carbon removals is higher than the carbon price, it makes sense to reduce emissions, and a compensation market will not realize any carbon removals.

In the net zero year (depicted here as slightly before 2040, equilibrium of emissions and carbon removals volumes is reached, meaning that every ton CO^2 of emission is compensated by one ton CO^2 of carbon removal. In the years after this equilibrium, the working of market forces means that two paths are possible. Either the emission reduction scheme remains intact, in which case carbon removals will not be financed anymore because of lack of demand from emitters (figure 6a). Alternatively (and arguably politically more realistically), the gross emission reduction target is loosened for a net (emissions – removals) goal, emissions will not be reduced, or may even increase again in the face of increased carbon removal supply (figure 6c). If a market is to be an instrument that procures carbon removals, it will always put pressures on the emission reduction paths, thus having a mitigation deterring effect. If emissions and removals are fungible one to one, and reduction policy is loosened, emissions will always approximate removal volumes, thus producing a net-zero scenario with high emissions and high removals levels (figure 6c)

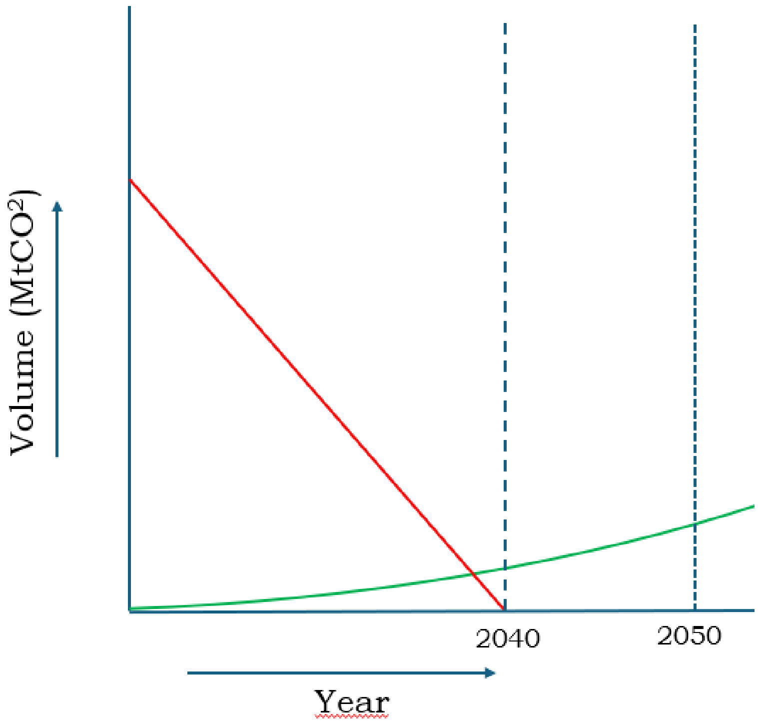
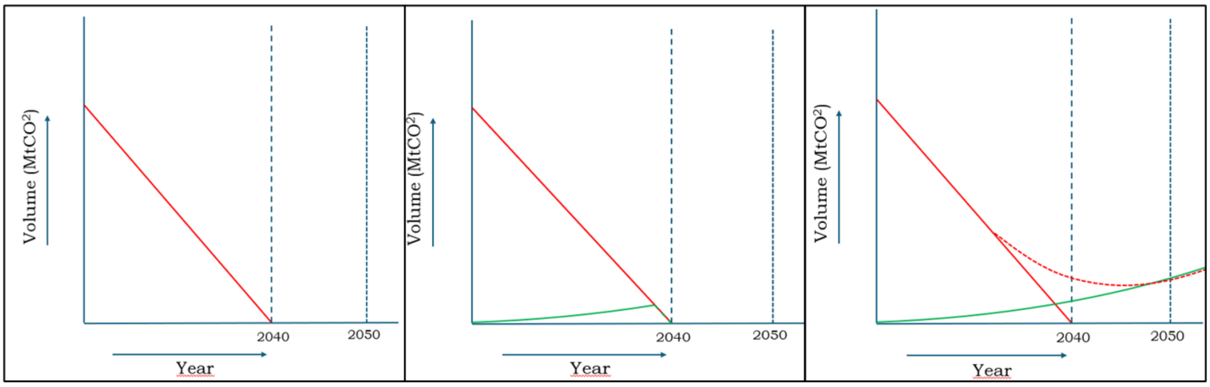


Figure 5: Stylized demand and supply volumes on a hypothetical carbon removal compensation market.. Green: carbon removal volumes (assumed independent of price) red: emission volumes (stylized after the EU ETS cap-and-trade system, ending in 2040). Own work.

Figure 6: suboptimal compensation market outcomes (stylized after EU ETS)



6a: Pemission < Premoval
Red: emission reduction target, green: carbon removal volumes (assumed independent of price)

6b: Pemission > Premoval, intact emission reduction target. Red: emission reduction target, green: carbon removal volumes (assumed independent of price)

6c: Pemission > Premoval, loosened emission reduction target (net zero in 2050). Red: emission reduction target, red dash: emission volumes after loosening, green: carbon removal volumes (assumed independent of price)

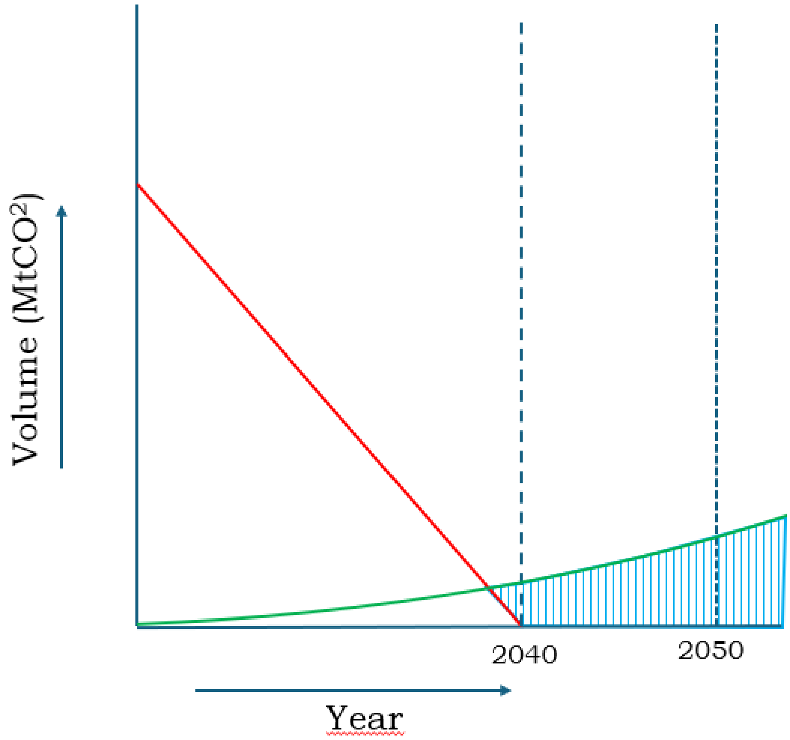


Figure 7: Stylized demand and supply volumes on a hypothetical carbon removal compensation market. Green: carbon removal volumes (assumed independent of price), red: emission volumes (stylized after the EU ETS cap-and-trade system, ending in 2040), blue: net negative emissions volumes. Own work.

The problem depicted in figure 5 above carries implications for net negative removals as well. Any carbon removal volume above residual emission volume contributes to net negative. All respondents that were asked how to realize net negative emissions, indicated responsibility for government. This was either in the form of direct government procurement of net negative emissions (EU1, EU2, NL1, NL3) or in some kind of regulated obligation for private parties (EU1, NL1).

Figure 7 shows the financing gap for net negative: a private compensation market will not provide net negative emissions. The outcome of an unregulated market will either be as in figure 6a or 6b: in either case, no net negative will be realised. The realization of carbon removal as this public good can be done in different ways: the government can fund carbon removals with public money up to a desired level via a tender or reverse auction (as indicated by NL1, NL3 and EU2). Alternatively, responsibility ("property rights") for historic emissions already in the atmosphere can be assigned to market parties. Especially EU1 proposed this issue: he mentioned a division of responsibility based on historic profit margins and/or upstream supplier volumes. NL1 had some reservations about this idea, pointing towards a lack of alternative action at the time of emission. An obligation with retroactive effect for historic emitters to realize carbon removals seems not in line with economic efficiency, since the emitter cannot change its behaviour in a rational decision-making process. NL1 saw the discussion about responsibility for historic emissions as one that should be based on justice and fairness criteria, thus warranting a political decision.

One last issue is indicated shows up in figure 6a: a compensation market may, if the carbon price is lower than the cost of removals, not even purchase carbon removals, in which case the market is useless in scaling up.

NL1 pointed toward a further issue: a compensation market in which emissions and removals are fungible is not a catch-all solution, and while its institution does provide some demand pull for innovation, he calls it explicitly not an innovation instrument. The limited demand-pull that such a market does provide only provides benefits to techniques that are almost market-ready.

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California:

Respondent CA1b indicated that California, in its most recent Scoping Plan, planned for carbon removals to compensate what amounts to 25% of 1990 emissions by its net-zero year (2045). He called this volume of carbon removals excessively high, comparing it to 5% in Washington (state) and 15% in New York. CA1a further mentioned that except for SB 308, no serious policy discussion on instruments to provide this potential is being undertaken in California.

However, respondent CA1b did provide some interesting statements on the cap-and-trade market instrument that is currently in working for emission reduction in California:

> ***CA1b:*** *But it's just like the symbolic value of saying, "We did a market thing," has prompted all this work and complexity just to make this thing appear to be playing a big role.*

And:

> ***CA1b:*** *If you're going in and pushing for reforms during those five years, industry just comes in and says, "no we settled this. We got the cap-and-trade thing in place, we don't need any more of this stuff." So [..] you not only go quiet about [reforming] cap-and-trade, you end up suppressing discussion of other stuff too.*

Furthermore, CA1b also mentioned the mop-up function of this cap-and-trade market instruments: any emission reduction not delivered by sectoral climate policies should be done by cap-and-trade. However, he also indicated that the importance and effectiveness of this cap-and-trade mechanism in California was often overstressed. Therefore, he feared a similar dynamic arising: carbon removals in a compensation market overrepresented and overburdened. Initiative for other climate policy (sectoral policies) would be squashed with the argument that the market could provide the desired effect.

Conclusion:

This section has identified what a compensation market can and cannot achieve. A market, given proper internalization, provides efficient outcomes; in theory, it can come to an efficient allocation of residual emissions, given that the volume of residual emissions is fixed beforehand.

However, the lack of accurate information about future value is problematic; but even if such information was available, compensation market actors will not of their own accord procure removals for net negative. Instead, a compensation market will put pressure on emission reduction target, having a mitigation deterring effect. In an further unregulated outcome aiming at net zero, total removals will match total emissions, meaning no net negative is realized. Further, in the face of low carbon prices and high removal costs, it is questionable at least whether a compensation market will even purchase removals. From the Californian case springs a more political dimension: a market incites a rhetoric of efficiency. Therefore, there is often rhetorical overreliance on it within climate policy. Thus, the institution of a market, even if it is flawed, may hinder the development of further, more effective, climate policy. The market is not a catch-all solution, but often, it is seen as such.

Residual emissions

In the literature review, the concept of separate targets was discussed, wherein countries separately indicate volumes of residual emissions and carbon removals to avoid mitigation deterrence. Preferably, these decisions are also taken separately. The literature indicated that many countries currently are not explicit about either their residual emission targets, the sectoral origins of these residual emissions and/or the criteria for designating them, and the way to net zero in general.
Relevant Sensitizing Concept:
SC11: Definition of residual emissions volumes

In the interviews, the following question was asked:

When and how should residual emission volumes be designated?

<u>Netherlands:</u>
The Netherlands, at this moment, does not have carbon removal targets: there is a national goal of 55% emission reduction and a net zero target for 2050. There is thus no instance of separate target-setting yet; the update of the Dutch Climate Law target entailed a move from a 95% reduction target to a net zero target . However, the newest Climate Plan is expected to contain two gross targets for emission reduction and carbon removals, additional to a net target.

NL1 indicated the need for an iterative process in determining those targets. Development in emission reduction technology, together with deep uncertainty in the potential for carbon removal, mean that according to him, it is not wise to take a decision on gross volumes now and lock it in for the coming decades. He pleads for a target that is regularly revised. This way, a government can avoid taking away the incentive for emission reduction for activities that could be designated hard-to-abate. Further, NL1 indicated the desire for the emission and removal targets to be designated separately and not with removals as a “stopgap” for emissions.

Respondent EU2 also pleaded for an iterative process, but stressed that updates to those targets should only be allowed to be more stringent: there should always be pressure on emissions to go down, and removals to go up. Further, he indicated that the discussion about residual emissions at this moment only serves to relieve pressure on emission reduction. As an example, he mentioned that 40% of emissions under the EU ETS come from (easy-to-mitigate) coal, and thus a discussion on hard-to-abate emissions now will only cause lock-in.

EU2 indicated that “we have no idea how big residual emissions volumes are going to be”, stating that DG CLIMA of the European Commission works with an 87-92% range of reducible emissions.

Complementary to the process of target-setting and residual emissions volumes, respondents also proposed different criteria for the process of selecting residual emissions. Common ground is that most respondents agree that the decision should be more than a hard financial decision, although cost-benefit analysis should play a major role. A cap-and-trade instrument like the EU ETS is technically able to designate the hardest-to-abate emissions in terms of cost effectiveness (provided all societal costs and benefits are internalized), but respondent NL1 doubted the proper internalization of costs. He indicated that decisions should be made marginally, i.e. the costs should reflect the total societal costs of both emissions and removals of the last ton CO^2 in 2050: the price of emissions and removals now says very little about the costs and benefits in 2050, since market participants cannot accurately predict the situation then. If an instrument like EU ETS is the only instrument used to come to a cost-efficient compensation level of carbon removals and emissions, and costs are not properly internalized, there will not only be mitigation deterrence, but the outcome will also not be societally efficient.

As to how to then make the decision, NL1 indicated that the executive government (ministry) could set the framework for making the selection, but ultimately, selecting which emissions are tolerable in 2050 and which are not should be a democratic decision. Social and ethical considerations, which are hard to adequately internalize in price, should be part of this selection process. According to EU2, the European Commission realizes that this process should include social and ethical discussions.

As an example of the problem, NL1 mentioned risotto rice production, which carries cultural value but inextricably emits carbon. He thought it likely that society would allow some risotto production and consumption in 2050, but at the same time thought it should not continue uninhibitedly. EU2 added another dimension to cost-efficiency: he compared the examples of cement production and private airplanes. Cement production is hard to decarbonize, with current technology allowing for 40% emission reduction in the production process. Private aviation is also hard to decarbonize. The behaviour of these products in a cap-and-trade scheme for selecting hard-to-abate emissions is hard to predict, especially given that societal costs and benefits are not fully internalized. He thus pleaded for a discussion on the societal use of these products, implying that cement is more indispensable for society and the economy than private aviation.

Both EU1 and EU2 indicated that the discussion on which emissions should be considered residual could have started already, but for strategical reasons has not. Fear of lock-in and mitigation deterrence has put this subject 'in the freezer'.

With regard to the internalization of costs, NL3 predicted (political) difficulty in continuing pressure for emission reductions, especially if the cost of carbon removal may in the future be cheaper than the cost of the last emission reductions. Even if both are not traded in a market for compensation, pressure will exist to allow compensation.

<u>California:</u>

The process of target setting in California is not codified in law. The legislature can set climate targets more or less if and when it wants, while CARB makes a plan for the execution of these targets every five years in the form of the Scoping Plan.

Respondent CA1a indicated that the last Scoping Plan (drafted by CARB) planned for 75% emission reductions in 2045, with the other 25% compensated by carbon removals. However, the legislature simultaneously came with an 85% emission reduction target and passed this law months before the Scoping Plan was due. According to CA1a, this presented a problem for CARB and the Scoping Plan. Their solution was to plan for 17 Mton additional CCS in the power sector in 2045 (which would not be present in 2040), so that the 85% emission reduction target would technically be reached.

CA1a indicated that the Scoping Plan is aspirational and a declaration of intent, but does not have legally binding value. However, he said that even though legal status is lacking, it possesses socializing value; project developers and emitting industry base expectations and actions around the document.

> ***CA1a:*** *My big worry is we'll have a non-binding plan for net zero, that will sort of socialize a very heavy reliance on carbon removal, that will socialize not cutting as many emission reductions as we want, and declares, sort of in passing, that 2030 is solved. And now, does it matter if there's a non-binding plan to that effect? You could say, "Oh, it's just a non-binding plan." Well, what happens when somebody brings that to the utility regulator and says, "Why are you guys pushing this hard? Here's this plan [..] Says we're fine."*

An important dynamic comes forward from this above quote. CA1b mentioned that past Scoping Plans have always been vague and not actionable, and the 2022 Scoping Plan was especially vague. From the 2017 Scoping Plan, many questions remained about how to achieve the 2030 target of 40% emission reduction compared to 1990 levels. CA1a indicates that California is not on track for that target, but that in the 2022 Scoping Plan, a mere 6 pages are dedicated to achieving the 2030 target, with the rest proposing an not-so-ambitious and very ambiguous pathway to 2045, which raises even more questions about implementation. At the same time, CARB was unfriendly to bill SB308, which sought to "colour in" those targets by providing a scaling mechanism for carbon removals. A shift in focus toward a later target thus has potential to distract from near-term emission reduction targets.

California thus has some sense of separate targets, with a net zero goal in 2045 and a emission reduction goal in 2030 and 2045. However, it does not explicitly plan for a carbon removals volume target, nor does it explicitly mention the source of residual emissions (15% in 2045). Further, according to CA1a, no meaningful plan (except the amended SB308, which is a legislature bill) is being developed by CARB to actually achieve the levels of carbon removals planned for in 2045.

Respondent CA1b recommended "ripping off the band-aid" when talking about the origins of residual emissions: the discussion about what emissions society wants to continue by the net zero year should be had as soon as possible. However, no such discussion is taking place in California. Residual emissions are defined as 15% (100%-85%), with no real indication of which emitters will be allowed to continue by the net-zero year.

<u>Conclusion:</u>

The discussion about residual emissions is hard, because besides economic factors (emission abatement costs), social and ethical considerations are at play. Target-setting for residual emissions is preferably done apart from target-setting for removals to avoid mitigation deterrence as much as possible. To avoid lock-in, these volume targets should be regularly updated. The Netherlands went from a 95% emission reduction target in 2050 to a net zero target, which is arguably not an improvement from the climate perspective. A net zero *and* 95% reduction target would have provided more clarity on the volume of residual emissions. In California, it was implied that by instituting a 2045 net zero target, the focus on achieving the 2030 withered. Furthermore, even if the strategy for achieving the reduction targets is vague and non-actionable, it does have societal impact: the strategy is socialized in decision-making, and actors will base decisions on it, even if it does not contain binding value.

In the EU, there is recognition that the choices for designating residual emissions need to be made in democratic processes, because they involve enormous impacts on future society. In California, these choices are made by the non-democratically elected CARB, which also does not respond well to legislative oversight.

Division of competences

A theme that came up in the interviews, but was not explicitly mentioned in the expectations beforehand, was about the division of competences in drafting and implementing carbon removal policy.

<u>Netherlands:</u>
As indicated in the case contextualization above, in the Netherlands, the ministry of Economic Affairs and Climate drafts climate legislation for approval by the legislature, as well as being responsible for its implementation. From the legislature, several legally binding requests have been made, to which the minister and his ministry must answer.

Respondent NL3 indicated that carbon removals, especially with regard to CCS and CCU, presents a complex coordination problem, with different subdivisions of the ministry (and different ministries) working on CCU, CCS and carbon removals. He indicated that coordination should take place in order to come up with policies that stimulate an effective mix of these three technologies. His fear was that detachment may lead to ineffective policy and too much bureaucratic burden on the market parties involved.

Furthermore, respondent NL2 indicated that the ministry was possibly at risk of locking-in fossil CCS by its cooperation with fossil companies in the development of the infrastructure.

<u>California:</u>
In California, AB 32 delegated authority for the implementation of emissions policy to CARB, while the legislature remained in charge of the drafting of targets. Respondent CA1b has characterized CARB as having a “quarterbacking role”, which in European terms would amount to it having the lead and coordinating the efforts of other involved government agencies. According to CA1b, this gives CARB an amount of influence seen almost nowhere else in the world.
CA1a stated about CARB:

> ***CA1a:*** *The regulator basically does not respond to legislative direction and arguably doesn't follow the law on a lot of critical policy issues.*

Although AB 197, signed into law in 2016, included measures to increase legislative oversight and control over CARB, and thus its accountability, the above statement implies that it may yet not be enough (AB-197, 2016).

Furthermore, the public letter of the Californian governor, in which he asked CARB for a target for carbon removals of 20MtCO^2 in 2030 and 100MtCO^2 in 2045 raises questions as to the influence the governor - the head of the executive - has over CARB (Gavin Newsom, 2022). Why the governor should ask publicly instead of order internally is one question, but CA1a indicated that CARB stretched or bended the interpretation of ‘carbon removals’ so as to include fossil-origin CCS.

> ***CA1a:*** *The relationship between what the law is and what the law requires and what the regulator does is itself politically fraught.*

CA1a also stressed his concern for the corporate capture of CARB by special interests, by whom he meant industry parties. Thus, not only do different government agencies have different competences and degrees of influence, but there also seems a difference in appetite for climate action.

Conclusion:
In California, the executive (CARB) does not respond well to the directions the legislature provides: this leads to somewhat of a 'battle of wills' visible in the carbon removal policy landscape. Concentrating influence in one agency has the potential to improve the effectiveness of decision-making, but in the Californian case, the lack of democratic accountability raises questions about industry capture. In the Dutch case, quite the opposite approach also was questioned: lack of coordination between decision-making entities may lead to incoherent and ineffective policy.

Strategic avoidance

A theme that was not covered in the expectations beforehand, but came to the forefront in some interviews and thus will be described in this section is a concept I dub *strategic ignoring*. In short, strategic ignoring is ignoring, or keeping quiet about, carbon removal in previous years by actors that would normally be in favour of climate action, would reasonably be expected to have knowledge about carbon removals, but saw them as a Pandora's box, perhaps necessary for reaching net zero but distracting from the emission reductions so drastically needed.

In the interviews, two respondents indicated this type of behaviour. One stated that he "works in a policy field from which he's trying to distract as much attention as possible", because his belief is that at least as much discussion should go to emission reductions. Another indicated that left-wing [pro-climate action] parties are not in favour of carbon removals and have not brought up the subject, because it distracts from emission reductions. Respondent CA1a indicated that in California, pro-climate action environmental justice groups are for this exact reason not in favour of the usage of carbon removals. It is unlikely that these climate action proponents have been unaware of the existence of carbon removals until very recently: more likely, they have strategically ignored the concept, delaying its discussion until as late as possible.

While these reactions are predictable when talking about industry initiatives that claim to work towards climate neutrality, but may be hiding behind a veil, they are more surprising when they show up in relation to a technique that the IPCC deems inevitable for limiting global warming to well below 2 degrees Celsius. The *strategic* part of strategic ignoring, then, is to delay bringing up the subject until as much emission reductions as possible are already implemented, leaving the potential for mitigation deterrence as small as possible.

Role of government: foresight

The literature review revealed questions about the role of government. Not only seems there a role in realizing net negative emissions – addressed in other sections – but the external effects different carbon removal techniques have, their insufficient internalization, and the interplay with CCS and CCU seem to plead for a more steering role on what techniques are desired in what quantities.
Relevant Sensitizing Concept:
SC8: The role of government; stimulating and delimiting the use of carbon removals

In the interviews, the following question was asked:

> *How can governments proceed in stimulating but limiting carbon removals*?

Netherlands:

The parliamentary request that led to the Netherlands developing a roadmap for carbon removals stated:

> ***Motie E&B:*** *Considering that different techniques for carbon removal are available, but these differ in maturity, potential and cost-effectiveness,*

While the request for EU definitions of CCS, CCU and carbon removals stated:

> ***Motie K&T:*** *Aware that in supporting and selecting techniques for carbon removal […] the climate impact should be considered. […], aware that the deployment of CCS, CCU and CDR [carbon removals] can cause a carbon lock-in effect,*

Both these parliamentary requests imply a degree of government control over what carbon removals techniques are desirable and should be implemented. Respondent NL1 indicated that the government should practice foresight:

> ***NL1:*** *what makes the discussion difficult, is that you're not talking about here and now, but about a far future. […] and at some point, you will have people realizing,* "wow, these are the consequences of a choice we made 30 years ago."

He indicated as well that market forces cannot make accurate choices, because of short-term interests:

> ***NL1:*** *But even still I think that people and businesses will in the short term make stupid economic choices, simply because they do not optimize over the next 1000 years, but over the next 20 years and thus they will optimize wrong.*

Further, NL3 indicated that in the relationship between CCS, CCU and carbon removals:

> ***NL3:*** *It is all a balancing act, and if on one side a heavy weight is added, it all becomes much more difficult.*

EU2 added that it is the task of government to ensure that carbon removal techniques deployed remain within 'sustainable potentials', derived from the theory of planetary boundaries. In his view, the government should set criteria for the deployment of carbon removal techniques that range beyond just climate benefit. As necessary criteria, he identified at least the use of renewable energy, the impacts on biodiversity, land use and water use.

<u>California:</u>
Respondent CA1b indicated with regard to carbon removal and CCS, but also about new industries in general:

> ***CA1b****: You need typically legislation, you need regulatory coordination. [..]*
> *It's not a surprise that you see new industries that are trying to create themselves, and create the infrastructure around themselves, working directly with the government to figure that out. And of course it's going to take a lot of private capital and a private sector interest to do that.*
> *But it is not a surprise that there's a coordinating role for the government in that work.*

When asked for a characterization of Californian carbon removal policy thus far, however, CA1a indicated:

__CA1a:__ So the way I would interpret things is there's so much money from the federal government, from the federal tax credits and their support on the permitting side from both the state and the federal government for this underground CO^2 injection that quite a lot is happening in that space. But it's not being guided by a coherent, articulate policy discussion that said, how much carbon removal should we have? What kind of carbon removal should we have? Those sorts of questions are not really well articulated in the policy environment.

In sum, the Californian carbon removal policy landscape can be described as dominated by some incentives (which mainly target CCS infrastructure), without real guidance on what the desired future situation is. While the understanding that the government should play a role in sketching such a coherent vision for the future is present, no action is taken, according to CA1a. Instead, he mentioned, the current mentality with regard to carbon removals can be described as:

__CA1b__: If you rely on it [carbon removals] to be this magical thing that will deliver at low cost whatever you need, no matter when you need it, you won't get it. Just like if you assume carbon removal will mop up all of your problems, it will fail.

__CA1a:__ Politically, sufficient consensus with industry has been reached that certain kinds of projects are good and those political interests are not necessarily interested in asking those broader questions.

Conclusion:
Respondents in both cases indicated the need for the government to develop a strategic vision that steers towards an outcome deemed societally relevant. In the Netherlands, such a vision is being worked on as a result of parliamentary action; in California, the regulator does not communicate such a vision explicitly and transparently: our respondents suspect that industry capture has established a vision in the back of policymakers' minds.

Multilevel governance

In the literature review, the dynamics of supranational government were discussed, including the motivations for the division of competences among the national level. The concept of functional spillovers was discussed as a possible pressure for delegation of authority to the supranational entity, while the delegation itself can serve as credible commitment for electorally-bound national governments.
Relevant Sensitizing Concept:
SC12: Dynamics of multilevel governance

In the interviews, the following question was asked:

What interplay is there between the supranational entity (EU/US) versus national policy? How do supranational climate frameworks influence national policy?

Netherlands:
The respondents indicated a range of areas in which the supranational EU impacted national carbon removal policy.

First, respondents NL2 and NL3 indicated that CO^2, once captured from either the atmosphere or from fossil origin, falls under the European Single Market. Therefore, nationally-imposed restrictions on this market are severely limited. The respondents differed in opinion about whether this is good or bad, but it is almost certain that national governments cannot exercise total control over at least the CO^2 transport and storage infrastructure. Further, NL2 indicated that because the CO^2

transport and storage market is already a part of the EU's competence under the single market, this likely provides a significant functional spillover effect towards the realm of carbon removal policy. It may not be sensible, or even easy, to develop national policy for carbon removals if the CO^2 captured must then enter a market regulated on the European level. Thus, countries may in the face of this spillover pressure decide to then agree on developing carbon removal policy on the EU level, as well. NL1 certainly indicated a Dutch effort to regulate carbon removals on the European scale, but did not mention the CCS infrastructure explicitly as driving this effort: other factors may thus be at play.

Furthermore, EU1 pointed towards existing EU climate policy frameworks as a way exclude open-system and non-permanent removals from being used for compensation, although EU2 indicated that "Europe is not ready for that discussion". Using the existing frameworks could be an opportunity to keep the division between fossil emissions and biosphere carbon removals as sharp as possible. If at a European level, this distinction is made, it likely pushes member states to behave accordingly and commit to not using non-permanent and open-system removals for compensating fossil emissions.

In a similar vein, the parliamentary request by Dutch parliament can be read, which "requests the government to plead for European definitions of CCS, CCU and CDR" (Motie Teunissen & Kröger). The reason the Dutch parliament wants European-level definitions, may be due to the spill-over effect coming from CCS as outlined above, but may also serve as a commitment device, ensuring that national governments are bound to a European safeguard for what counts as CCS, CCU and carbon removals. In this sense, subsequent governments may be barred from counting a technique that has questionable climate benefit under the banner of carbon removals. In some regard, the Carbon Removal Certification Framework (CRCF) directive has already laid down standards for what the European Commission counts as 'true' carbon removals; the directive is however only applicable to the voluntary market, and thus not binding (yet) for national climate policies.

EU2 characterized the European Commission and the European decision-making process as having a "poking" role towards member states: by putting carbon removals on the agenda, the Commission can more or less force member states to devote attention to it. Further, EU2 described the impact of European legislation for carbon removals as the following:

> ***EU2:*** *If the EU does well [with regard to carbon removal policy], member states have to do well. If the EU does poorly, the member states can still do better. Worst case scenario is if the EU does nothing, because then member states will also do nothing.*

A final area in which supranational dynamics were said to be at play is in the accounting. The Dutch Climate Law is based on the UNFCCC accounting, which differs from the way the EU keeps account of climate progress. NL1 indicated that emissions reductions in Dutch industry falling under the EU ETS *do* count for the UNFCCC accounts, but not for the Dutch national contribution to the Effort Sharing Regulation. Thus there is a certain tension between the European and UNFCCC obligations that the Netherlands needs to fulfil. The choice of where carbon removals are integrated within the EU climate architecture thus carries important consequences for Dutch obligations.

For instance, if a carbon removal plant is operational in the Netherlands and allowed to sell removal certificates under the EU ETS; it *might* be the case that for the European accounting, that volume of carbon removal does not count towards the Dutch contribution (instead falling under the EU ETS), while in the UNFCCC (and thus Dutch Climate Law) accounting, that same carbon removal *does* count towards national climate progress.

How this tension will exactly play out is at this time still unsure, but the tension between UNFCCC and EU accounting is likely to generate path dependency issues. The choice of integrating carbon removals in EU climate architecture will thus be made under influence of architectural choices (and their flaws) made in the past.

<u>California:</u>
CA1b indicated that California during the last decades has gathered quite a strong reputation for being a climate leader, both on the US state level and the international level. On the US subnational level, California is one of the few sources of climate leadership, often pioneering because of its strong administrative capacity. Other US states that want to implement climate policy therefore often follow California's example: CA1b called the state "the 800-pound gorilla in the state climate game". This leadership role of California becomes even more pronounced once the federal government is either gridlocked or in Republican hands, since climate leadership then will not come from Washington DC. CA1a indicated that:

> ***CA1a****: And so a lot of the work in California is oriented politically around showing other people our accomplishments.*

CA1b added that:

> ***CA1b:*** And the thing that worries me is we have sold the story that we figured it all out, rather than we're one of the places that is doing the most to figure it out and we will have some wins and some losses; and people who copy us uncritically will miss that.

Additionally, CA1a stated that "there really isn't a lot of active support for carbon removal at either the state or federal level". From the federal level, the 45Q tax credit provides large amounts of money for CO^2 injection, and the Infrastructure act subsidizes DACCS hubs. These subsidies are aimed at developing the technology and infrastructure that is necessary to achieve large-scale DACCS and CCS.

Thus, even though Californian policy does not provide a clear picture of what techniques it wants in which volumes at the moment, US federal policy does influence the possibilities the Californian government has in working towards such a (hypothetical) view. A large subsidy for all CO^2 injection techniques is likely to generate path dependency. Once CCS infrastructure is built, it will likely be used; thus, Californian policymakers that in the future manage to sketch a detailed net-zero vision will be presented with a *fait accompli*.

<u>Conclusion:</u>
The roles of the EU and the US in carbon removal policy differ significantly. While the US is seen as a climate inactive entity, which does provide some direct subsidies for development of techniques, but no strategic steering or other carbon removal policy. California thus has a leading role: showing progress at the subnational level may inspire other states to also take action. The EU, has proven an important arena for the development of carbon removal policy. Member states that are ambitious push for EU action, with EU action resulting in action from all member states. Due to functional spill-over, the role of the EU in carbon removals could increase even more. Whether this results in EU procurement of carbon removals, or in a more framework-setting role, is at this point still uncertain.

Conclusion

Key decisions and trade-offs in Dutch carbon removal policy

From the respondents' answers about the Dutch case of carbon removal strategy and development policy, a couple of key elements can be distilled in their observation of the problems surrounding carbon removals and the Dutch strategy to overcome these. No legally binding targets have specified the role of removals yet, however, an established policy discussion is ongoing, in which the characteristics and use cases of carbon removals are considered.

In the interviews, unclear intertemporal trade-offs appear multiple times. The two main examples of this are the allocation of geological carbon storage capacity, and the compensation-net negative trade-off.

In the allocation of geological storage, choices are now being made with current prices of storage and current carbon prices. Thus, CO^2 from fossil CCS is stored and the infrastructure is developed. In the future, that same storage capacity can be used for CCS and for carbon removals: however, for the future, the price and quantity of storage, the carbon price and the price for carbon removals are all deeply uncertain.

What is certain, however, is that a ton CO^2 from fossil origin stored *now* precludes a future ton of CO^2 being stored, and thus drives up future prices of storage. No informed decision can thus be made about efficient allocation of storage. In the short term, fossil CCS can serve to finance developing storage infrastructure, but it is questionable whether CO^2 stored now provides the most societally efficient outcome.

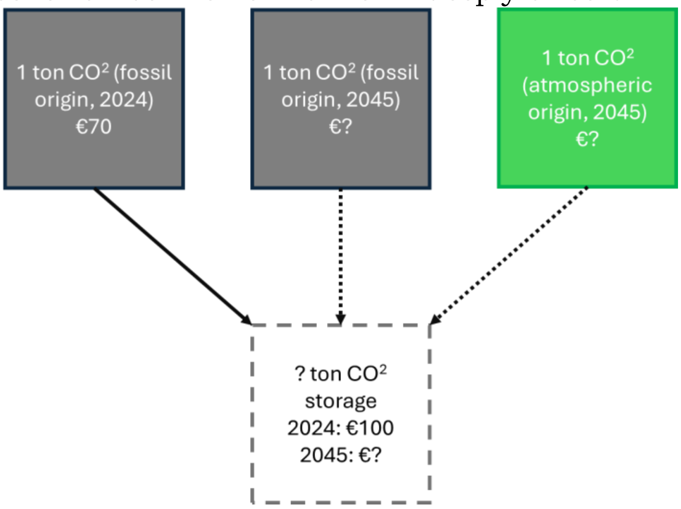

Figure 8: visualisation of uncertainty in the intertemporal trade-off surrounding geological CO² injection capacity, between current and future fossil CCS and future carbon removals. Own work.

Furthermore, it can be questioned whether granting companies dependent on fossil CCS the ownership over the carbon transport and injection infrastructure is a good idea: yes, fossil fuel companies do possess know-how about this type of infrastructure, but the natural monopoly associated with the ownership of such pipelines has the potential to raise issues. One of our respondents indicated that abuse of market power to restrict access to such networks was not unthinkable despite Third Party Access (c.f. EU gas liberalisation legislation). Further research is very welcome on this subject.

The second intertemporal trade-off was illustrated through the compensation market. The question here is about what has more value; the certain hard-to-abate emissions or the avoidance of climate damage. Based on that valuation, the purpose of carbon removal can be distinguished, using it for either compensation or net negative, and residual emission targets established.

However, that valuation has to be made without accurate information on the future cost of climate damage caused by one ton CO^2 emitted, the benefit of avoided climate damage caused by one ton CO^2 removed, and the future cost of removals. The only thing that is accurately known, is the economic benefit of emission. Since the damage caused by climate change lies in the future, and can at this moment not be accurately quantified, it is often underrepresented in market parties' decision-making. Therefore, the fundamental problem can be described as the scarcely-founded assumption that:

$$\mathbf{P_{emission} + MU_{emission} > MU_{removal} - P_{removal}}$$

In which $\mathbf{P_{emission}}$ is the carbon price for one ton of emissions, $\mathbf{MU_{emission}}$ is the (negative) marginal societal utility for one ton of emissions, $\mathbf{MU_{removal}}$ is the (positive) marginal societal utility for one ton of carbon removal, and $\mathbf{P_{removal}}$ is the cost of one ton of carbon removal. In this assumption, only $\mathbf{P_{emission}}$ is actually accurately known, and thus likely to be overrepresented in the equation.

In the face of this uncertainty, our respondents all expressed the view that the market is unlikely to produce a societally optimal outcome, because especially $\mathbf{MU_{emission}}$ and $\mathbf{MU_{removal}}$ would, even if known, not be internalized adequately. An instituted compensation market would thus allocate carbon removals to compensation of residual emissions at the expense of net negative emissions (figure 9). Further, the values indicated above may be uncertain now, but are even more uncertain over time: the equation would have different values in 2024 than in 2045. However, a removal realized today would, through occupying geological storage and through other means, restrict the potential for future removals. An emission done today with the promise of carbon removal realized later to compensate carries even more uncertainty.

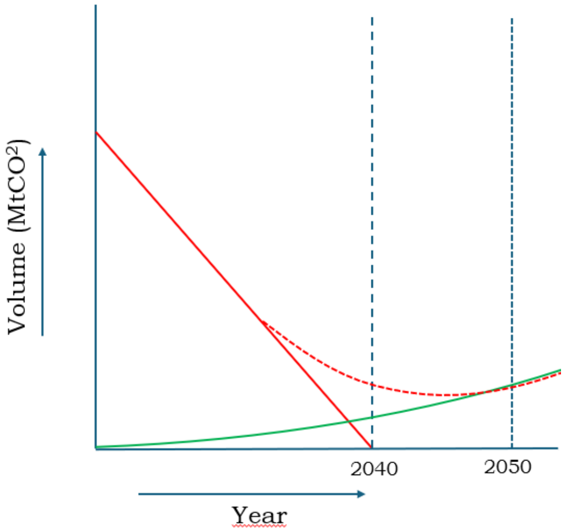

Figure 9: mitigation deterrence from a compensation market. Pemission > Premoval, loosened emission reduction target (net zero in 2050). Red: emission reduction target, red dash: emission volumes after loosening, green: carbon removal volumes (assumed independent of price)

With regard to non-permanent and open-system removals, the uncertainty is greater yet. Where the utility of a marginal ton of CO^2 in the atmosphere was indicated as unknown in the equation above, with these non-permanent and open-system removals, the amount of CO^2 is not even known. Therefore, using these compensation techniques for compensation of residual emissions seems unwise. Rather, they should be stimulated through other, non-climate policy and preferably not count as carbon removals.

Like the market, the government does not possess a crystal ball, either. However, in navigating this trade-off with uncertainty at one end, government can exercise more caution than the market would. A compensation market would consist of those with an interest to sell either carbon removal or products made in a carbon-emitting process: thus, parties with a vested interest. While governments (and especially democratically elected politicians) can also be short-sighted, they are arguably better able to make rational decisions.

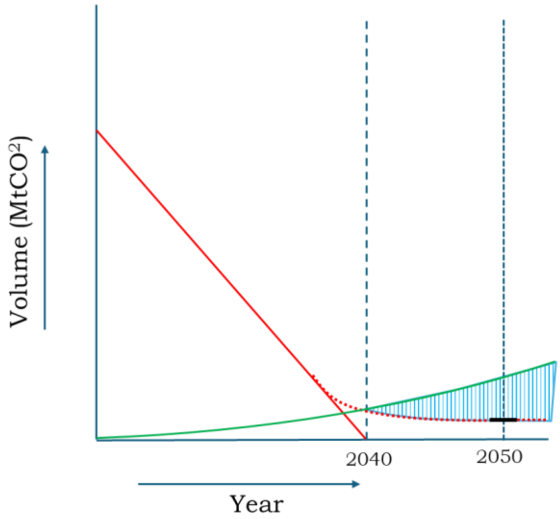

Figure 10: the effect of a residual emissions target on a compensation market. Green: carbon removal volumes (assumed independent of price), red: emission volumes (stylized after the EU ETS cap-and-trade system, ending in 2040), red dash: emission volumes after loosening of initial target, blue: net negative emissions volumes, black: residual emissions target. Own work.

In exercising this caution, a government can set emission reduction targets, limiting the amount of residual emissions in any given year, and thereby limiting amount of removals that can be used for compensation in that year, safeguarding these removals for net negative (figure 10). Setting such a residual emissions target (labelled the "separate targets approach") improves the potential for net negative (and thus climate benefit), but also means that removal volumes in excess of the residual emissions volume must be financed by other means: either by public procurement or by imposing obligations on other parties than the emitter. This constitutes a trade-off: the less residual emissions allowed, the smaller the compensation market, and the more government responsibility in realizing carbon removals.

One argument for allowing a compensation market without a volume limit, especially before a net-zero year, is that demand pull for innovation will arise, promising developers a business case. Our respondents indicated that demand pull is not a catch-all solution: environmental and other externalities may not be sufficiently internalized in such a market, and demand pull only functions for high TRL, almost market-ready techniques, so that more innovation instruments are necessary. However, allowing market parties to purchase compensating carbon removal certificates unlimitedly before the net-zero year could, when combined with a tight and robust emission reduction target, and when only using sustainable removals, provide demand pull for removals. At the same time, it could keep the public costs of realizing removals lower. This does, however, likely come at the cost of less emission reductions before target years. Furthermore, a compensation market may even disincentivize innovation in nascent removal techniques that are deemed 'too expensive': if DACCS is expected to cost €400/$MtCO^2$, what conclusion will a developer draw if faced with a compensation market that is consistently priced and around €100/$MtCO^2$?

From the data gathered in the Dutch case, it becomes clear that a compensation market is an instrument often discussed for the deployment of carbon removals. For the climate and societal outcomes, however, it matters enormously what that market is and is not allowed to do under government regulation. An insufficiently regulated compensation market may cause type-3 mitigation deterrence (emission reductions substituted for the promise of carbon removals), due to the market not accurately estimating the potential of carbon removals.

The above discussion relates to a point raised by one respondent: namely that decisions about which emissions should be considered residual and about how much climate ambition should be pursued are decisions that bring along so much societal and ethical impact that they, in the view of this respondent, should be taken democratically. It is up to a democracy to articulate a vision of what it thinks society should be like: not up to individual polluters' willingness to pay.

The impact of the EU on Dutch carbon removal policy

With regard to carbon removals, supranational climate frameworks play somewhat of an ambiguous role in the Dutch case. The European Union was seen to have a stimulating and facilitating role thus far. Stimulating, because Commission proposals force the member states to devote attention to carbon removal policy. Facilitating, because the EU thus far has implemented common definitions of carbon removal and announced a place for it in its 2040 target. In the realms of definition-setting and future target-setting, EU initiative may make it easier for member states to credibly commit to climate goals. However, the LULUCF goal set by the EU for large volumes of land-based non-permanent removals is not in line with Dutch potentials and priorities.

The UNFCCC accounting framework presents a problem in the realm of non-permanent removals. Even if these removals are only stimulated for other purposes than climate, and domestically kept out of compensation, the UNFCCC accounting will add all emissions and removals to produce one net number. Until this problem is solved, this simplified addition creates a mitigation deterring effect at state level.

Since carbon removals have been identified as a public good, and CO^2 is already a part of the European Single Market, important questions can be raised about the future role of the EU in realizing carbon removals. Our respondents indicated a preference for carbon removal deployment policy on the EU level, deeming it more efficient. However, realizing a public good – especially in the necessary volumes of carbon removals – requires funds. In the coming years, it will be interesting to watch the European discussion unfold: CO^2 as part of the single market predicts a functional spillover effect and thus more EU control over carbon removals, but member states transferring additional funds to the EU to realize removals seems unlikely at least.

Furthermore, the way the EU decides to structure the CO^2 transport market will likely generate path dependencies for carbon removals. If this market is treated as solely business-to-business, and government control thus limited, it may be hard for a national government to provide foresight on efficient divisions between CCS, CCU and CDR and steer the market towards a societally optimal outcome. A business-to-business market could lock in an outcome that is not long-term efficient, since it only considers short-term incentives.

The EU at this moment thus facilitates and stimulates the discussion about carbon removals, but is likely to take on broader competences in the future.

Key decisions and trade-offs in Californian carbon removal policy

In California, a target for net zero in 2045 was set, including a strategy with high volumes of carbon removals and little detail on how to achieve these targets. From the policy documents, a struggle between CARB and the legislature (and arguably the governor) can be identified, with the legislature implementing emission reduction targets and the governor asking for carbon removal targets, while CARB is suspected by our respondents to use as much of its legal room for manoeuvre (and arguably more) to implement these targets and keep emission reduction pressure away from emitting industry by means of carbon removals, physical or rhetorical. The shifting of beacons towards a 2045 target in this view is intended to distract from the lack of progress in reaching the 2030 target.

In any case, the concentration of competences in one non-elected regulatory agency may be questionable. Not only does a super-agency increase susceptibility to industry capture, but perhaps more importantly, it transfers decision-making competences away from democratic legitimacy. Since the decisions on especially residual emissions carry enormous societal impact, a strong normative case could be made that these decisions should be made under close democratic control, and not by a regulatory authority.

As of now, no action is enshrined in policy to develop the large volumes of carbon removals planned for in the Scoping Plan. This current situation can be classified as an instance of type-1 mitigation deterrence on a state level: emission reductions are substituted for carbon removals, but currently, it is highly doubtful that these removals will materialize.

A climate-hopeful note is that during this research, the legislative attempt to institute carbon removal scale-up requirements in bill SB308, which was previously held up, was amended and reconsidered in the Assembly. This bill, if passed in its current form, would specify which removals can be used for compensation, and set volume targets for their rollout, beginning with 1% of total emissions in 2030. Thereby, the legislature seeks to fill the gaping hole in Californian carbon removal policy, a hole left by CARB. This will turn out to be a continuation of the 'battle of wills' between a climate-ambitious legislature and a regulator that does not seem to respond to democratic direction.

The impact of US federal policy on Californian carbon removal policy

The concrete impact the US federal climate government has on Californian carbon removals comes from two concrete policies.

The DACCS subsidies under the Infrastructure Act carry a lot of weight: California has been deemed too small to promote innovation of a technology by itself. Therefore, the US federal government freeing up money for DACCS demonstration plants is a significant and climate-beneficial move. However, other carbon removal techniques are not subsidized, and potentials for DACCS remain uncertain: deployment at large scale before 2050 is all but certain.

The other large federal funding source is the 45Q tax credit, which stimulates any CO^2 injection. Fossil CCS, and to a lesser extent, BECCS projects can use this revenue to develop infrastructure. However, varying degrees of climate benefit are not distinguished between in this subsidy.

The lack of explicit strategy in the deployment of CCS and carbon removals means that outcomes are uncertain. These subsidies are a means, but the end is unclear. If this lack of strategy endures, type-2 mitigation deterrence may arise, in which additional emissions are caused by the subsidized but uncoordinated roll-out of carbon removals.

Subsidizing climate-mitigating technologies has been deemed a second-best outcome, but they are a way in which an otherwise gridlocked federal executive government can achieve some climate action and help out more climate-ambitious states.

However, if and when California decides to establish an actionable strategic vision for net-zero and net negative, it may find itself confronted with path dependency caused by such subsidies. For instance, federally-backed fossil CCS plants could be constructed within the state: reducing the action potential and increasing the costs for the state government to phase out those fossil entities.

Conclusion: how Dutch and Californian carbon removal strategy compare

This research has compared the navigation of trade-offs and decisions in carbon removal strategy between California and the Netherlands. A couple overall conclusions may be drawn from the explicit comparison of both cases.

Respondents for the Dutch case are well aware of the lasting effects choices made at this stage can have well into the future, and are focused on the long-term climate outcome. The recognition of these intertemporal trade-offs has led the Dutch government to develop a long-term strategic vision for carbon removals, in which explicit choices will be made for the navigation of these trade-offs. After this vision is explicitly put forward in the roadmap for carbon removals, more detailed policy surrounding scale-up is expected to be made.

On the other hand, in California, the sequence seems the other way around. Stimuli for CCS and DACCS are already implemented, and targets for removals set, before a discussion on the end vision and the way there is held. A lack of broad strategy will cause uncertainty about the outcomes, while a lack of effective government support for removals will lead to mitigation deterrence, wherein both removals and the emission reductions they are substituted for will not materialize.

If the discussion on a vision of climate neutral society and the role of carbon removals therein is not being held before the deployment of removals, path dependencies generated by previous policy may already have restricted certain outcomes. A compensation market has been shown as an important example of such a path dependence-creating instrument. Such a market can by design not realize net negative emissions; nor can it make accurate estimations about carbon removal potentials. Thus, if such a market were to be implemented in the short term, important normative choices (how much and which kind of residual emissions does society want, how much net negative emissions) could be obscured. These choices may provide benefit for some interests, but are doubtful to lead to a societally optimal outcome, and if taken by a non-elected actor, do not carry the democratic legitimacy that should accompany decisions of this importance. The significant external effects carbon removals can have on other policy domains, while underrepresented in this research, only reinforce this need for democratic decision-making.

Thus, carbon removal strategy should be discussed in a transparent and democratically accountable manner. The problems and trade-offs identified in this study can serve as a starting point, perhaps the most important being how to ensure carbon removals do not take away the incentive to reduce emissions. Private interests may benefit from societal silence on this issue, and even crucial decision-makers may opt to strategically ignore the subject. However, the consequences carbon removals can have on future society call for a transparent democratic discussion.

During this research, we have seen that mitigation deterrence is to be avoided. Especially allowing private companies to choose between mitigation or removals is deemed undesirable, because these firms are not able to take rational decisions on the time-scale necessary. On a state level, both Californian and Dutch respondents indicate that substituting emission reductions for removals in some amount may be chosen for. The societal implications of potentially allowing this state-level mitigation deterrence, however, mean that a decision on this topic should follow from a democratic discussion about vision for society, including transparency and accountability for decision-makers. At this moment, the Netherlands seems to be better on track in facilitating such a democratic discussion than California is.

Carbon removals will prove both an integral part of a climate-neutral future, and an important battleground in reaching that future. While much is yet uncertain about their deployment, one thing is especially clear: carbon removals are too important to (future) society to let private interests or even non-elected regulators make all the decisions. The same conclusion extends to the role of supranational government: important decisions on the optimal scale of provision for the public good of carbon removals are yet to be taken. These decisions can have important implications for the democratic legitimacy of future climate policy.

Discussion

This research has sought to provide a problem analysis about carbon removals in government policy, specifically about CCS/CCU, non-permanent removals and compensation market. From the outset, the expectation was that these trade-offs and problems would be distilled from the answers of respondents, and then compared between the cases to gain deeper understanding of both problem and case. For the Dutch case, this expectation came true, and the analysis took a more economic form.

However, the Californian case presented an unexpected outcome: although carbon removals were integrated in targets to high volumes, not much carbon removal policy turned out to actually be in place. In the move to then explain this absence, the analysis took on a more governance/political science perspective. This means that a comparison on the substantive navigation of trade-off and problems could not be executed, but a comparison about the form of this navigation resulting from political realities could be done. A more political turn has thus been made during the course of this research. Still, the Dutch case yields important insights about trade-offs and problems in carbon removal policy: these have just not been compared to a Californian counterpart.

As a part of this Dutch case, several contributions have been made to economic and governance theory. The trade-offs through time, uncertainty surrounding non-permanent removals, as well as the inability of a compensation market to realize both emission reductions and carbon removals, have been provided as economic theoretical backing for recommendations that were previously made in the policy area. This study contains a first attempt at characterizing carbon removals in economic theory, although it did not come up with one overarching theoretical framework for all concepts studied.

The societal relevance of this research is in outlining which decisions are key in developing carbon removals, and demonstrating how these decisions could be reflected in policy. In line with the conclusion of this study (democratic decision-making is essential for carbon removal policy), the development of theory about carbon removals is essential for facilitating a societal discussions. For academia, this research may provide one of the starting points for further examination of carbon removals from social science and/or economic disciplines. Especially for the economic research that already exists about carbon removals, the theorization of net negative emissions as a public good should warrant careful re-evaluation of modelling: the literature review has identified that existing economic models optimize toward net zero outcomes, not net negative.

This research has produced findings that are in line with Mazzucato's call for a steering government in societal transitions (Mazzucato, 2019). At multiple instances in the data, a large role for government is called for in indicating the direction of transition. Further, this research has added to Mazzucato's theory by showing that government indeed needs to steer, but that it matters which part of government does the steering: such decisions with wide-ranging societal impact should preferably be taken by democratically elected institutions, not by regulatory or supranational institutions that struggle with democratic deficits.

Future research is welcomed on almost any aspect of carbon removals: especially, the functioning of Third Party Access in CO^2 transport infrastructure is suspected to make an interesting case study. From the EU liberalization of the gas market in the early 2000s, important lessons about infrastructure owners' natural monopoly and market power were learnt; a study on this phenomenon in CO^2 transport infrastructure would be very welcome.

Further, delving deeper into the specifics EU of decision-making on carbon removals than this research could would also prove an interesting research topic. This new policy field, combined with different expectation from different societal and political actors, may yield a rich case study on how, when and why the EU uses its agenda-setting power to make progress in new policy areas. Other fruitful avenues of approach may include Majone's regulatory state theory, elements of which at first glance seem to be present in the governance of carbon removals (Majone, 1994).

Policy recommendations

Limit a compensation market
This research has shown that although the representation of a market mechanism in policy rhetoric is significant, the option of integrating carbon removals into a cap-and-trade market is limited in what it can achieve, and comes with significant trade-offs. Opting to use a market mechanism to deploy carbon removals can mask important choices and lock them in. Therefore, policymakers should think carefully about the desired outcome and under what conditions a market can deliver them.

Trade-offs start now, with their other end unknown
Policymakers should be thinking cautiously about the future: several of the trade-offs (geological storage, compensation versus net negative) have already started to be navigated or are due to start in the near future, while the value of the future alternative is not accurately known. Caution is advised.

Execution is as important as design of policy
From our respondents, the image arose that mitigation deterrence is a concern mostly in the design of policy, avoiding that the policy has a deterring effect when implemented. While this is definitely important, the Californian case shows that a lack of policy, and by extension, poorly executed policy, can also cause mitigation deterrence. It is not only what a government *is* doing for carbon removals that counts, arguably, what it *isn't* doing is more important.

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Appendix A: case study protocol

From the literature review, the following sensitizing concepts have been derived:

SC1: Mitigation deterrence and emission reduction-carbon removal trade-off
SC2: Tradeoff between carbon removal and CCS&CCU
SC3: Definitions of permanent versus non-permanent carbon removal
SC4: The role of non-permanent carbon removals in climate policy
SC5: Efficient pricing for non-permanent carbon removals
SC6: Demand pull for innovation through markets
SC7: How to achieve net negative?
SC8: The role of government; stimulating and delimiting the use of carbon removals
SC9: The size of the residual emissions compensation market towards 2050
SC10: Consumption of carbon removals as emissions offset/compensation versus public net negative
SC11: Definition of residual emissions volumes
SC12: Dynamics of multilevel governance

These sensitizing concepts will be used to guide the interview guide and the content analysis.

Content analysis of documents:
Relevant (published) legislation of both cases needs to be analysed and coded. Furthermore, public communication and press releases are of interest to this analysis. These will be coded and compared to the interview data.

Interview respondents:
Gathering respondents will start from the researchers network. The snowball method will be used, in which every respondent will be asked to provide details on potential further respondents. The interviews will as much as possible be conducted online, so that the threshold for responding is low and recording is made easy.

Respondent types:

A. knowledgeable about NL
B. knowledgeable about CA
C. knowledgeable about both

For types A & B: deep dive into single case; no deep comparison asked
For type C (if available): Ask to compare between the cases more than deep delve single case

Interview script:

- Welcome: explain background & aim of study, check **consent**. **RECORD.**
- Ask about their **area of knowledge** and **role**
- How do you perceive the **relationship between emission reduction and carbon removals** in government policy, especially with regard to **mitigation deterrence?**
- There is a need to **scale up** carbon removals; what **role should governments** play in that?

- What **ways** are there to **scale up** carbon removal? Who has a role? What are their advantages and drawbacks?
- Specifically about **market** mechanisms; what can and can't they achieve?
- How do you see the relationship between the purposes of carbon removals; specifically between **offsetting** and **net negative?**
- **(For economists)** How do you think of carbon removals an **economic good**?
- Is there an **optimal size** for the **compensation market towards 2050**? What factors influence that size? Can there be **overconsumption?**
- How can governments **safeguard** the use of carbon removals for **net negative?**
- How can governments proceed in **stimulating but limiting carbon removals?**
- Is there a **societally optimal long-term deployment level of carbon removals**? Can it be underused or overused, and what **factors influence** the optimal level?
- How do you see the **relationship between CDR & CCS/CCU?**
- What interplay is there between the *supranational entity* **(EU/US)** versus national policy? How do **supranational climate frameworks** influence national policy?
- **When** and **how** should **residual emission volumes** be designated?
- What role should governments assign to **non-permanent removals** in **climate policy**? Can they be used for **compensation**?
- How can an **efficient price for non-permanent removals** be established?
- Conclude and thank; ask for **snowball respondents**

Report

In the report of the analysis, relevant interview data will first be described, after which relationships between key concepts will be established, to develop theory. Visualisation may take place in the form of a model; graphical lines depicting relationships.
As an outline, first the data from the Dutch case will be described, with respective conclusions coming from the Dutch case.
Afterwards, the Californian case data is outlined, with conclusions from this case.
A comparison between the two will inform the final conclusions.

Appendix B: respondents

Dutch case:

Respondent NL1: Interview with policymaker at the Dutch ministry of Economic Affairs & Climate. Length: 55:39

Respondent NL2: Interview with policymaker at the Dutch ministry of Economic Affairs & Climate. Length: 54:36

Respondent NL3: Interview with policy advisor at the Rijkdienst voor Ondernemend Nederland, a Dutch executive agency for businesses. Length: 1:00:21

Respondent EU1: Interview with Science & Advocacy Officer at an EU-level carbon removal NGO. Length: 53:42

Respondent EU2: Interview with Science & Advocacy Officer at an EU-level carbon market & carbon removal NGO. Length: 42:27

Californian case:

Respondent CA1a: interview with policy researcher and advisor to the Californian and US governments on carbon removals. Length: 53:39.

Respondent CA1b: interview with CA1a with an US journalist researching California's 2022 Scoping Plan. Length: 1:16:08.