

What will carbon dioxide removal look like in the Netherlands?

A Dynamic Adaptive Policy Pathway approach

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This thesis is the final requirement for my Master Complex Systems Engineering & Management. After this, I am a student no longer, which feels surreal. Apparently, the process of writing a thesis can be hard. Not in terms of labour, but in terms of motivation to get started and knowing when you need to stop thinking and second guessing yourself. I am grateful to be finishing this project, the making and writing somehow felt too long and too short at the same time.

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Executive summary

The EU is currently not on track to hit its climate emission reduction goals. Furthermore, even rapid reduction will not be sufficient to achieve net-zero greenhouse gas emissions. Carbon dioxide removal (CDR) will be necessary to eliminate difficult-to-abate residual emissions and could assist in accounting for historical emissions. The process of CDR involves the capture and storage of atmospheric or biogenic short-cycle carbon in a carbon sinks, with the duration of the storage depending on the storage method.

However, the development of CDR remains at an early stage, both in terms of the technological maturity of individual removal methods and the evolution of the policy framework. At the European level, the Carbon Removal and Carbon Farming (CRCF) regulation is currently being developed to establish minimum standards for assessing carbon removals. This early stage of development raises important questions regarding the design and implementation of CDR policies and methods capable of effectively reducing climate impact. There are various CDR methods available, and no single method can meet all the objectives and challenges. Consequently, the selection and deployment of both CDR methods and policies should be tailored to local and regional contexts. In response to these challenges, the Netherlands has developed a roadmap that outlines possibilities until 2050 while prioritising actions that can be implemented in the short term.

To further explore the requirements for the Netherlands, the following research question was developed: **What contribution can Dynamic Adaptive Policy Pathways make to the development of carbon dioxide removal in the Netherlands?**

The Dynamic adaptive policy pathways (DAPP) approach was developed to deal with long-term planning in situations characterised by deep uncertainty. It was designed to deal with adaptation decision-making within water systems and has not previously been used for the CDR sector. As a result, the goal of this thesis was twofold: to assess the applicability of the DAPP approach in the CDR sector and to determine the policy recommendations resulting from its implementation.

To achieve this, an 'early adopter' application of the DAPP approach was developed. The objective was to identify constraints that could hinder the implementation of policy actions and to determine the conditions under which policies might fail. This was achieved by constructing potential development pathways for CDR based on the perspectives of stereotypical actors. These pathways were developed iteratively using academic literature and relevant policy documents, after which the resulting pathway designs and their underlying assumptions were evaluated through interviews with stakeholders representing a range of backgrounds across the CDR sector.

Pathway maps were developed for four context scenarios based on two axes: the distinction between the current free market and a mandated market, and the eligibility of only permanent CDR or both permanent and temporary CDR. While the first axis was intended to frame discussions on the use of temporary CDR, the interviews focused primarily on the role of temporary removals and the criteria that determine whether a removal should be considered permanent. This highlights the absence of a universally accepted definition of permanence within the current CDR market. Although the

CRCF is expected to establish a clear definition of permanence, its method-specific requirements may lead to the misclassification of methods that do not fit neatly within predefined categories. Furthermore, interviewees suggested that temporary CDR could serve as a countermeasure to short-term emissions. However, this research did not identify or develop a specific mechanism through which such a coupling could be implemented.

As a consequence of the second scenario axis, contrasting a free market with mandated removals, discussions during the interviews shifted towards the economic mechanisms required to achieve CDR deployment objectives. Within the context of this thesis, a mandate refers to a requirement for companies to finance or utilise carbon removal methods. A central topic of discussion was whether CDR should be incorporated into the EU ETS (Emissions Trading System) or supported through the allocation of ETS revenues, for example via schemes such as SDE++, to stimulate market development and incentivise investment in CDR methods. Interviewees generally agreed that, at least in the short term, additional financial incentives are required beyond the reputational benefits that currently drive investment.

By applying the Dynamic Adaptive Policy Pathways (DAPP) approach, a framework was established for evaluating the factors that may influence the development of CDR. Although the pathway maps proved useful for identifying potential trade-offs and stakeholder perspectives, they were considered less effective as tools for analysing those trade-offs in depth or for developing actionable policy measures. While the process of constructing the pathways facilitated the exploration of constraints and competing viewpoints, the resulting maps did not communicate these complexities as effectively to stakeholders.

Based on the findings of this research, policymakers should, in the short term, assess policies that establish a clear definition of residual emissions and determine whether temporary removals can be used to offset them. In addition, policymakers should evaluate mechanisms for funding, or mandating the funding of, CDR methods and consider policy adjustments that improve support for pilot projects and innovation. In the longer term, policy development should address the implications of fossil CCS on the availability of CCS-storage capacity and support continued research and development of emerging technologies such as direct air carbon capture and storage and mineralisation.

The DAPP approach used in this study could be improved by incorporating quantitative methods, such as modelling, as seen in other DAPP studies. Future research could also explore pathway development at a higher level of aggregation, where CDR is considered alongside mitigation measures and land-use practices. Alternatively, a more specialised application focusing on specific CDR methods or subsectors may provide more profound insights into future development pathways.

Abbreviations

Abbreviation	Definition
BCR	Biochar Carbon Removal
BECCS	Bioenergy with Carbon Capture and Storage
BioCCS	Biogenic Carbon Capture and Storage
CBAM	EU Carbon Border Adjustment Mechanism
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CDR	Carbon Dioxide Removal
CRCF	European Carbon Removals and Carbon Farming Regulation
CO ₂ e	Carbon Dioxide Equivalent
DACCS	Direct Air Carbon Capture and Storage
DAPP	Dynamic Adaptive Policy Pathways
DEI+	Subsidy Demonstration Energy and Climate Innovation
ETS	Emissions Trading System
EU	European Union
EW&M	Enhanced Weathering and Mineralisation
EW	Enhanced Weathering
mCDR	Marine Carbon Dioxide Removal
MtPA	Million Tonnes Per Annum
MOOI	Subsidy Mission-driven Research, Development and Innovation
NbS	Nature-based Solutions
OCDR	Ocean Carbon Dioxide Removal
ONETs	Ocean-based Negative Emissions Technologies
SDE++	Subsidy Stimulating Sustainable Energy Production and Climate Transition
TRL	Technology Readiness Level
GHG	Greenhouse Gas
GWP	Global Warming Potential
LULUCF	Land Use, Land-Use Change and Forestry

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1 Introduction

Climate change is one of the most pressing issues on the current policy agenda. To address this, the European Union has set legally binding targets to reach net-zero greenhouse gas (GHG) emissions by 2050 (European Commission, 2025a), in order to meet its obligations under the Paris Climate Agreement. However, emissions reduction alone will not be sufficient to achieve this goal. Removal of GHG emissions will also be required to compensate for residual emissions (Brad & Schneider, 2023). The practice of removing GHG emissions from the atmosphere has come to be known as Carbon Dioxide Removal (CDR). The European Commission estimates that, from 2040 to 2050, the annual amount of CO_{2e} that needs to be captured and permanently stored is approximately 250 Mt (European Commission, 2025b). To put this amount into perspective, that is roughly equivalent to one-tenth of the EU's GHG emissions in 2023 (Ritchie & Roser, 2020).

However, currently the EU is not on track to meet the CDR targets as terrestrial removals have decreased, and significant industrial CDR activities have yet to materialise, as laid out in the Regulation (EU) 2024/3012, also known as the carbon removal and certification framework (CRCF) (European Union, 2024). The CRCF is the principal European framework for CDR, dividing the sequestration of CO₂ into permanent removals, carbon farming and carbon utilisation (the temporary removal of CO₂).

1.1 CDR within the Netherlands

The Netherlands is among the frontrunners for the CDR sector within the EU (Directorate-General for Climate Action (European Commission) & Ramboll Management Consulting, 2025). To position CDR in policy, the Netherlands Ministry of Climate Policy and Green Growth KGG (2025) created a roadmap for the development of CDR, framing the problem at three levels: global (trade and agreements), EU (creation of a market and incentives) and national (supporting the rollout of CDR).

For this project, the focus will be on the national level of policy development in the Netherlands. Even if net-zero GHG emissions are achieved, keeping emissions below net-zero and addressing global carbon overshoots will be necessary post-2050 in the Netherlands (KGG, 2025). Currently, the Netherlands emits 174 MtCO_{2e} annually (Carbon Gap, 2025). The previous Dutch government has indicated that a contribution of 20 to 25 MtCO_{2e} of CDR per year during the period of 2040 to 2050 could be required from the Netherlands (KGG, 2025).

In terms of specific CDR policies, the Netherlands currently has an obligation to remove -435 ktCO_{2e} annually in 2030 under the Land Use, Land Use Change and Forestry (LULUCF) sector, compared to the emissions from 2017 to 2019 by this sector (Erbach & Dewulf, 2024). This sector should reach a level of 1.8 MtonCO_{2e} net residual emissions in 2030 (KGG, 2025). Other policies currently in place include developmental subsidies. The Stimulation of sustainable energy production and climate transition (SDE++) is the most important national subsidy instrument, it requires a Technology Readiness Level (TRL) of 9 (KGG, 2025). A level that has not yet been achieved by most CDR methods. This subsidy program is also more in line with the Netherlands current focus on mitigation.

1.2 What falls under CDR

Before proceeding, it is important to discuss what falls within the scope of CDR. A requirement for CDR is that atmospheric CO_2 is removed. Thus, Carbon Capture and Storage (CCS) or Carbon Capture and Utilisation (CCU) from a fossil source does not fall under CDR, nor does bioenergy without CCS. These approaches do not reduce the quantity of CO_2 already present in the atmosphere; rather, they reduce the amount of CO_2 emitted into the atmosphere. The removal of CO_2 by forests is also considered a form of CDR; however, it is generally classified as a temporary CDR method. In contrast, methods such as Bioenergy with Carbon Capture and Storage (BECCS), Direct Air Carbon Capture and Storage (DACCS), and Enhanced Weathering and Mineralisation (EW&M), are often classified as permanent forms of CDR (KGG, 2025). The differences between CCS, CCU, and CDR are illustrated in Figure 1.

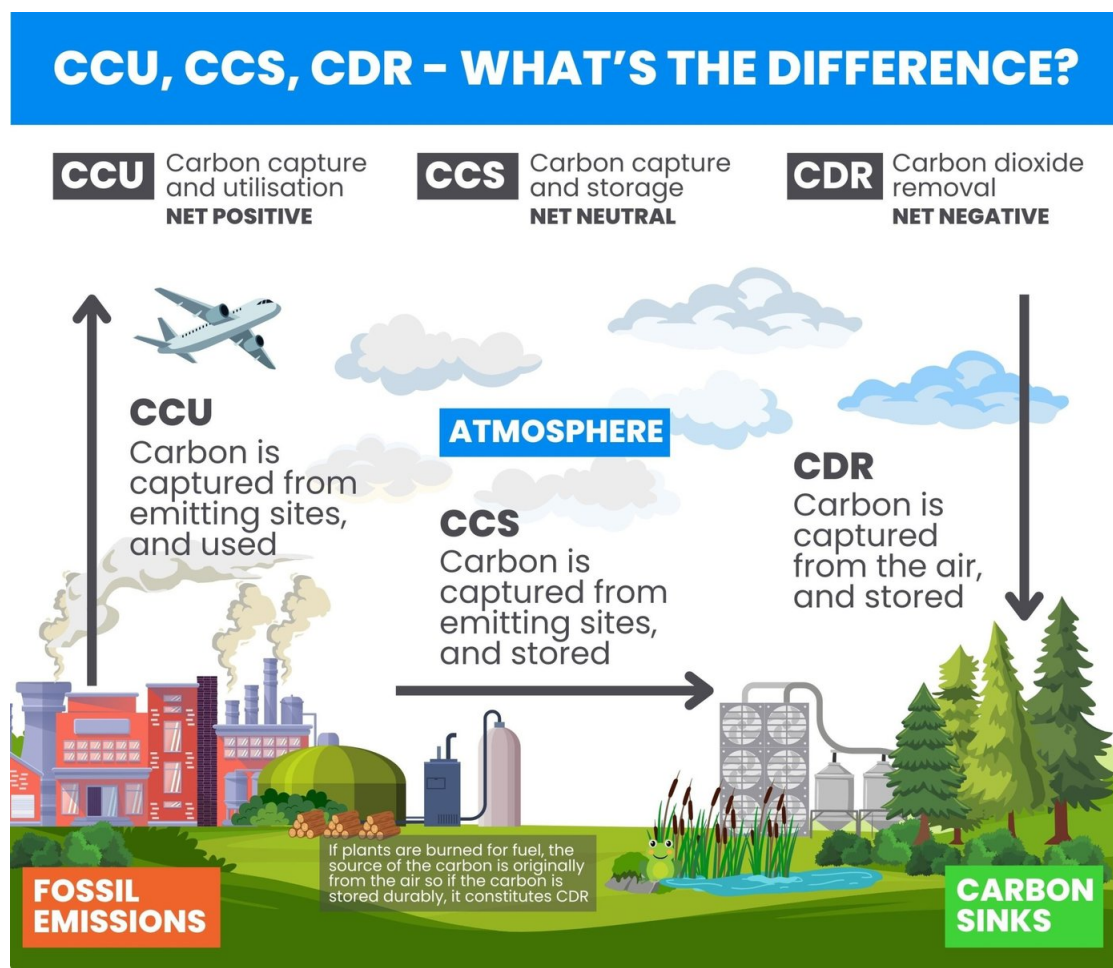


Figure 1: An overview of the difference between carbon removal, carbon utilisation and carbon capture and storage from Carbon Gap (2026a).

1.3 The risks and uncertainties in CDR policy

The development of CDR policy involves several risks and uncertainties. One frequently discussed concern is the potential moral hazard associated with the continued use of fossil fuels (Günther et al., 2024; Lamb et al., 2025; Schreyer et al., 2020). The existence of technologies that can, in principle, remove emissions after they have occurred may reduce incentives to pursue rapid emission reductions. At the same time, this

characteristic also represents one of the key benefits of CDR. Carbon removal offers a mechanism for addressing historical emissions and compensating for residual emissions that are difficult or impossible to eliminate entirely.

However, this moral hazard is only one of several challenges. Another major issue concerns the financing of carbon removals (Bednar et al., 2021; Brad & Schneider, 2023; Honegger et al., 2022). Questions remain regarding who should bear the costs of removal activities and under what governance arrangements these removals should be financed. At present, the market is voluntary, meaning that neither the use of CDR nor the accounting standards applied to removals are mandated (Carbon Gap, 2026b). The absence of universally adopted standards for evaluating and integrating different CDR methods creates a risk of insufficient deployment as well as the proliferation of low-quality removal credits.

These issues are closely linked to the broader question of how the sector can scale to a level that contributes meaningfully to climate mitigation and whether such scaling can occur within the required timeframe (KGG, 2025). Yet, there is currently no consensus on whether large-scale expansion of the CDR sector should be actively pursued. While some stakeholders view rapid scaling as essential for achieving climate targets, others remain concerned about the technological, environmental, and governance uncertainties associated with widespread deployment.

Consequently, the challenges surrounding CDR extend beyond technological feasibility and economic performance. Equally important are questions of governance and societal acceptance: How should different CDR methods be evaluated? Which standards should determine their quality and eligibility? How should their deployment be incentivised, and to what extent should policymakers actively support sector growth? Addressing these questions requires not only an understanding of the technologies themselves but also consideration of the broader Dutch context in which CDR policies and markets are expected to develop.

1.4 Methods

Currently, there is still a lot of uncertainty regarding the best policies to pursue in order to develop CDR, and how to integrate them with current policies on emission reductions (KGG, 2025). In the early development of a sector, value-based approaches may provide more useful insights than purely economically based approaches (Harvey et al., 2023). Thus, this work will focus on using a qualitative approach to evaluate the CDR sector. The Dynamic Adaptive Policy Pathways (DAPP) approach is an approach designed to prevent future lock-ins from occurring based on current policy and scenarios in situations characterised by deep uncertainty (Lawrence et al., 2019). This will require looking at technical challenges and opportunities, and policy and regulation requirements in the Dutch context, while also considering time horizons beyond those covered by current policy advice, such as that provided by the Netherlands Scientific Climate Council (WKR, 2024). The DAPP approach was designed for water adaptation policy and has since been used for climate adaptation. However, it has never been used for policymaking in the CDR sector (Di Fant et al., 2025). It is thus even a question whether the DAPP approach can be used to evaluate the CDR sector. This work therefore has a dual focus, evaluating the wider CDR sector and evaluating whether DAPP can be applied to the CDR sector.

To capture the discussion in the emerging sector, this study will combine the use of desk research and interviews. This allows the evaluation of both institutional perspectives on the CDR sector and the viewpoints of stakeholders operating within it.

1.5 Research questions

Given the need for effective policymaking and improved insights into the uncertain and evolving CDR sector, the following research question was formulated: **What contribution can Dynamic Adaptive Policy Pathways make to the development of carbon dioxide removal in the Netherlands?**

Sub-questions:

1. What is the current policy and regulatory context for CDR in the Netherlands?
2. What are plausible policy pathways for CDR deployment in the Netherlands?
3. How do stakeholders evaluate these pathways?

1.6 Relevance for CoSEM

An important component of the CoSEM master's programme is the analysis of socio-technical systems, which comprise interacting technical, institutional, economic, and social dimensions. This thesis investigates the emerging CDR sector in the Netherlands through the application of the DAPP approach. As such, the research examines CDR not merely as a collection of CDR methods, but as a developing socio-technical system shaped by interactions between technological innovation, policy developments, economic incentives and societal values.

1.7 Thesis outline

Following this introductory chapter, which defines CDR, discusses some risks, and introduces the Dutch context, the thesis is structured into eight chapters. Chapter 2 will present some core concepts and background information necessary to understand the various methods of performing CDR, and the discussion surrounding their implementation. Chapter 3 presents the methodology used, both the data collection process and the process of analysing the data collected using the DAPP approach. Followed by Chapter 4, which further establishes the Dutch context and describes the elements required to develop the DAPP maps. These DAPP maps are then presented in Chapter 5, along with how the stereotypical actors, and design directions are present within the maps. Chapter 6 presents the results of the interviews along various aspects, comparing the framing of the pathways and the framing adopted by different stakeholders. The implications and discussion that result from these interviews, as well as the development of the pathways, will be presented in Chapter 7. Lastly, Chapter 8 presents the conclusions and recommendations for both CDR policy and the application of the DAPP approach for the CDR sector. The AI-statement and appendices for this thesis can be found after the references.

2 Core concepts

This chapter will provide a general overview of the CDR methods, as well as more in-depth information on specific aspects of the sector. The concepts discussed are included because they represent the key dimensions through which the CDR sector is currently debated by policymakers, and researchers. Understanding the differences between CDR methods, the implications of market design, and the requirements for MRV frameworks is essential for evaluating the effectiveness, credibility, and scalability of CDR methods. As such, these concepts provide a foundation upon which the remaining research can be built.

2.1 The CDR methods

Figure 2 presents an overview of various CDR methods and their storage durations. The methods considered for this thesis include BECCS, DACCS, mineralisation, wood building, and LULUCF-based methods such as afforestation, reforestation, and soil carbon sequestration. These methods were included based on their potential according to WKR (2024) as presented in Figure 3 and the literature review in Chapter 2.5.

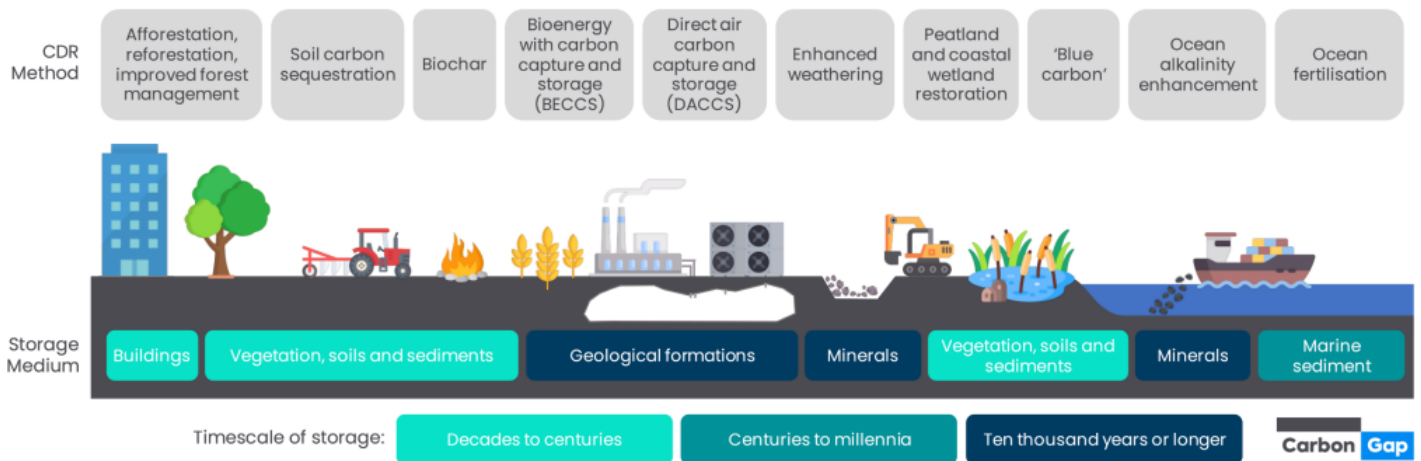


Figure 2: An overview of various carbon removal methods from Carbon Gap (2026a).

The chosen CDR methods are highlighted before going into the core principles. The first methods to highlight are CCS-based, the principal idea is that carbon is captured from the air (DACCS) or from biomass source (BECCS or Bio-CCS) and subsequently stored in a geological formation. The storage duration is approximately millennia (Franks et al., 2026), and these methods are thus classified as permanent storage methods. Bio-CCS including BECCS has the highest potential capacity for permanent storage in the Netherlands according to the WKR (2024), although this is heavily dependent on assumptions regarding biomass availability. DACCS will likely not be technologically relevant in the Netherlands before 2050 (WKR, 2024). However, it might become relevant depending on its development beyond 2050. BECCS has as a positive co-benefit the production of power, while DACCS has no co-benefit (NEGEM Consortium, 2024), apart from the development of DAC, which has some potential for CCU. However, BECCS has other drawbacks. The sourcing of biomass can lead to

reduced removals from LULUCF methods. While BECCS also acts as an extra burden for bioenergy, there is no clear incentive to shoulder this burden (Tanzer et al., 2025).

The second method to discuss is EW&M. This is a reference to the process of mineralisation which involves the reaction of CO₂ with minerals, resulting in the CO₂ being bound in the structure of these minerals (Huan et al., 2024). Enhanced weathering (EW) falls under the ex-situ subsection of mineralisation and is one of the most discussed forms. EW consists of speeding up natural weathering by spreading certain crushed rocks into the open environment. The enhanced part is the extra CO₂ removal capacity gained by crushing and spreading out the rocks. There is also the in-situ mineralisation subsection, which consists of pumping CO₂ (solutions) underground in certain rock formations and thereby binding the CO₂ in the rock formations (Huan et al., 2024).

A third method highlighted is biochar carbon removal (BCR). Biochar is produced through the pyrolysis of biomass, depending on the biomass feedstock and the temperature used for the pyrolysis process, the amount of char made compared to the co-product such as bio-oils can differ. The storage duration is approximately a century (Franks et al., 2026). Biochar will be categorised as a temporary removal technique under soil-carbon sequestration for this project. This was done to distinguish BCR from permanent removal methods for this project.

The use of bio-based building materials as a CDR method is also part of the discussion within the Netherlands (WKR, 2024). Within this thesis, the bio-based building category will be described as wood building. The use of wood building is considered a temporary removal method (WKR, 2024). Wood building is the practice of using biomass with the express purpose of sequestering the carbon within the material for longer periods. The use of biomass materials does bring some risk of non-sustainable biomass and competition with other uses for biomass.

The final CDR methods to highlight are the LULUCF methods. These cover emissions and removals directly caused by human activities regarding land use, land-use change and forestry. For the Netherlands, afforestation and reforestation, and sequestration in the soil form the main opportunities regarding LULUCF based CDR (WKR, 2024). Afforestation is the practice of creating forests where forests have not recently existed. Reforestation is the practice of restoring existing forests, for CDR this means making sure they sequester more carbon than would under a business-as-usual scenario. Lastly, soil-carbon sequestration is the practice of increasing carbon storage within the soil through the addition of biomass or minerals.

The last aspect of LULUCF is agriculture, which is responsible for more than 10% of GHG emissions in 2023 (Erbach & Dewulf, 2024), and therefore represents a sector with a large potential for emission reduction. Enhanced carbon farming is the name for the farming practices aimed at increasing carbon sequestration. Generally, all of these methods would be regarded as temporary removal methods.

The potential, developmental stage, costs, and effects of all of these various methods of conducting CDR can be observed in Figure 3 below.

Table 1: Overview of the most important CDR methods for the Netherlands and their characteristics, based on data from CE Delft (2023). 'Potential NL' gives the realistic potential for the Netherlands in 2050, the 'Costs' describe the expected costs in 2050. The development stage is based on the technology readiness level (TRL): low (TRL of 1 to 5; exploratory/development), average (TRL of 6 or 7; prototype at scale/demonstration) or high (TRL of 8 or 9; operational/commercial).

Method	Storage period	Potential NL MtCO ₂ /yr	Development stage	Costs €/tCO ₂ removed	Main synergies	Main negative side effects
Afforestation and reforestation	Temporary	0.7	High	50-1000	+ Biodiversity	- Spatial footprint and potential competition with food production - Risk of unsustainable forest management
Carbon sequestration in the soil	Temporary	0.5-0.9	High	0-50	+ Improved soil quality and water management	- Risk of methane emissions in peatlands
Blue carbon management	Temporary	Unknown	Low-Average	9 ¹⁹	+ Biodiversity + Coastal protection	
Biochar	Temporary	0.05	Low-Average	200-1500	+ Improved soil quality	- Risk of large spatial footprint and possible competition with food production - Risk of use of non-sustainable biomass
Timber construction	Temporary	3.9 ²⁰	High	Unknown ²¹	+ Lower emissions than conventional building materials	
Bioplastics	Temporary	Unknown ²²	Low-High	60-80	+ By-products of economic value	
BioCCS	Permanent ²³	22.2 ²⁴	Average-High	0-110	+ Energy production + Potential source of carbon ²⁵	
DACCS	Permanent	Unknown ²⁶	Low-High	85-540	+ Potential source of synthetic carbon ²⁷	- High energy consumption
Mineralisation	Permanent	5.4	Low-High	50-70	+ Economic value (e.g. as fill sand or in building materials) + Reduced soil erosion	- High energy consumption (due to grinding and transport)

Figure 3: An overview of the potential of carbon removal methods from WKR (2024).

2.2 Regulatory discussion on the market structure

The first concept to discuss is market structure. Currently, the CRCF creates a voluntary framework for carbon removals. But, research and policy documents emphasise the need for separate CDR goals to facilitate the creation of incentives for carbon removals (Bednar et al., 2021; Günther et al., 2024; Honegger et al., 2022; Lamb et al., 2024). The creation of mandated removals, and the way in which these removals may be used or reported, were supposed to be laid out in the Green Claims Directives, but its implementation has been paused (Carbon Gap, 2025). Thus, there is no required legal framework on how to account and present the removals falling under the CRCF framework in terms of net emissions accounting. There is currently not a legal requirement to conduct removals, or make sure they meet the standards set by the CRCF. Thus, a major point of discussion is whether there should be some form of mandated removals and, if so, what such a mandate should look like.

2.3 Heterogeneity in CDR methods

The second concept highlighted is the heterogeneity of existing CDR methods. In section 2.1, the different CDR methods are presented. But in reality, these methods are not as uniform as is presented there. The general idea is similar, but the evaluation of the effectiveness, desirability and risks differs depending on the specific implementation or design of the method. For example, all BECCS plants operate on the same principal, biomass captures atmospheric CO₂, after which the biomass is combusted and the resulting emissions are captured and stored. In some discussions, the principal idea will be challenged, the process still emits some amount of CO₂. However, for the most part, the evaluation will be focused on the question of what type of biomass is used, how the feedstock is replenished, and how short-term impacts should be weighed against long-term impacts in the evaluation of the method. The debate regarding which aspects should be prioritised in the evaluation of CDR methods is still ongoing.

2.4 MRV: Monitoring, reporting and verification

Several components have already been developed to assess the effectiveness of removals. The CRCF establishes four criteria that must be met to ensure the quality of removals (“QU.A.L.I.T.Y” criteria): quantification, additionality, long-term storage and sustainability (Carbon Gap, 2026b). Additional criteria that could be considered, or that may fall within these categories, include uniqueness, accounting for carbon leakage, traceability, the principle of "do no significant harm", and geographical or organisational attribution.

2.4.1 Quantification

Under quantification several aspects need to be established: the initial removal, the removal over time, and the risk of leakage. These can differ greatly between methods. For example, BECCS initially utilises an existing (temporary) carbon storage for its fuel source, meaning an initial increase in carbon in the atmosphere in the short term and (possibly) making BECCS carbon-positive for a few decades (Babin et al., 2021). However, in the long term, a reduction can be achieved if the biomass is grown and utilised again in a cycle. This contrasts with DACCS, which provides a high initial removal but little change over time (assuming no leakage occurs), and forests, which generally provide removals gradually over time without an initial removal effect. This makes it sometimes difficult to compare methods with each other, especially if the quantification needs to be done in terms of temperature impact instead of amount of removal. Any quantification approach should satisfy several requirements. First, the CRCF states that the removal must be a net benefit and represent a net reduction of GHG over its lifecycle (European Union, 2024). So a removal should constitute a removal from the atmosphere, considering any emissions generated in the capture process and storage lifetime (Tanzer & Ramírez, 2019). Tanzer and Ramírez (2019) also includes the need for permanence to count as a negative emission, whereas the CRCF (European Union, 2024) does allow temporary removals as long as there is clear quantification and transparency regarding the storage duration and climate impact of the removal.

2.4.2 Additionality

The risk of non-additionality is especially relevant in situations where removal claims are being made to account for the offsetting of emissions. If a removal likely had taken place without the presence of a policy, then there is a high chance of non-additionality. Additionality can be assessed in relation to three primary risks of non-additionality: regulatory surplus, common practice, and financial additionality (Carbon Gap, 2026b). Regulatory surplus can be observed in the LULUCF sector, where emissions reduction goals already require the transformation of the European land sector into a carbon sink. The issuance of credits therefore runs the risk of non-additionality in the sense that these removals are already covered under existing regulation. A common practice could for example be enhanced oil recovery (EOR). If fossil extraction already widely uses atmospheric CO₂, then the creation of a requirement to use EOR using atmospheric CO₂ may not be considered additional. Lastly, financial additionality brings into question if the additional financing is decisive in the investment decision being taken. For example, a logging company managing a tree farm shouldn't receive a credit for growing trees because their investment in growing trees would have been made regardless of the credits.

2.4.3 Long-term storage

The definition of long-term storage is subjective, especially in the current voluntary market. The CRCF, for example, represents BCR as a permanent storage method (European Union, 2024) while Franks et al. (2026), for example, designate it as temporary. In general, for a removal to be considered temporary for the CRCF, it should be subject to a storage period of at least 35 years. While for it to be considered permanent, the removal should remove the carbon for a period of several centuries (European Union, 2024), whereas Franks et al. (2026) argue that storage should persist for thousands of years. The CRCF also includes carbon farming activities with a minimum storage period of five years (European Union, 2024).

However, it should be noted that currently, there is no requirement to use the standards set by the CRCF. The market thus allows the use of storage methods lasting one year or ten years, and a company can claim they reached net zero-GHG emissions based on this accounting. In the current situation, it is thus the accreditation body that determines whether something is considered a removal or permanent. Then there is the question of new technologies, they may theoretically achieve a certain storage duration, but in practice there is no assurance until the designated storage period has been completed. Another question is whether it is feasible to monitor for hundreds to thousands of years. In reality, some degree of uncertainty is inherent in any claim of "permanent" storage. The magnitude of this uncertainty depends both on the underlying storage mechanism and on the environmental conditions surrounding the carbon sink.

2.4.4 Sustainability

The sustainability criterion can be viewed from an economic, social and community benefit action, and ecological standpoint.

economic sustainability looks at the frameworks in place to ensure continued support of the method during its lifetime of removal and storage, such as the management of forests. Economic sustainability can also encompass, for example, the impacts of source-

ing biomass from poorer regions. The population might be reliant on this inexpensive energy source, while the wealthy nations may want to utilise it for their CDR (Honegger et al., 2022). In order for biomass to be sustainable, it must thus not significantly damage or deprive local communities of their economic opportunities. This is where the distributive justice issue arises.

This can also be framed from a Sustainable Development Goals (SDGs) perspective, as done by Honegger et al. (2022). They highlight that all biomass-sourced CDR options can have potential negative impacts on several SDGs. This can occur when maximising quantified removals becomes the primary objective and the co-benefits of biodiversity, water quality and health are not considered (Honegger et al., 2022). This highlights the ecological and land-use dimensions of sustainability.

A social and community-benefit perspective looks at CDR in light of the practice of energy justice. Sovacool et al. (2025) highlights the views of various experts regarding themes such as social acceptance, and the licence to operate. They highlight the engagement of local communities, citizens and stakeholders as a driver of successful innovation. For CDR, this suggests that the impact on wider society should be considered when deciding whether to implement certain methods. It can also be framed as the question of what is required for the responsible implementation of CDR? (KIN, n.d.)

2.5 Background literature

The objective of this review is to identify the scientific literature in which discussions regarding the development of CDR occur, with a particular emphasis on policy in the context of the EU and the Netherlands. Some key discussions highlighted are the inclusion of CDR in the EU ETS, the role of permanence in policymaking, moral hazards present in the CDR sector, and the use of economic models.

A first point of discussion found is the potential use of the EU Emission Trading System (EU ETS) as a method of funding CDR. Bednar et al. (2021) argues that current ETS cannot suitably account for negative emissions (i.e. CDR), as it sees negative emissions as purely offsets. They propose a system in which a carbon debt is incurred by “temporarily” storing the CO₂ in the atmosphere, and in which debtors thus become responsible for delivering net CDR (Bednar et al., 2021). Brad and Schneider (2023) also warns of using CDR within the EU ETS framework. They point out there is a risk of using CDR certificates to delay the decarbonisation of difficult to abate sectors. Mitigation measures are definitive measures, no emissions have occurred; however, CDR has inherent risks of leakage or reversibility because an emission has occurred. This corresponds with the conclusions of Günther et al. (2024), which also advises policymakers to distinguish between emission mitigation and removal. Günther et al. (2024) points out that current CRCF regulation explicitly excludes ETS applicable carbon removal units, but caution against the possible future inclusion of permanent CDR measures in the ETS system. Honegger et al. (2022) also highlights that this is already being discussed in political and academic contexts. These papers illustrate the potential for a system in which CDR begins to compete with conventional reduction methods if it is integrated into the ETS. Consequently, the subsequent recommendation for the separation of CDR and mitigation targets (Bednar et al., 2021; Günther et al., 2024; Honegger et al., 2022; Lamb et al., 2024) is based on the distinct functions of

emission reduction and removal. This also aligns with the results of Gidden et al. (2023), which found that novel technologies such as DACCS in developed countries are no substitute for emission reductions in developing countries.

Due to historical accountability and the expenses associated with CDR, it is argued in the literature that industrialised nations must be at the forefront of these technologies. Schenuit et al. (2025), for example, found that the Indian government actively called on developed countries to create carbon space for developing countries, which is the use of CDR in industrialised countries to allow developing countries to emit more and longer. Schreyer et al. (2020) also highlights that the experimental nature of these technologies will make the abatement cheaper for follower nations, as frontrunners will have to experiment to find suitable options and commercialise technologies. Both these statements are then also value-based recommendations, looking at the justice issue of how to equitably share costs and benefits based on historical accountability and economic power.

Another major theme discussed is the definition of permanence for CDR methods. Chiaramonti et al. (2024), for example, argue that BCR should be classified as a permanent method, as it showed nearly no signs of degradation after 15 years in real-world use. This contrasts with other sources, which regard BCR as less than permanent due to its estimated storage duration being significantly shorter than that of CCS-based methods (Franks et al., 2026; KGG, 2025; WKR, 2024). EU CRCF regulation will make a distinction between permanent methods and temporary removals (European Union, 2024). In a recent report commissioned by the EU, BCR, DACCS and BioCCS are noted as permanent methods (Directorate-General for Climate Action (European Commission) & Ramboll Management Consulting, 2025), EW&M was also designated as a permanent method, but lacks an adopted certification standard at the point of writing (Directorate-General for Climate Action, 2025). Franks et al. (2026) also warn of market failures arising from the non-permanent CDR, they highlight the bankruptcy of storage firms, accidental release or a shift in costs to later generations by utilising cheaper non-permanent CDR. Therefore, there is still a significant amount of debate regarding the definition of "permanent".

This discussion is particularly pertinent in light of the potential risk of temporary credits slowing down emissions reductions when they are permitted to be used as a substitute for reductions. This would necessitate a further scaling up of removals in the long term (Günther et al., 2024). Meanwhile, there is also a chance that these credits will be exploited to support the ongoing use of fossil fuels (Lamb et al., 2025). How to deal with the moral hazard of non-permanent CDR remains a matter of debate, as it might be able to make CDR more economically viable in the short term (WKR, 2024) but can cause increased risk in the long term if scaling-up of permanent storage methods does not occur.

Many sources use models to try to estimate CDR requirements or scenarios. Integrated assessment models (IAMs) are often used (Bednar et al., 2021; Gidden et al., 2023; Schenuit et al., 2025; Schreyer et al., 2020) while Franks et al. (2026) uses a different economics-based model. However, the use of such models in CDR research is not without criticism. Harvey et al. (2023) notes that these models are not very suitable in situations in which there exists considerable uncertainty because of their sensitivity to economic assumptions. They argue the current uncertainty in the CDR sector is too high for these models to be useful. Honegger et al. (2022) also displays criticism

towards IAMs, finding that IAMs often have an overly optimistic and one-dimensional view of the scaling up of CDR. The general criticism is that the IAMs boil the challenge of CDR down to a purely economic perspective instead of the complex social, technical and economic problem that CDR presents.

3 Methodology

3.1 The research flow diagram and method per sub-questions

In Figure 4, an overview is presented of how this research was designed. The output of each sub-question was used to inform the subsequent sub-question.

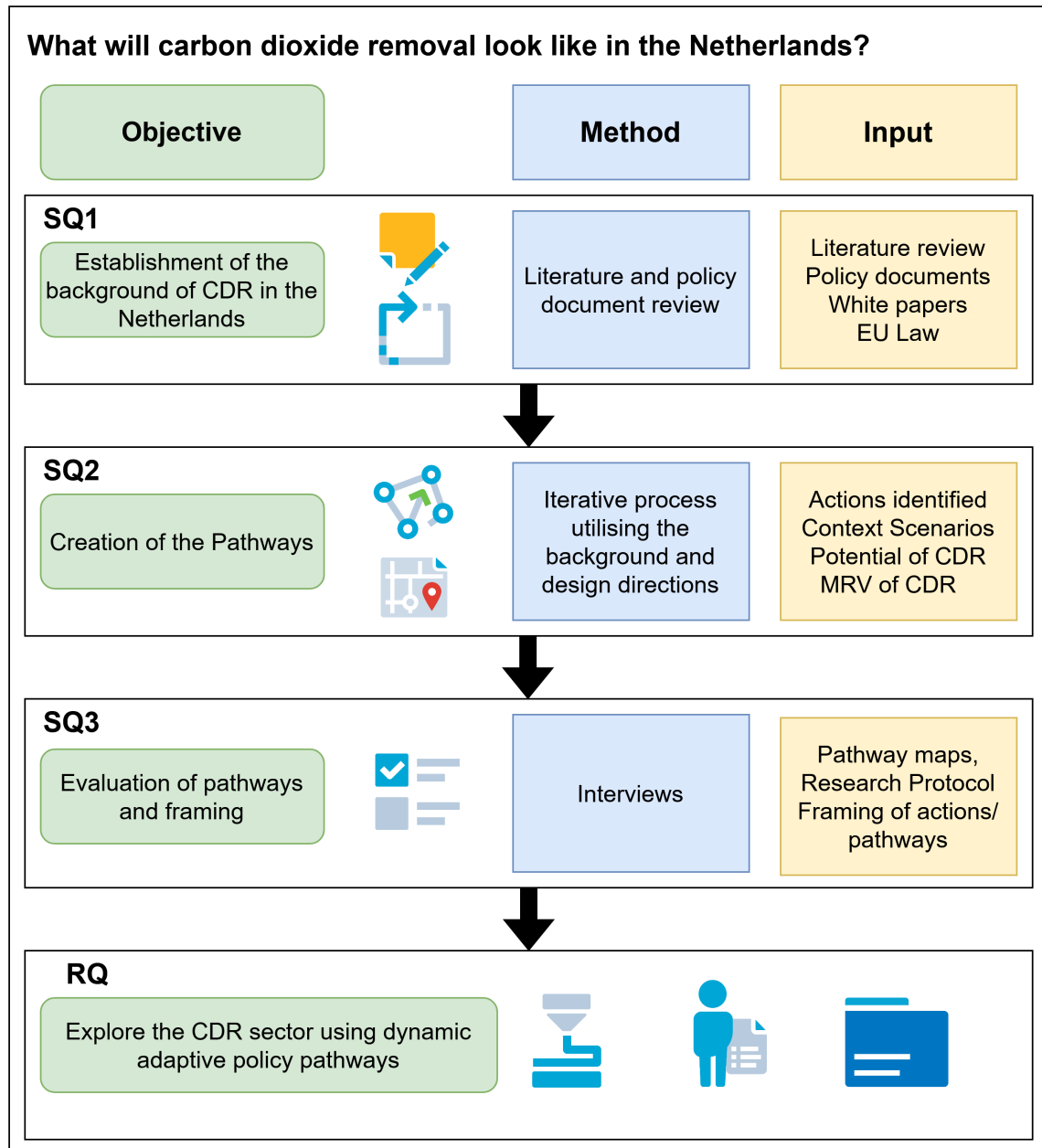


Figure 4: The research flow diagram showing an overview of this project.

3.1.1 Sub-question 1: CDR in the Netherlands

SQ1: What is the current policy and regulatory context for CDR in the Netherlands?

This question is intended to establish the background and design space of Dutch CDR policy. It is used to identify the characteristics of CDR specifically for the Dutch context. The method used to answer this question is a review of policy documents and scientific literature. Literature can give a better overview on the general questions about the CDR sector, while policy documents can highlight the possibilities and limitations for the Netherlands. This question forms the foundation for the development of the pathways.

3.1.2 Sub-question 2: Development of pathways

SQ2: What are plausible policy pathways for CDR deployment in the Netherlands?

The DAPP approach is used to answer this question. This means an iterative approach drawing on both the Dutch policy context and the broader literature on the various CDR methods. This background involves plausible actions and their potential within the Netherlands, the context scenarios developed and the use of the stereotypical actor design directions. The development of these pathways is inherently subjective as it deals with assumptions regarding the future potential of methods which are not fully developed. Thus, the pathways are established to demonstrate the potential of the Netherlands and to serve as a means of generating discussion points for evaluation.

3.1.3 Sub-question 3: Evaluation of pathways

SQ3: How do stakeholders evaluate these pathways?

The different policy actions available to the Netherlands are already identified in policy documents and literature, but the evaluation can be further refined with the help of expert interviews. This is because the chosen framing and interpretations of the impacts of various factors are subjective. The evaluation of the pathways and the framing created for these pathways will help identify persisting differences in stakeholder values regarding key aspects relevant to the CDR sector. Disagreements regarding the framing of the context scenarios may arise among the stakeholders, such as an excessively optimistic or pessimistic perspective on a specific method. Finding the precise points of difference between the pathway framing and the framing of the stakeholders is the objective of the interviews. Furthermore, the goal is also to identify areas of disagreement between stakeholders.

3.2 Data collection

3.2.1 Literature and policy document review

A literature and policy document review was conducted, with a focus on policy options and the current situation in the Netherlands. For this review, the Scopus database was used. The query used for general information about policies and methods was (*“carbon dioxide removal”*) AND (*policy OR policies OR governance*). The results were further specified with publication year after 2019, subsequently the number of

articles was further scoped to European affiliate countries and funding from European sources such as Horizon 2020. Finally, only articles published in English and classified as final publications were included. When developing the individual actions, the same search criteria were applied in Scopus to gather additional information on specific CDR methods. Using a snowballing approach, policy documents were identified through the roadmap (KGG, 2025), from which the sources cited, including Kampman et al. (2023) and WKR (2024), were gathered. Next to this Carbon Gap (2025) shows specific policy developments regarding CDR in the Netherlands.

3.2.2 Interviews

For this research, five semi-structured interviews were conducted after the development of the initial pathways. The goal was to evaluate and discuss the implementation of CDR in the Netherlands according to the perspective of the interviewees. The goal is to evaluate three things in each pathway map: conditions under which policy fails, dependence of actions on one another, and value perspective trade-offs taking place. Before starting the interview, a quick explanation of the DAPP approach and the framing of these pathways was given. Afterwards, the pathways were shown while conducting the interviews. The goal was to interview at least a single person representing an NGO, a policymaking organisation and a stakeholder active in the current market. The stakeholders interviewed and their sectors are shown in Table 1, these stakeholders are all active in the Netherlands. The numbering reflects the order in which the interviews were conducted. This also impacted what was obtained out of these interviews, as points raised by earlier interviews have impacted the following interviews. Statements from previous interviews were employed with the goal of ascertaining the subtleties of the opinions that differed or were similar between the participants. The protocol was used as guidance to steer the conversation towards certain CDR aspects, to ensure these aspects could be compared across interviews. The goal was to conduct interviews where the interviewees were provided the opportunity to highlight the issues they considered most important and explain where their viewpoints deviated. The interview protocol can be found in Appendix A, while the informed consent and HREC documents can be found in Appendix B.

Table 1: Overview of interviewees

Person	Sector	Experience
P1	NGO	Has developed a white paper vision on CDR
P2	Knowledge institute	Researched DOCCS and broader CDR development
P3	Market party	Sells credits within wood-based building solutions
P4	Policymaking	Works on national policy development (the technological side)
P5	Market party	Focus on temporary removal and farming credits

For this thesis, a thematic analysis of the interviews was conducted to notice whether the interviewees expressed similar views regarding certain risks or presented contradictory perspectives. The coding was conducted using a theoretical thematic approach, meaning the codes were developed according to excerpts from the interviews for the explicit goal of meeting a certain research question (Braun & Clarke, 2006). This is

done while keeping in mind the main points that the interviews were meant to cover. The codebook and how its development can be found in appendix C, Table 6. The results of the thematic analysis are presented in Chapter 6.

3.2.3 Workshop

In addition to the semi-structured interviews, it was possible to engage with various researchers, climate NGOs and developers of various CDR methods at a workshop on the development of responsible CDR organised by the Dutch Climate Research Initiative (KIN, n.d.). Although not a formalised data source for this project, the viewpoints expressed during this workshop did help to see the various perspectives on the development of the sector and highlighted perspectives that had received less attention in the research before the workshop. The workshop took place before any interviews were conducted.

3.3 Data analysis: DAPP approach

The primary approach used in this research is the Dynamic Adaptive Policy Pathway approach. The DAPP approach is a planning tool that helps design strategies which can be sustained under multiple highly uncertain scenarios (Lawrence et al., 2019). The idea is to create a pathway, consisting of a series of actions, which can be adapted over the lifetime based on the actual development of the system. It encourages stakeholders to think about the future implementation of their plans and the different trade-offs inherent in an uncertain system (Cradock-Henry et al., 2018). As laid out in Harvey et al. (2023), given the high degree of uncertainty in the CDR sector qualitative approaches might be more suitable than quantitative approaches. Thus, for this project, the focus will be placed on a qualitative approach by engaging with stakeholders. Participatory approaches not only involve stakeholders with a vested interest, but they can also help identify suitable opportunities and assess the desirability and feasibility of pathways (Cradock-Henry et al., 2018).

The development of the DAPP approach is shown in Figure 5. For this project, the actual implementation and monitoring will not be included and no preferred pathway will be selected, so the developmental cycle will consist of steps one to five.



Figure 5: The development of Dynamic adaptive policy pathways from Haasnoot et al. (2013)

3.3.1 The development of pathways

The development of pathways, and their use, can be approached in multiple ways. An overview of Di Fant et al. (2025), laid out different 'Archetypes' describing the use of DAPP in practice. This research aligns mostly with the "Early Adopter" archetype, which means the goal of the DAPP approach will be to define conditions under which an adaption is required and indicate the dependence of actions on previous actions (Di Fant et al., 2025). The timing of adaption points will thus be an indication of when it's expected that an action will stop performing, and should not be considered a precise point in time (Di Fant et al., 2025).

3.3.2 Stereotypical actors

In this study, stereotypical actor pathways will be established to represent the diverse values that are present in the different pathway approaches, and decisions that are required for achieving the defined objective. The stereotypical pathways approaches will include: Nature environmentalist, Tech-optimist, Economist, and Framework architect. The idea behind the 'Nature environmentalist' is to capture the values of nature preservation and that an increased number of reductions should not come from the point of damaging existing ecosystems; this means an increased favour to options which can also improve the ecology. The 'Tech-optimist' stereotype tries to capture the stereotype of a person who believes that technological advancements, if sufficiently invested in, will lead to cost-effective technologies; they generally favour the technological and scalable approaches. The 'Economist' stereotype is designed to represent a cost-effective perspective; the cheapest approach is favoured, with less emphasis placed on co-benefits or side effects. The final stereotype which will be used is the 'Framework architect' to highlight the idea that the goals are achievable through the creation of the

“right” frameworks. This perspective places greater emphasis on financial and policy instruments that may influence the development of the CDR market.

4 The foundation of dynamic adaptive policy pathways

This paper’s approach to developing dynamic adaptive policy pathways can be broken down into three distinct phases. The background and Dutch policy context were first established, thereby establishing the objectives and context scenarios within which the decisions are made. Secondly, actions available to policymakers were identified and framed for the Netherlands. Afterwards, the pathways were developed iteratively, taking the different stereotypical actors into account.

4.1 The current situation

The Netherlands has already taken several steps regarding CDR policy by developing a roadmap (KGG, 2025) based largely on the Clearing the Air report (WKR, 2024). The focus in this report is clearly on the research and scaling-up of existing options. The main subsidies for scaling up come from SDE++, and according to the roadmap CCS, Bio-based CDR, and CCU based CDR are all applicable for subsidies (KGG, 2025). SDE++ has some requirements: a Technology Readiness Level (TRL) of 9, sufficient market interest, and technical ability to be implemented in the SDE++ scheme (KGG, 2025). The other subsidies mentioned in the roadmap are research subsidies through funds such as Top Sector Energy (TSE), Demonstration Energy and Climate Innovation (DEI+), Mission-driven Research, Development and Innovation (MOOI) and CETPartnership. Most of these programmes focus on emissions reduction and would need to be adapted to support CDR activities (KGG, 2025). Additionally, there is some mention of a national incentive programme through the creation of carbon hubs for demonstration and testing purposes and the use of existing subsidies. The creation of carbon hubs can be considered the continued investment of Gasunie, the Dutch gas transmission network operator, in projects to create CO₂ transport and storage. However, these projects are currently framed more as emissions reduction measures targeting fossil and industrial emissions than as CDR initiatives (e.g. Porthos, Aramis). Another action which could be highlighted is the EU mandated LULUCF reduction target of 1.8 Mt CO₂e by 2030 in net residual emissions from this sector. In total, the Netherlands aims for 800 ktCO₂e of carbon storage by 2030 in this sector (Erbach & Dewulf, 2024). The primary aim of this legislation is emissions reduction, but in practice will likely amount to some temporary CDR taking place.

4.2 Establishing the objectives of the pathways

The objective of the pathways was developed based upon a literature review and policy document analysis of what may be required in terms of CDR for the Netherlands by 2100. The goal is formulated as follows: *The amount of CDR in the Netherlands should be such that the Netherlands has adequately contributed its share under the EU NDC framework for 2050, and IPCC AR6 1.5-2 °C for 2100.*

For the DAPP approach, a clear objective is required (Haasnoot et al., 2013). Currently, no such clear goal exists for CDR within the Netherlands. This is because it is unknown how much CDR will be required to achieve net-zero GHG emissions and

how many historical emissions will be removed based on values or requirements for temperature goals. The goal is a derivative of the EU NDC, which is insufficient for reaching the IPCC 1.5 °C target according to Climate Action Tracker (2024). The EU has quantified the amount of CDR required per member state for the IPCC AR6 1.5-2 °C scenario (NEGEM Consortium, 2024). Depending on whether responsibility-based, equity-based, or capacity-based allocation approaches are employed, the required range for the Netherlands varies from 1.17 to 18.58 GtCO₂ (Sunny et al., 2021). For this project, 5 GtCO₂e will be considered to meet the requirement for the Netherlands. The choice of 5 Gt CO₂e was based primarily on the PRIMAP CDR target of 4.53 Gt CO₂ (Sunny et al., 2021), adjusted to approximately account for emissions between 2019 and 2025, given that this target considers the emissions produced between 1750 and 2019. The rounded value of 5 Gt CO₂e also better reflects the uncertainty associated with estimating the Dutch contribution.

4.3 Creation of scenarios

Seeing as this project focuses on the policies required to support CDR, the context scenarios will focus on this, highlighting policy uncertainties that are influential but are not directly determined by the Netherlands. These context scenarios are based on active discussion currently taking place in the CDR sector, but which will be decided on an EU level and thus cannot be directly changed by Dutch policymakers. These contexts inform the design directions represented in the pathway maps, as shown in Figure 6.

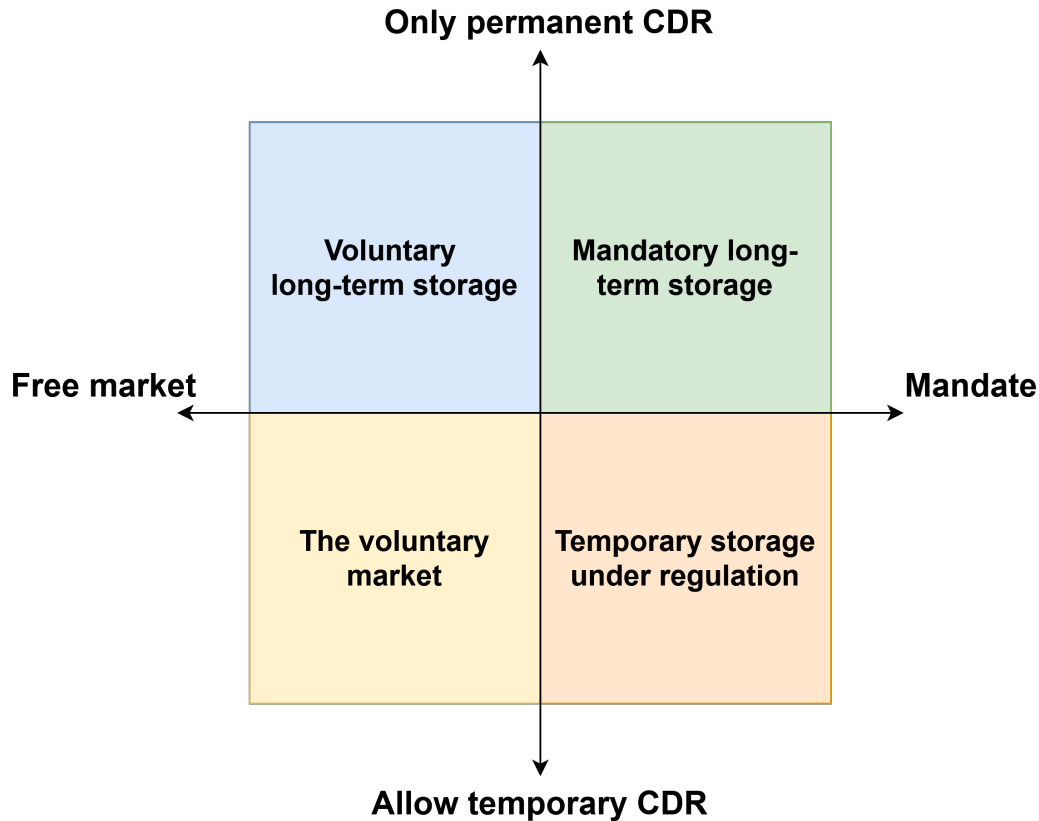


Figure 6: A visual representation of the context scenario axes and the resulting design directions.

4.3.1 Temporary versus permanent

The first axis concerns whether temporary CDR should be permitted alongside permanent CDR, or whether only permanent CDR should be allowed. This decision depends largely on the framework being built by the EU. Currently, the EU will allow temporary CDR in the CRCF (European Union, 2024), although the accounting framework for temporary CDR has not been completed yet. However, this comes with the drawbacks of (possible) increased risk of reversal and an increased burden in the future, requiring additional removals if the stored carbon is subsequently re-emitted. The advantage of allowing temporary CDR is that these methods are generally at a more advanced stage of development (WKR, 2024), and thus can be scaled more quickly. This could help ease the short-term burden of meeting emissions reduction or carbon-removal targets until the more permanent solutions have reached technological maturity. Additionally, some temporary methods like switches in land management practices or wood buildings can have additional co-benefits, making the use of these methods more politically feasible.

In the roadmap, the Netherlands recognises the difficulty in scaling up the Nature-based Solutions (NbS) in the Netherlands due to these being land intensive and the relatively high existing land use in the Netherlands (KGG, 2025). However, the roadmap also highlights the role that these options could play. They also discuss the possibility of using temporary carbon removals to offset the impacts of short-term GHG emissions (Carbon Gap, 2025).

4.3.2 Voluntary market versus mandated removals

The second axis concerns the market design of carbon removals. Removal targets may remain voluntary or may become legally mandated in the future, forming the second uncertainty axis considered in this research. A voluntary market incentivises market actors to focus on the lowest-cost methods possible, or allows attention to be focused on uncertain future removal potential. For example, in Lamb et al. (2025), it is argued that some fossil fuel companies use CDR to justify the continuation of existing fossil fuel practices.

Mandates can be implemented in various ways. Meckling and Biber (2021) distinguishes mandates between upstream, fossil extraction, and downstream sale. For CDR methods, a mandate could take the form of a requirement to remove CO₂ for emitters, for example, through a tax within the ETS system (downstream approach). Alternatively, fossil companies could be required to remove a certain amount of CO₂ per amount of oil or gas extracted (upstream approach). Within Meckling and Biber (2021), there is an argument for an “Incentive + mandate” approach, which entails starting with tax-credit support for removals and gradually shifting towards increasingly stringent removal mandates. This is partially similar to the ETS system, which in theory began with a large allocation of credits before gradually transitioning towards a progressively smaller allocation. However, as highlighted by de Perthuis and Trotignon (2014), the initial implementation of such a system may not always be effective, as changes in economic and political conditions can hamper efforts to strengthen the mandate, thereby reducing its effectiveness and credibility.

4.4 Available actions

In general, governments can consider 4 main actions: subsidisation, taxation, standards and bans.

Subsidies can be divided into subsidies for current technology and future technology (Blanchard et al., 2023). Subsidies for current technologies or methods could, for example, include supporting the creation of a CCS pipeline and storage site (i.e. the Dutch Porthos Project). Alternatively, mandates requiring a certain level of deployment of a method are discussed in Blanchard et al. (2023), but they also note two moral hazards, the difficulty in estimating learning curves and the difficulty with phasing out subsidies. Meanwhile, subsidies on future technologies can be considered investments in R&D, which Blanchard et al. (2023) argues is not happening enough because the carbon price is too low to warrant significant investment.

When considering the various actions that policymakers can take, it is important to consider who will perform the removals, as the government does not currently manage deployment of CDR themselves. Corporations currently carry out the actual removals, which can then be certified and sold to other companies looking to offset their emissions. The setting of standards is currently undertaken by certification companies rather than the Dutch government, with the CRCF being the first example of a voluntary governmental standard for credits.

Currently, companies are not required to perform or pay for removals, only for emissions under the ETS. As a result, there is a gap in accounting for removals; who will be responsible for funding CDR, and how much responsibility does each stakeholder have? There is, however, a role for the Netherlands in creating this incentive. The WKR (2024) presents three options for creating demand and financing for removals:

1. The creation of an obligation to conduct removals
2. The (partial) integration in the EU ETS
3. The government procurement of CO₂ removal credits

The first action could be considered a ban on operating without undertaking removals, while the integration within the EU ETS can be considered a form of taxation, and the government procurement can be considered a form of subsidisation for removal companies (when conducted in the form of a tender or payment).

Other actions for the Netherlands proposed in WKR (2024) are:

1. Providing clarity on the intended role of CO₂ removal in climate policy, in accordance with the Paris Agreement and national goals.
2. Stimulate innovation in new permanent methods and cost reduction
3. Create a market with sufficient storage and transport capacity for CO₂
4. Ensuring public participation and acceptance for general removal policy and specific removal methods and projects.

To further specify the actions available to the Netherlands, the following sections examine the various CDR methods and frame them for use in the pathways.

4.4.1 CCS-based actions

To conduct certain CDR methods, CCS storage and transportation infrastructure needs to be in place. The potential for offshore storage of CO₂ has been presented by the white paper from Dooley et al. (2025), they discuss two current projects, Porthos and Aramis, with Porthos having a total storage potential of 35 Mt or 2.5 Million tonnes Per Annum (MtPA). Aramis has a potential of 30 MtPA or 400 Mt in total if fully developed and expanded. EBN and Gasunie (2022) looked at the potential storage of CO₂ under the North Sea and the Netherlands. They concluded that there is a practical capacity of 1700 Mt offshore and 1100 Mt onshore of potential CCS, although their focus lay on the offshore CCS. Theoretically, 2246 Mt and 1392 Mt are the theoretical limits of storage, leaving the Groningen Gas field out of contention, the difference between practical and theoretical capacity appears to be mainly due to the size of the fields (EBN & Gasunie, 2022). Smaller fields will likely not be economically viable for development (EBN & Gasunie, 2022). The consultancy firm Xodus Group (2023), projects international demand for storage capacity of 130 MtPA within the North Sea by 2040 and 300 MtPA by 2050, which would exceed the need for this project. However, this does include the North Sea storage of Norway, Denmark and the UK. Additionally, they do seem to include the Groningen Field in this and more Saline Aquifers. The overarching theme across these white papers is they all state the efficacy of creating cross-border and combined infrastructure (Dooley et al., 2025; EBN & Gasunie, 2022; Xodus Group, 2023). According to Damen et al. (2009), the storage potential of the Groningen gas field could be up to 7 Gt, although this should be considered slightly speculative given the age of this estimate. However, if storage underneath the Groningen gas field is allowed to take place, which might be politically infeasible in the short term, then CDR methods using CCS-based storage could potentially meet the requirements set for this paper.

The utilisation of BECCS has a significant technical potential (22.2 MtPA in 2050) in terms of what removals could take place in the Netherlands (WKR, 2024) (the cumulative removals could reach 339 Mt by 2050 (Kampman et al., 2023)). However, the generation of electricity can be done with lower-emission alternatives, even if these BE-emissions come from the short carbon cycle. This raises the question whether it is desirable to utilise BECCS on a significant enough scale in the Netherlands. Realising the technical potential of BECCS is also dependent on importing biomass, seeing as the Netherlands does not have sufficient land availability to create biomass on the scale estimated (Kampman et al., 2023; WKR, 2024). This would thus shift the burden of biomass production to another ecosystem, with the risk of sustainability and distributive justice issues with effects and benefits occurring in different places. This highlights one of the main problems of the CCS route of storage, namely the need for a constant long-term supply of CO₂. Carbon capture facilities are not perfect, and claimed technical capacity and actual capture efficiency can differ greatly. In other words, emissions will be released for an extended period, irrespective of whether they are generated from short-cycle biomass.

In 2050, the Netherlands' technical potential for DACCS (including DOCCS) is unknown (WKR, 2024). However, it is estimated to lie between 0 and 17 MtPA, but is highly uncertain, and its potential is thus indicated as >0 for the cumulative estimation (Kampman et al., 2023). This means that at least before 2050 the source for CCS-based removals will mainly need to come from biomass, which has emissions. And

even beyond 2050 it is questionable whether the Netherlands has significant potential for DACCS sites because of the relatively limited potential for low carbon energy production beyond replacing current energy requirements. However, in case sufficient low carbon energy is available, and DACCS or DOCCS achieve sufficient improvements in energy efficiency and cost per kilogram of CO₂ captured, then these CCS technologies would be favourable for the Netherlands.

4.4.2 Mineralisation

Mineralisation, particularly enhanced weathering, presents three challenges for the Netherlands: firstly, the limited availability of the required materials in the Netherlands; secondly, the costs and consequences of mining; and finally, the difficulty of accounting for the efficiency and timing of removals.

There is a large potential for mineralisation globally in the Gt CO₂ per year scale (Campbell et al., 2022). One important consideration is that surface weathering might be more effective in tropical regions because of higher mineral dissolution rates (Campbell et al., 2022), and might be slightly less effective for the Netherlands. Another disadvantage for the Netherlands is the transport of materials from the quarry, the farther away, the more emissions would need to be considered resulting in a reduction in effectiveness (Campbell et al., 2022). These points make the use of mineralisation in the Netherlands pricier than in other regions. However, it might be possible to use olivine instead of filler sand for coastal defence, at which point this form of EW could become price competitive with international mineralisation (Kampman et al., 2023). This would also present an opportunity to conduct CDR with a maximum estimate of 4.7 MtPA in 2050 (Kampman et al., 2023).

Another form of mineralisation discussed is "Enhanced ocean alkalinity". It involves adding minerals to seawater which provides the additional benefit of reducing acidification. However, the rocks in which these minerals occur also may contain heavy metals and other pollutants, which could negatively impact the local environment. Another problem is that the monitoring, reporting and verification (MRV) of ocean-based approaches are not yet developed (Ma et al., 2026). Campbell et al. (2022) also highlights the difficulty in MRV for the ocean-based mineralisation solutions. Although the method behind the terrestrial and ocean approaches is very similar, the trade-offs, especially in our lack of understanding of ocean-based approaches, should not necessarily be considered equivalent.

The utilisation of mineralisation as a form of carbon capture and utilisation is also sometimes presented and discussed. Most commonly, this takes the form of sequestration in concrete. Rosa et al. (2022) demonstrate a niche alternative for combining bio-energy and mineralisation of CO₂ into concrete. The potential for the Netherlands using this type of sequestration is estimated at 0.5 MtPA (Rosa et al., 2022). However, Di Maria et al. (2020) shows that the utilisation of CO₂ capturing minerals in concrete can have negative side effects for the strength of the concrete compared to normal concrete. The source of the biomass and the process must thus be looked at not only as a point in reducing GWP, but also look at the other environmental impacts. Sometimes bio-char is also discussed in the context of mineralisation (Huan et al., 2024). They note that the inclusion of biochar in cement could enhance the absorption rate, with the drawback of decreasing the strength of the concrete (Huan et al., 2024). In general, the utilisation of mineralisation in concrete could contribute, but it might encourage

continued reliance on concrete. It should be noted that we likely will always need to use some amount of concrete, and thus these mineralisation approaches are, in general, favourable if they reduce emissions across the entire value chain. The general use of minerals in concrete is estimated to have a potential of 0.7 MtPA in 2050 (Kampman et al., 2023). The company Paebbl (2026) is actively working on this in the Netherlands and claim to have a facility with a removal capacity of around one kt CO₂e per year operating in the Netherlands.

4.4.3 Temporary options: NbS and use of bio-materials

One view encountered regarding nature-based solutions is: “Nature-based solutions including forest restoration, wetland rehabilitation, soil carbon enhancement and marine ecosystem augmentation are characterized by low implementation costs, strong ecological co-benefits and broad social acceptability.” (Ma et al., 2026). However, the implementation of NbS may not be as straightforward as this characterisation suggests.

One aspect that should be noted is the suitability of the Netherlands for these temporary removal options. In general, the Netherlands has a constrained and allocated land use. Most of these solutions are not feasible at a significant scale (KGG, 2025). This does not imply that they cannot help the Netherlands meet its goals, at least in the short term. The EU’s policy on LULUCF already requires the Netherlands to reduce emissions from this sector (Erbach & Dewulf, 2024; Kallio & Garvik, 2026). Thus, some changes in forest management need to happen regardless of CDR goals. Some NGO actors thus argue for the exclusion of forest-based CDR from accounting. They favour the creation and maintenance of forests, but feel that the inclusion in CDR frameworks would create the wrong incentives. The focus should be placed on increasing biodiversity and sustainable forests, while CDR would give an incentive to fast-growing monoculture forests. The question therefore becomes whether the CRCF framework sufficiently addresses these issues. According to McDonald et al. (2025), the CRCF framework insufficiently accounts for non-additionality and non-permanence.

In Kallio and Garvik (2026), there is a discussion on whether the LULUCF regulation actually results in emissions reductions or just a shift to other regions to account for the reduced timber yields. This highlights the trade-off issue with some NbS, for example if there is an increase in wood building then there may be increased demand for different types of wood. The sourcing of this wood may result in an increase in external wood cutting if the EU limits the amount of forest that can be harvested or if monoculture wood farms are phased out.

Wetland restoration is an interesting option, but it highlights the difficulty in accounting for the climate effects of a measure. Next to sequestering CO₂, these wetlands can also be a methane (CH₄) source (Taillardat et al., 2020). The amounts of CO₂ and CH₄ that are associated with a wetland, and the cost of restoration, differs according to its type. And in the short-term, restoration of wetlands could have an increased effect on the climate depending on the accounting (Taillardat et al., 2020).

The use of enhanced carbon farming can be explained as the use of two practices: first, growing carbon sinks (such as trees) alongside farmland rather than cultivating crops in those areas. And the second practice is the case of harvesting crops with the explicit goal of turning them into a carbon sink for removals. This last practice

does have some correlation with wood building, for example, as the growing of fibres for bio-based insulation. There must thus be an assurance that no double accounting happens in this situation, where both the farmer and the building company present it as carbon-negative. The practice of carbon farming is distinct from temporary removals within the CRCF framework. With farming practices requiring at least a 5-year storage duration to at least a 35-year storage duration for temporary removals Carbon Gap, 2026b.

The building of wooden buildings, or biogenic materials for building, can be considered a temporary carbon removal of carbon. Ordinarily, the storage duration of 35 years will be met, and thus it would qualify as at least a temporary removal for the CRCF. A major difficulty appears in the accounting for the storage duration of bio-based buildings, as at the point of building it is unknown how long a certain part of the construction will stay unchanged. This is usually accounted for by not lending out all the credits produced, but retaining a proportion of the credits which can 'disappear' when the storage duration is not met or leakage occurs.

In this project, soil carbon sequestration is distinguished from other carbon farming practices. Sequestration of additional carbon in the ground can occur due to better soil management practices (Vistarte et al., 2024). Vistarte et al. (2024) note that carbon sequestration occurs more readily in warmer climates, and thus specific climate conditions should be considered in the sequestration strategies. For this project, the utilisation of biochar is considered soil carbon sequestration, not only because of its ability to sequester carbon but also because of the co-benefits of plant productivity and nutrient cycling (Vistarte et al., 2024). Nevertheless, it is crucial to acknowledge that the quality of biochar is also significant (Vistarte et al., 2024). The amount of carbon stored and the duration of sequestration depend on the feedstock and the temperature at which the biomass is converted.

4.4.4 Policy and innovation actions

McDonald et al. (2025) is one of many authors who raise the possibility of using ETS funds for the financing of removals. This was also a mentioned position by stakeholders at the KIN workshop. It does, however, bring up the question of what it would replace in terms of funding. The revenue the Netherlands receives from the ETS goes towards the SDE++, MOOI, DEI+ and other subsidy and research frameworks (European Environment Agency, 2025). In reality, the idea of using existing ETS revenue would therefore involve reallocating funding currently designated for mitigation measures. At this point, this might not be advisable, given that reducing emissions remains preferable than utilising CDR. For this project, it thus means that instead of replacing existing ETS funds, there would be an additional tax on top of the usual ETS price, and thus an expansion of revenue. This would lead to two incentives, firstly it would make mitigation more attractive as it reduces the extra costs incurred. Secondly, it would generate a direct investment force for removals in the short term when the costs are too high to invest. This would allow for funding being in place during the transition phase required to scale up different CDR technologies and NbS. The further implications of ETS-based actions are discussed in chapter 7.1.5.

A carbon bank refers to the investment of public funds in carbon removals, often discussed in relation to the proposed European Industrialisation Bank (Viloria & Mäkelä,

2025). Vilorio and Mäkelä (2025) give five steps for the creation of such a bank: explicitly include CDR in the mandate of the bank, establish a pilot, coordinate with existing instruments, engage with national banks, and lastly create an internal taskforce and toolkit. In this project, the creation of a national bank would allow for the use of carbon contracts for difference which could ensure that companies deliver on an amount of removals at a pre-agreed price, through a tender (Gerres & Linares, 2022). The use of a bank would allow for high-quality removals to enter the market. It might, however, encourage use of current lower-cost approaches which could impact the possible development of currently more expensive versions. Another question regarding public funding is where the money would come from (what trade-offs would be required to fund CDR over something else).

Investment in R&D is already taking place with the use of DEI+, MOOI, TSE and CETPartnership (KGG, 2025). However, it could be argued that more funding for R&D is required to achieve the required scale-up. Solutions such as DOCCS, DACCS and mineralisation will likely not be able to reach their full potential without additional investment in the development of these technologies. R&D would also allow for the possible creation of new techniques and technologies. In the KIN workshop, there was broad agreement that further R&D investment would be required, especially in cross-disciplinary projects.

4.4.5 Overview of actions

A specific framing must be chosen for the actions included in the pathways. This framing is based on the overview presented above. For each action and method, the framing in this project could deviate from the framing used in other projects. The following Table 2 provides a summary of these actions.

Table 2: Overview of actions, advantages, and trade-offs as framed for this thesis

Action	Description	Advantage	Trade-offs
Permanent			
Create CCS-hubs	The creation of CCS transport and storage infrastructure (like Porthos, Aramis, Northern Lights)	Large-scale storage potential, permanent storage	Allows fossil actors to use CCS as reduction method, which can delay moving away from fossil fuels.
Subsidise DACCS deployment	Directly subsidising the deployment of DACCS/DOCCS	Gives a clear monetary incentive to invest	DACCS/DOCCS has high energy requirements, monetary costs to the public.
Subsidise CCS	Subsidies for CCS-based removals	Incentive for CCS regardless of biogenic or direct source	CCS-based options are not an endless sink, advantage for industrial parties with experience.
Subsidise use of BECCS	Direct subsidy for the removals taking place with BECCS	Permanence of storage, co-benefit of energy generation, technical readiness	Effectiveness dependent on source of biomass, may hurt removals from forests (creation of monocultures), short-term impact from continuation of emissions from biogenic sources.

Action		Description	Advantage	Trade-offs
Subsidise R&D	CCS	Research into storage sites (on land/aquifers), enhanced capture capabilities	Higher storage capacity of CCS if additional sites open up	Costs versus uncertain rewards.
Subsidise Mineralisation R&D		Some mineralisation methods have great theoretical potential but have low technological readiness/competitiveness	Increases the chance of competitive commercial products	Costs versus uncertain rewards.
Subsidise Mineralisation deployment		Directly subsidising the deployment of mineralisation	Creation of permanent CDR, possible products delivered such as concrete	Public costs; mining damage occurs elsewhere.
Allow storage Groningen		The possible use of the Groningen gas field for CCS was mentioned internationally, but is likely not politically viable in the short-term	High theoretical storage capability	Political viability, general viability of storage under land, and moral hazard from continuation of fossil CCS.
Retrofit current BE facilities		Within mandates, current BE facilities could be required to utilise CCS technology	Direct mitigation measure	If fossil fuels persist, this may disadvantage bioenergy and create long-term dependence on BE and its associated emissions.
Require use CCS		A requirement to store biogenic or directly captured carbon when extraction of fossil occurs	Fossil companies become directly responsible for CDR	Dependence on fossil extraction and thus a (temporary) stopgap measure
Temporary				
Reforestation		Restoring and managing existing forests better	Creating a better carbon sink on existing forest-covered land, socially acceptable	Continued costs of forest management, reversibility risk
Creation of new forests		Creation of forests on farm/built-up land which was not covered with forests before (or recently)	New carbon sink, recreational, biodiversity	Costs, land use allocation, reversibility risk
Wood building		Incentivisation of construction using bio-based materials such as wood, or hemp fibre.	Temporary carbon sink, less unforeseen reversibility risk	Uncertainty in storage duration, risk of double accounting after demolition
Enhanced carbon farming		Agroforestry or similar methods in which crops are grown with the explicit goal to store carbon alongside conventional crops	Biodiversity, environmental resilience (temperature, wind)	Land use allocation, management costs
Soil-carbon sequestration		Cover cropping or adding biochar to the soil to enhance the share of carbon stored in the soil	Co-benefits for farming	Difficulty in determining storage duration
Policy/innovation				
Carbon Bank		Government-run auctions or tenders for CDR	Best cost options, allows for the setting of strict conditions (high-quality credits)	Public financing of actions, more favourable for industrial parties with resources for scale.

Action	Description	Advantage	Trade-offs
ETS-tax	Linking emission rights to the funding of CDR	The companies emitting most pay the most; widely discussed	ETS does not cover all sectors (e.g., farming, military), shrinking revenue over time due to a decrease in credits, takes existing funds away from mitigation.
Invest in R&D	General increase in R&D funding regardless of technical readiness level	Increases the chance for potential but underdeveloped options; most existing options would also benefit from more R&D	Costs versus uncertain rewards, cannot help scaling up directly.
New technology	Within the timeframe of 70 years there is a high chance that a method may be developed that cannot currently be anticipated	Potential breakthrough solutions	Very uncertain; hazard of shifting responsibility to the future when relying on this option; requires substantial R&D.

4.4.6 The general uncertainty of MRV

The certainty associated with the accounting of various removal methods differs, and even within individual methods, the degree of certainty can vary. For example, mineralisation through enhanced weathering can have a CO₂ uptake period measured in years, making it difficult to accurately quantify removals at a specific point in time. By contrast, ex-situ mineralisation in reactors is relatively straightforward in terms of MRV (Campbell et al., 2022). The following Table 3 presents a simplified overview of the various methods in terms of uptake time, Storage duration, MRV, and TRLs. The framing presented in this table was used in the development of the pathways.

Table 3: Simplified overview of carbon removal methods in terms of uptake time, storage duration, ease of MRV, and TRL

Method	Uptake time	Storage duration	MRV	TRL
BECCS	Medium (biomass growth + capture)	Permanent (geological)	Medium-High (complex supply chain)	High (8–9) (Ma et al., 2026)
DACCS	Fast (direct capture)	Permanent (geological)	High (measurable capture and storage)	Medium (5–6) (Ma et al., 2026)
Enhanced carbon farming	Medium (years–decades)	Temporary (reversible)	Low-Medium (measurement uncertainty depending on practice)	High (7–9)(primarily an incentive-related challenge;(Vistarte et al., 2024))
Forests	Slow (decades)	Temporary (decades–centuries, reversible)	Medium (uncertainty, disturbance risk)	High (8–9) (KGG, 2025)
Mineralisation	Medium (EW over periods of years (Campbell et al., 2022))	Permanent	High (stable chemical storage)	Medium (3–7) (Huan et al., 2024; Ma et al., 2026) to High (8–9) (KGG, 2025)
Soil carbon sequestration	Medium (years–decades)	Temporary (reversible)	Low-Medium (high variability)	Medium-High (7–8) (KGG, 2025; Ma et al., 2026)
Wood construction	Slow-Medium (growth + use phase)	Temporary (decades–centuries)	Medium (tracking required)	High (8–9) (WKR, 2024)

5 Resulting pathways

Based on the formulation of the problem, the decision of the goal and the available actions, four scenario-specific pathways have been designed. The pathways within each scenario were designed with stereotypical actors in mind, and they aim to demonstrate the various value perspectives available for achieving the CDR goal. In this chapter, the maps created for the evaluation with stakeholders will be presented and the framing of each stereotypical pathway will be elaborated upon.

5.1 The development of pathways

The pathway maps were developed iteratively with the framing as created in Chapter 4. The pathway maps do not always show all the available options for each context scenario, this was done to highlight different issues within each individual map and for the sake of readability. Table 4 shows the justification for the inclusion of actions for the first pathway map in Figure 7. The tables providing the justification for the remaining pathway maps can be found in Appendix D (Table 13, 14 and 15). The actors responsible for these actions are present in Table 12. The actual pathways highlighted are interpretations of what the stereotypical actors would choose when presented with the available actions. For each stereotype, one pathway will reach the stated goal (although they may end on the same final action).

Table 4: Justification for the inclusion and exclusion of actions in Pathway Map 1: Voluntary Long-Term Storage, X=Yes, O=No.

Action	Included	Reason for (non)inclusion	Timeline framing
Permanent			
Create CCS-hubs	X	Indirect subsidy	Dependence for scaling in 2040 (Roadmap)
Subsidise DACCS deployment	X	Direct subsidy of permanent method	Likely no significant potential before 2050, limit storage CCS
Subsidise CCS	X	Subsidy of storage method	The act of storing with CCS, limit storage sink CCS
Subsidise use of BECCS	X	Direct subsidy of permanent method	Potential when sink is available, limit storage sink
Subsidise CCS R&D	X	Developmental subsidy of permanent method	To account for increase storage using saline aquifers
Subsidise Mineralisation R&D	X	Developmental subsidy of permanent method	Dependence for scaling, mainly financial
Subsidise Mineralisation deployment	X	Direct subsidy of permanent method	Large potential if economics works out
Allow storage Groningen	X	Policy decision on permanent sink	Policy decision which would largely negate limitation of storage size CCS
Retrofit current BE Facilities	O	Mandate excluded	O
Require use CCS	O	Mandate excluded	O
Temporary			
Reforestation	O	Temporary action excluded	O
Creation of new forests	O	Temporary action excluded	O
Subsidise wood building	O	Temporary action excluded	O

Action	Included	Reason for (non)inclusion	Timeline framing
Enhanced carbon farming	O	Temporary action excluded	O
Soil-carbon sequestration	O	Temporary action excluded	O
Policy/innovation			
Carbon bank	X	Indirect subsidy	Government procurement, as an impulse, large scale after 2040 likely financial infeasible
ETS-tax	O	Mandate excluded	O
Invest in R&D	X	Developmental subsidy of potential permanent method	To account for general need to improve CDR, and underdeveloped methods, potential unknown/uncertain
New technology	X	Included to cover permanent method such as ocean alkalinity enhancement and DOCCS	Possible large potential, if sufficient R&D has been done

5.2 Design direction: Voluntary long-term storage

In a context where no temporary removals are permitted to count towards CDR goals and no removal mandate has been established, three types of removal methods are currently viable: BECCS, DACCS, and mineralisation. However, currently all are expensive and underdeveloped, especially mineralisation and DACCS. Unfortunately, mineralisation has only limited potential in the Netherlands, and is constrained by the limited natural availability of the required materials in the Netherlands. The pathway map presenting the possibilities in this context is shown in Figure 7, the timeline in the figure is based on the period 2026 to 2100, divided into ten blocks.

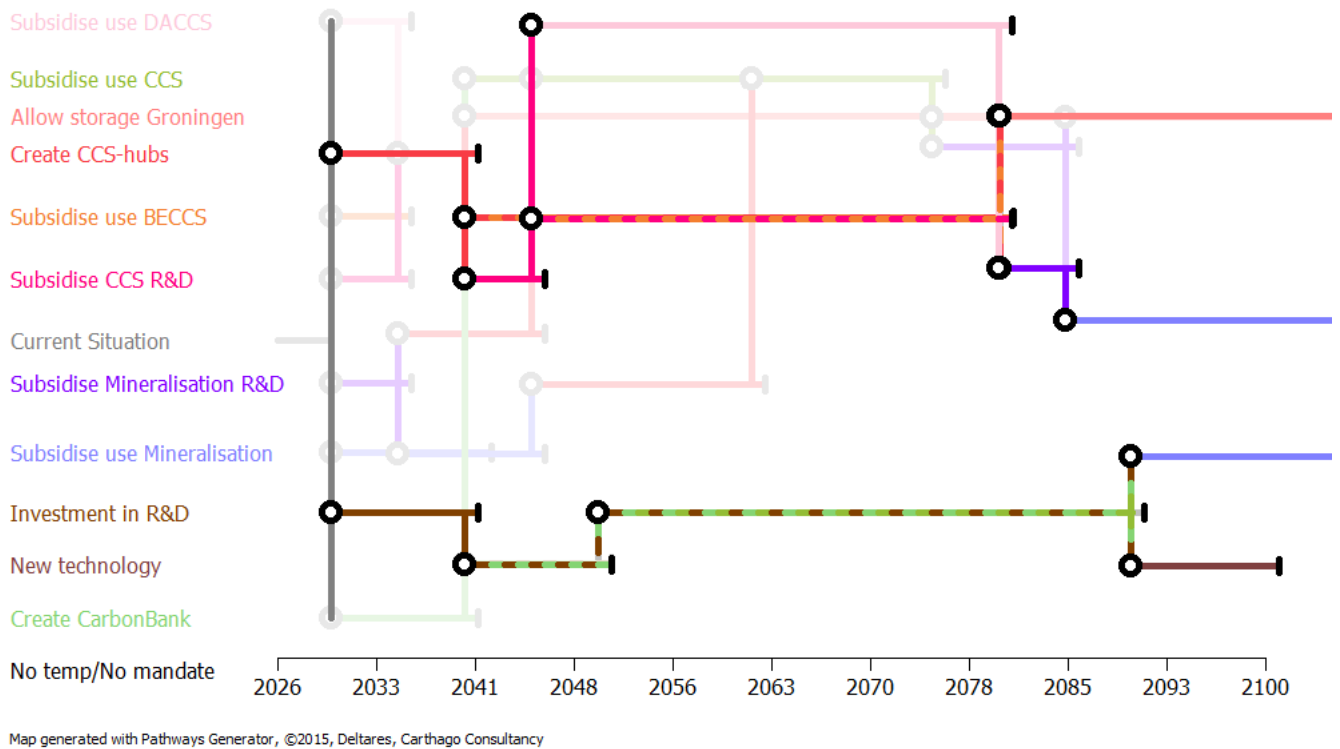


Figure 7: The first scenario pathway only allowing permanent removals and with no mandate

For each map, the designed stereotypical perspectives will be presented and are highlighted within the maps. The first perspective is the nature activist perspective. From this perspective, CCS would facilitate the continued use of fossil fuels and thus allow for a moral hazard to occur. Thus, an investment in R&D would be preferred combined with the creation of a carbon bank which does not favour one removal method over another. The subsidisation of CCS would then only follow after 2050, when net-zero emissions should have been achieved. This is to ensure that the utilisation of CCS does not incentivise the continuation of fossil fuel use. They would not support onshore CCS storage, meaning that there will likely need to be a shift to a new technology before 2100.

From the tech optimist perspective, CCS will be utilised without the moral hazard of the continuation of fossil-based CCS, meaning that CCS deployment and CCS-related research would improve the prospects for DACCS, allowing the use of storage fields until they are saturated, which would be before 2080 depending on assumptions regarding future costs. After this, they might allow the use of the Groningen field to continue the utilisation of the technology-based CCS approaches.

The most economic approach in terms of permanent storage is BECCS. The economist's view would then be to create CCS hubs and subsidise the conversion of existing bioenergy or waste plants to CCS, followed by a later switch to storage in the Groningen field or switching to mineralisation depending on projected removal costs.

In the framework architect approach, the creation of CCS hubs should only occur once large-scale deployment becomes necessary around 2040; before then, general R&D is

preferred. However, after this, a shift towards subsidisation of CCS and mineralisation deployment should occur. However, the utilisation of the Groningen Gas field would not be up for discussion because of political risks.

5.3 Design direction: Mandatory long-term storage

With the introduction of a mandate, separate CDR goals are developed alongside emission reduction goals. Practically, this means that the moral hazard associated with using CCS to prolong fossil fuel use gets removed from the discussion. However, because only permanent storage is permitted, the same removal methods remain available. Currently, there is no mandate to utilise the CRCF framework or another framework for certification. The choice is entirely voluntary, however with a mandate, there would be some common basis on which removals are certified within the EU. These mandates, if correctly developed, would ensure that methods could become more comparable in terms of removal and side effects or co-benefits. In addition, this scenario would also include progressive targets that parties must either achieve themselves or pay others to achieve, such as a separate ETS for removals-based goals. Importantly, this doesn't include integration with the existing ETS wherein the removals would need to compete with emission reduction measures. This ETS could, however, acquire partial funding or funding requirements from stakeholders currently required to operate in the ETS. However, how this funding would work in practice is unknown, as the EU has not and likely will not implement mandates before the evaluation of the current CRCF framework five years after it comes into effect (Carbon Gap, 2026b).

The use of a mandate changes the context of certain actions. The generation of a mandate establishes a specific removal target that must be achieved, which incentivises achieving a target rather than the quality of the removals themselves. So the creation of the target needs to be formulated correctly to disincentivise the use of low-quality removals. It also brings into question the financing of the targets, the allocation of responsibilities among stakeholders, and what level of risk is considered acceptable. One advantage of targets is that it signals an intention of a country, thereby providing industrial actors with greater investment certainty (Nascimento et al., 2021).

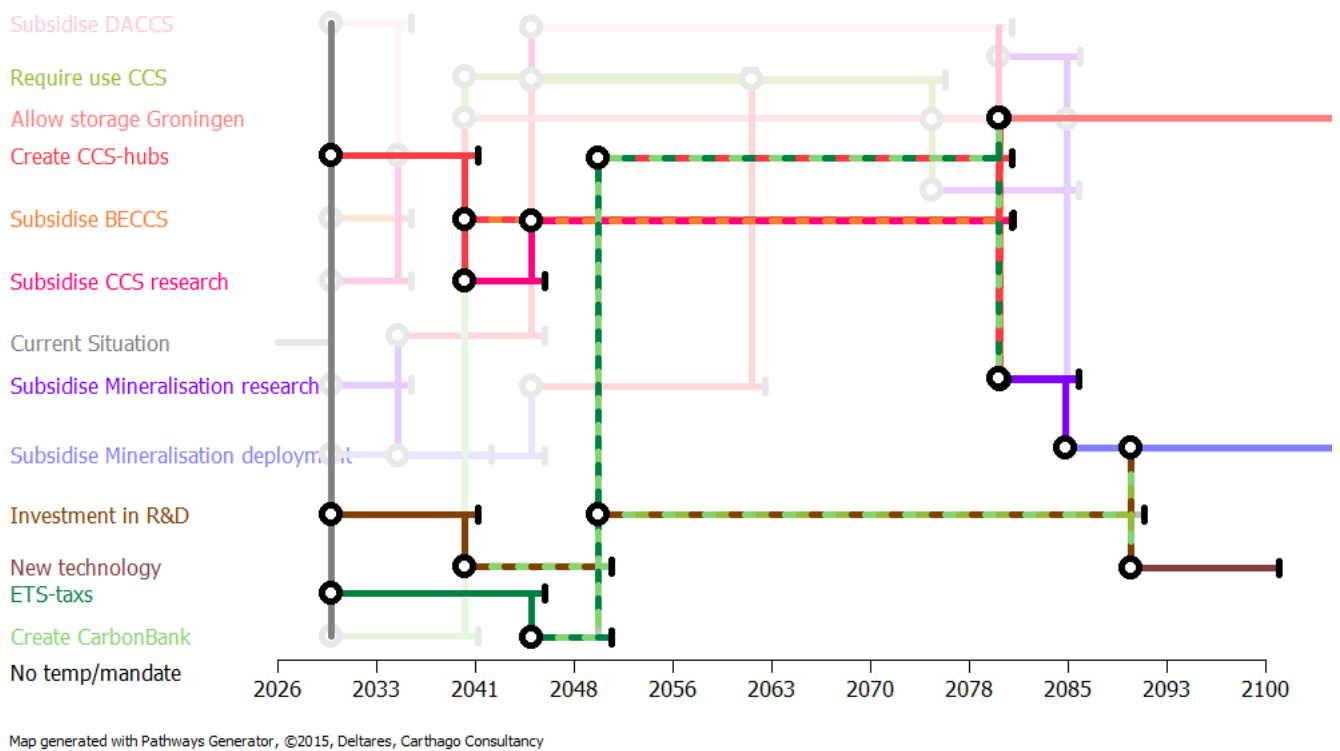


Figure 8: The second scenario pathway including permanent removals and a mandate.

The nature activist perspective shifts slightly; the principle presented in this pathway is that the emitter pays for removals. So some form of a tax within the ETS system on top of the purchase of emission allowances, would incentivise companies to not only move away quicker from fossil fuels. It also brings in a stable form of short-term financing. The creation of a carbon bank in which the government is a co-funder would allow the setting of more stringent conditions on what should count and what the quality of a removal should be. This would also mean requiring residual emitters to continue contributing to the financing of removals beyond net-zero GHG if achieved in 2050.

The tech optimist approach wouldn't change much with the introduction of a mandate, as the framing already incorporates the use of CCS-based approaches, through the creation of CCS hubs and the funding of research on CCS-based removals. A change which could occur in this pathway is that a requirement to use CCS could be introduced. This would require fossil emitters to utilise CCS for as much as possible before net-zero, while also requiring the use of CCS for bioenergy or other bio-based processes beyond net-zero GHG. This would require an earlier shift to the use of the Groningen field.

The market will decide that, while you are required to use CDR, the most cost-effective short-term method is the use of BECCS and the creation of CCS hubs. From the economist's perspective, the switch away from CCS-based methods beyond this will leave many sunk investments behind; consequently, they would be hesitant to transition to mineralisation and will take advantage of storage opportunities in the Groningen gas field.

The framework architect approach for this pathway map would be the utilisation of the ETS-tax and followed by the development of CCS hubs. This would still allow for

the use of mineralisation through ETS revenue while also allowing the development of CCS-based approaches before 2050. The framework architect will likely try to avoid the use of Groningen due to its historical and political implications. The final stages for this scenario would therefore need to rely on either a new non-CCS-based technology or mineralisation.

5.4 Design direction: The voluntary market

In the current CRCF framework, temporary CDR will be allowed (European Union, 2024). However, the use of temporary CDR within the CRCF introduces risks related to non-permanence and non-additionality (McDonald et al., 2025). The review of the implementation of temporary CDR within the CRCF is scheduled to take place in July 2026, too late for this project to account for any resulting changes to the policy landscape. Therefore, the focus of this study is on how temporary removals could be incorporated and how this was framed before this implementation.

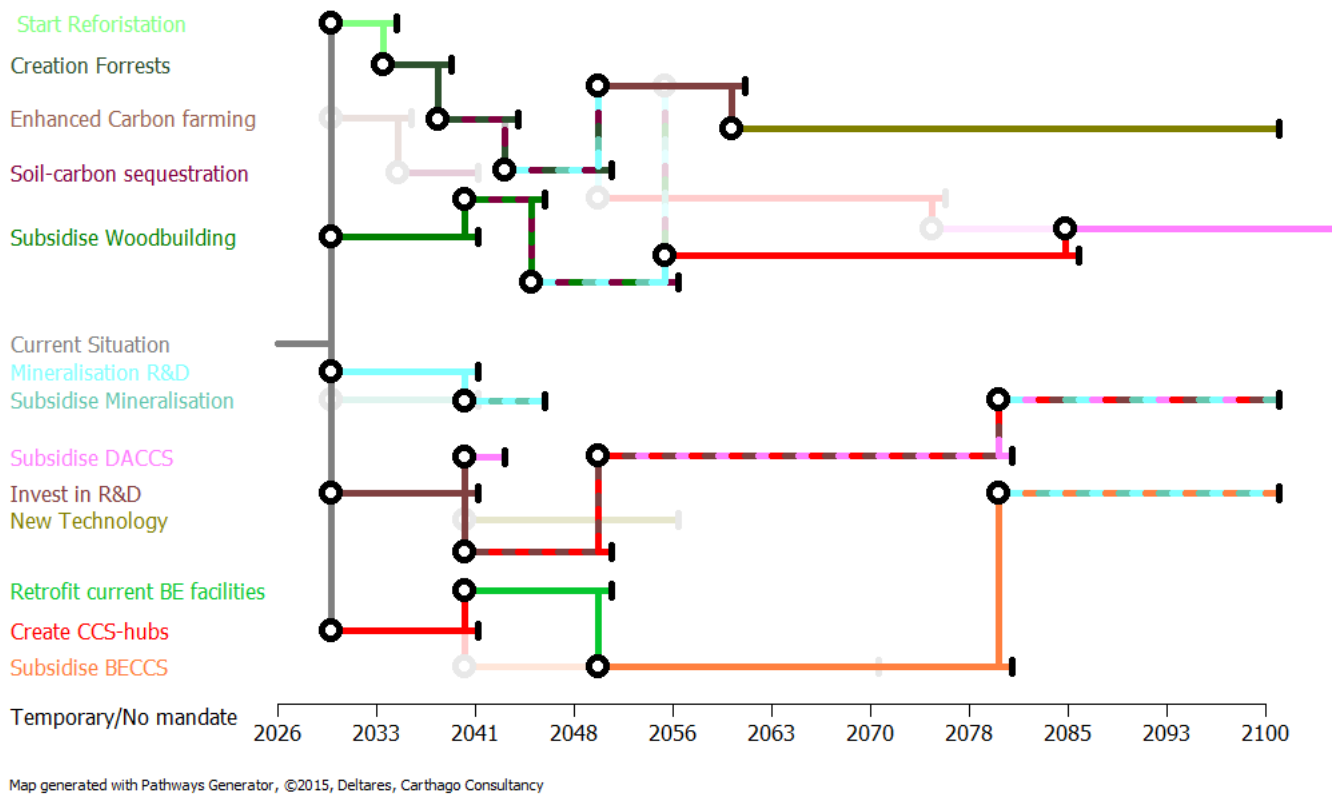


Figure 9: The third scenario pathway with permanent and temporary removals, and no mandate

From the nature activist perspective, the simultaneous use of both wood building and the sustainable creation of new forests is not feasible, as one would incentivise monoculture while the other would incentivise biodiverse forests. The choice would thus be to develop forests and mineralisation, and only allowing a switch to CCS hubs if the goal of net-zero GHG emissions by 2050 is reached. To minimise the risk of the continued use of fossil fuels.

The tech optimist perspective fully commits to R&D in the earlier stages to make DACCS and other CCS-based methods commercially viable and competitive. The

subsequent creation of CCS hubs and subsidisation will drive deployment thereafter while ending with a combination of investing in mineralisation research and deployment. This is an optimistic view in which the use of R&D will limit the risks of the various methods, such as reaching the storage capacity of gas fields.

The economist's perspective will once again follow a CCS- and bioenergy-based approach, only deviating this time with an initial focus on current BE facilities before subsidising Bio-CCS approaches further until the storage fields approach saturation at which point a shift towards subsidising mineralisation research and deployment would occur. The choice was made to not explicitly include the use of the Groningen gas field as an allowable pathway.

The framework architect would try to incorporate as many methods as possible, starting with the "most viable" current option, wood building. Afterwards, shifting towards a combination of R&D investments, mineralisation and later switches to CCS-based options, or if R&D works out a shift towards the utilisation of a new CDR method. The combination of both forestry and wood building would be possible from the perspective of the framework architect.

5.5 Design direction: Temporary storage under regulation

The introduction of a mandate again results in a slight change in context. A mandate could introduce minimum standards in terms of sustainability and would reduce the risk of creating unsustainable forests. This map also reflects what was likely envisioned during the development of the CRCF. However, no mandate currently exists. A difficulty in making such a map without current mandates is how it should be presented, whether through an ETS tax, a requirement to use CCS in certain situations, or separate targets for temporary and permanent removals.

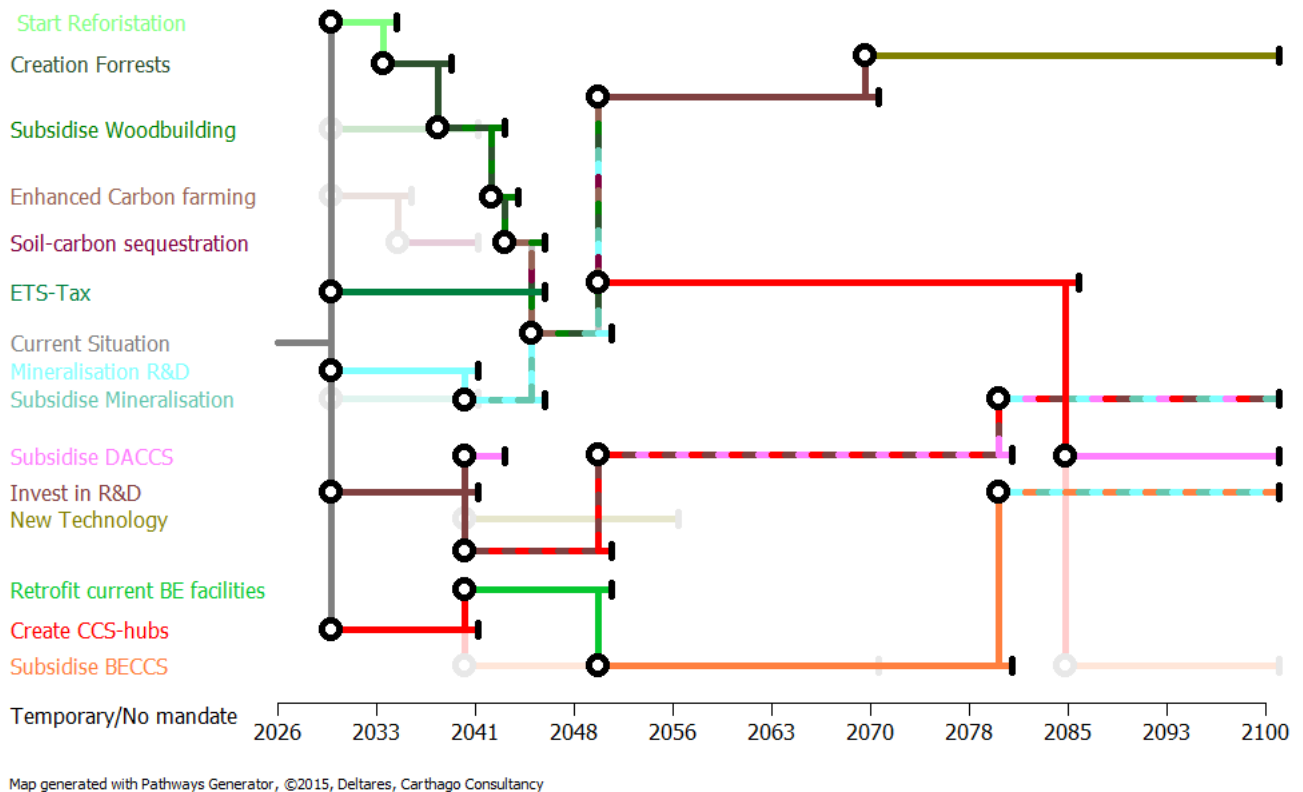


Figure 10: The fourth scenario pathway including permanent and temporary removals with a mandate

For the nature-based perspective, two changes will occur with the introduction of mandates, firstly, minimum standards will be introduced which require removals to meet minimal MRV criteria relating to sustainability, additionality and accounting. The timeframes will follow current CRCF legislation, so 35 years for temporary and 200 years for permanent storage. Secondly, ETS tax revenue will be used for CDR, thereby incorporating the mandated participation. The pathway laid out is thus a combination of various temporary removal practices, combined with the ETS-tax revenues with a subsequent investment in mineralisation and R&D. The choice in 2050, if net-zero GHG is met, would then be to focus on a new method or technology, or utilise CCS hubs with the ETS tax revenues to meet later goals.

The techno optimist follows the approach as in the other pathways with a focus on innovation, CCS hub creation and subsequent deployment of DACCS. A change which could occur is when, and whether DACCS deployment should be mandated or subsidised. The "Incentive + mandate" approach for the utilisation of DACCS would be the option that the tech optimist would prefer.

The economist's perspective doesn't change much compared to the scenario without a mandate, as the most scalable short-term option remains the CCS- and BECCS-based approaches, and only later will a shift towards DACCS or mineralisation make sense in terms of economics. Another challenge is the necessity of accounting for the costs of temporary removals. This is significantly influenced by the level of certainty required for a removal, the necessity of continuous monitoring of a removal, such as forests, and the necessity of repeating the removal practice after a specified period, such as enhanced carbon farming.

The framework architect perspective would be to first invest in mineralisation research and subsequently combine this with NbS approaches and the creation of CCS hubs, with a later shift towards DACCS if it becomes viable.

6 Results of the interviews

Multiple interviews were conducted utilising the pathways presented in the previous chapter. The interviewees were able to view the protocol in Appendix A. Within this interview protocol the pathway maps and possible discussion points for each pathway map are included. These questions were formulated at the same time the pathways were created. The views expressed within the interviews will be presented in relation to one another on various themes, highlighting the relation to the pathway framing and risks identified through the development of the pathways. The statements have been translated from Dutch into English. The translation and coding of quotations can be found in Appendix C. For each interview, the goal was to find out whether the interviewee's perspective differed from the established pathway framing, or from the perspectives of other interviewees. A shorthand (e.g., P1) will be used to refer to the interviewees, as presented in Table 1.

6.1 Permanence

One of the key questions underlying the pathways is whether temporary CDR methods should be permitted. Therefore, the interviewees were asked for their view on temporary and permanent CDR methods and how these methods should be used and evaluated.

The findings highlighted that most interviewees saw a potential use for temporary credits and NbS as compensation for short-term emissions, highlighted the need for safeguarding natural processes of sequestering CO₂ and recognised the risk of non-additionality. Interviewee P1 expressed support for the use of temporary removals or NbS in certain situations, "Temporary capture could be balanced against methane effects." (P1). And saw the value of incorporating these temporary removals, "It is important how nature-based solutions can be included in a carbon removal system." (P1). While P2 stated their uncertainty in the use of temporary CDR while actively conducting research on such a method, "We are still debating temporary removals and working with mangroves." (P2). However, both emphasised the importance of recognising and valuing existing nature-based sequestration processes, "You should safeguard and avoid slowing natural processes." (P1) and that, "It grows in the North Sea and is stored in the Wadden Sea, which is amazing" (P2). Meanwhile, they both also display an understanding of the additionality risks within nature-based solutions, "Additionality often arises in credits and requires careful handling due to risks." (P2), "No additional subsidy should be given for something already subsidised." (P1). P4 favoured the approach proposed by WKR (2024), "matching short-term sequestration against short-term emissions and permanent sequestration against long-term emissions.". While P3 wishes for their product to be classified as a temporary removal option, because "We want to fall within the CRCF." (P3). P3 therefore sees a role for temporary CDR within the EU, stating "High-quality credits are acceptable as compensation for emissions." (P3). For P5, the discussion of permanence was irrelevant, stating "my position is that I am dependent on what is decided by the certifiers and what is decided at the European Union level." and highlights that in the current situation, "then they basically say, if it is in a building, we currently see that as permanence.".

This framing deviates from how temporary removals were framed for use in the pathways. This is primarily due to the explicit separation of removals and mitigation chosen

for this project. The framework developed positions removals as a stand-alone feature to reach a certain removal target. While the use of temporary solutions to account for short-term GHG-emissions, acknowledges the role that temporary removals could play in mitigating the impacts of short-term GHG emissions.

One challenge brought up in the interviews was the absence of a clear definition of what constitutes a permanent removal. P4 stated that, "There is no clear permanence definition.", because of the unregulated market and the subjectivity in choosing such a definition. P2 similarly highlighted the absence of a clear definition, stating "Economic definitions of long-term, like 50 years, are questionable.", which shows that the definition used in practice can differ between companies. The CRCF will place a definition of 200 years, which might help standardise the differences currently observed across the market as laid out by P3, "Practical definition of permanence differs between parties.". P5 also saw that the permanence was not fully developed, in relation to carbon credits, "If it is in construction, then it concerns permanence. How long does that material remain in that construction? Well, there are not yet very strict rules about that.". P5 adopted a more pragmatic view of permanence stating they follow their certification bodies, "There are all kinds of models for that and we also have to comply with those methods.". This was further emphasised by the statement, "I think you can put it this way, the certifiers. In this case we work in the Netherlands with SNK and ONCRA, they determine the rules of the game and they in turn rely on scientific models.".

In conclusion, most participants acknowledged that temporary removals can have value, particularly for addressing short-term emissions, but stressed the need to account for risks such as additionality and reversibility. At the same time, there was broad recognition that nature-based sequestration should be safeguarded and valued. Interviewees noted that definitions of permanence vary across organisations and certification systems, creating uncertainty in the market. While the EU CRCF is expected to provide greater standardisation several participants indicated that, in practice, they are dependent on the rules established by certification bodies.

6.2 Mandates

Various forms of mandates are incorporated within the pathways. The interviews therefore explored how participants viewed the different approaches to mandating carbon removals.

Within Meckling and Biber (2021), the coupling of fossil extraction and removals was highlighted. The interviewees' perspectives on this approach were varied, with the majority of them holding a negative opinion due to the legitimization of fossil continuation. At the same time, some stated they preferred something to nothing. Three interviewees displayed a similar sentiment, P1 stated, "This maintains fossil compensation while long-term goals require net negative emissions.". P2 stated, "Linking CDR to fossil emissions is risky as it legitimises continuation.". P4 stated, "I can see that too (wariness of the link between fossil fuels and removal)". Only the view of P3 was slightly different, saying "At the same time, I would 100 times rather have someone buy off their emissions than do nothing." and highlighting the need for financing in order to scale, "Everything financial helps with scaling of removals." (P3). While P5 did not display a clear opinion about the coupling on fossil extraction, highlighting that the decision on where the mandate takes place was not his to make, "Whether it will be allowed into ETS 2 or ETS 3 in the future is up to politics." (P5).

The interviews also addressed the public funding of removals, a carbon bank for this proposal. For the most part, there was an agreement that additional funding would be required, although there were some questions about the source of public funding. P4 indicated that, "We're not quite there yet, but we'd like to roll this out now, and there are certainly still a few snags to sort out, particularly when it comes to technological routes. (Carbon bank)". And also stating that this was already widely discussed for temporary removals, "And they're also looking to launch a procurement programme for this (bio-based building materials and sustainable cultivation). I think that's more or less the general trend."(P4). P1 raised concerns regarding public funding, "The question remains where public funding will come from." While P5 argued that some form of public procurement would be necessary, "The government will have to continue taking a substantial leading role there. Also in identifying components that the private sector would be less likely to take up or be able to take up." and pointed to existing examples of public procurement by Dutch water authorities, "The Dutch water authority Vallei and Veluwe is the first water authority in the Netherlands that purchased a carbon farming project. From us, and last year they made a whole tender process out of it, and they truly are a frontrunner in the Netherlands."

One way of introducing funding would be to link carbon removals to the ETS, either through the use of ETS revenues or through the incorporation of removal credits into the market. Some interviewees showed favourability of incorporation of ETS revenues, but not of incorporating credits within ETS. P1, "Using ETS-auction revenues is a reasonable approach", and "We are not in favour of fully integrating it into the ETS because it reduces reduction incentives.". Meanwhile, P3 was supportive of the incorporation of credits within the ETS, "ETS integration helps create demand for removals.". Meanwhile, P4 opposed integration, stating "CDR should not be mixed with ETS reduction." because, "You really do need to treat them as two separate objectives". The topic was not explicitly discussed with P2. P5 regarded this as a political decision but did highlight that in current discussions the role of removal credits would not allow for a full replacement of emission rights, "(ETS) Suppose these credits also become part of that, then they become tradable and they become part of it. Then it will most likely only be for a limited portion."

The interviewees also highlighted that a form of mandate would be necessary for the sector to grow, while not sharing a common preferred method of mandating. P2 stated, "In our models, they only work if a certain amount of CDR is included; that should be your baseline.". Similarly, P3 stated, "Legislation will likely be needed if we need to utilise removals." but also stating "I don't care how; tools like mandates, subsidies, and pricing can stimulate demand.". While P4 provided an example of how mandates can stimulate sectoral development, "The requirement under the E-fuels well, there you can certainly see a real push towards the production of biofuels." and also, "So I do expect that if we set out a mandate, we'll be able to speed up the implementation a bit.". P5 also supported a degree of market obligation, "What I am also in favour of is having somewhat more obligation there, separate from the ETS in the voluntary market." because, "Otherwise, I think this market will not get off the ground on its own." or even, "But it may well be that at some point the market implodes because there has been stagnation for too long a period."

However, mandating CDR also presents several challenges such as the political will to stick with mandates and the potential that it would take resources away from emission

reductions. P4 highlighted the importance of timing, sector context and the effectiveness depending on political implementation, "I think the most important thing is that such a mandate is introduced at the right time.", "I think you do need to draw up a mandate like that with the sector in mind", "So the question is always: what role does politics then play?". P3 likewise stated, "Governments should prioritise green transition investments over other temporary emission reductions". This view was also echoed by P1, "In our view, fossil emissions should be reduced to zero as quickly as possible.". P2 also highlights the temporal factor stating, "Implementation requires piloting and experimentation." and, "This takes time, otherwise it leads to wasted investment.". The political aspect was also emphasised by P2, "How much are we willing to spend in the coming period to return to 1.5–2 degrees?".

In summary, the interviews showed broad support for some form of policy intervention to scale carbon removals, although opinions differed on the specific design. Most participants were cautious about directly linking removals to fossil fuel emissions or fully integrating removal credits into the ETS, due to concerns that this could weaken incentives for emissions reductions. At the same time, interviewees generally agreed that mandates, public procurement, subsidies, or other support mechanisms will likely be necessary to create sufficient demand for removals and stimulate market development. However, participants emphasised that the effectiveness of mandates is dependent on their implementation, sector-specific considerations, adequate funding, and alignment with broader reduction goals.

6.3 Goal framing and accounting

One challenge in developing the pathways was defining an appropriate goal. Interviewees were therefore asked for their views on the goal adopted for the pathways.

Lack of agreement on what should be included in the objective to achieve a specific number of removals or mitigations is one topic of discussion that came up. P1 believed that, "Even if land-use emissions are accounted for in another country, policymakers should consider scope 2 and 3 effects as well.". P2, by contrast, highlighted, "Legally, emissions beyond eight miles are not attributed domestically; authorities confirm this.". This is a reference to the territorial sea border of the Netherlands and P2's view that a lack of accounting in short-term emissions from the North Sea is occurring, "Emissions from systems like the North Sea should be considered anthropogenic and included in accounting.". While P3 highlights the amount of emissions of the government, with "They nearly can't follow the law (if a carbon price gets introduced)", stating the costs for the removal of their emissions would be too high. These statements suggest that there is no a uniform view of what should be counted, and who should be held responsible for these emissions, leading to a difficulty in goal setting.

The difficulty in goal setting for longer periods was also highlighted by P2, "In recent weeks, we have said it is not wise to set a minimum target if you also aim to minimise it to what is strictly necessary.", while also stating "In that sense, you should strive for a maximum, as the real risk is not overshooting what is desirable". This suggests that both minimum and maximum targets should be established, while efforts should focus on achieving the upper end of that range. Additionally, P1 struggles to define what is achievable, as evidenced by the statement, "Towards 2100 it becomes more uncertain what can realistically be said." The uncertainty associated with long-term projections

was also emphasised by P5, "But I find that very difficult, you know? I already find 2050 very, very difficult, let alone 2100."

The size of the goal was also a point of discussion with P2, P3 and P5 being unable to estimate whether 5 Gt in 2100 was feasible, "No, I do not have much expertise on that (5 Gt in 2100)." (P2), "I am unable to help with what is a realistic goal, but belief 5 Gt is plausible." (P3), "No, I do not have that.(opinion on 5Gt)" (P5). In contrast, P1 did not believe 5 Gt was plausible, stating that for 2100, "We do not expect it to exceed 25 megatons per year.", thereby implying that the Dutch roadmap may be unfeasible. P4 stated, "I think that, as far as the Netherlands is concerned, if we were to carry out everything here as a project, it wouldn't be possible, or at the very least we would face a significant shortage of space to do so." and "If we were to implement a target like that, we would really need to be able to trade those carbon credits on a global scale. Otherwise, it simply isn't feasible.". Nevertheless, P4 did reiterate the intent to remain on the current target set in the roadmap, "It's not a firm target yet. It is, however, something we're aiming for (20–25 MtPA by 2040-2050)"(P4), although also mentioning, "The roadmap is actually mainly focused on the first five years at the moment." which means a focus on market creation and R&D. During the KIN workshop, a widely shared view was that the target outlined in the roadmap was unrealistic and too ambitious to be achieved solely within the Netherlands.

In summary, the interviews highlighted substantial uncertainty regarding the appropriate scale and definition of CDR targets. Participants highlighted the difficulties in identifying which emissions should be counted and who should be responsible for them, which complicates the process of setting specific goals. Interviewees also emphasised the uncertainty associated with long-term projections, with several questioning the feasibility of estimating CDR needs towards 2100. While some participants saw the proposed Dutch targets as plausible, others considered them overly ambitious, particularly if removals must be delivered domestically. The interviews point to general trends whereby future goals will have to strike a balance between ambition and pragmatic limitations of scaling, accounting uncertainty, and uncertain technical advancement.

6.4 Scaling and piloting

In literature and the workshop, the need for additional R&D was emphasised. Accordingly, the pathways incorporate both general R&D measures and technology-specific R&D actions.

Although the necessity of research and development was emphasized throughout the interviews, the emphasis on the barriers to research varied between the need for more regulatory space to conduct experiments and the lack of funding. P2 argued that a barrier for R&D was the ability to conduct pilots, "Research exemptions are sensitive but necessary to enable scaling." (P2) and, "Implementation requires piloting and experimentation." (P2). P4 also highlighted this, "As a researcher, you do need to have the space and freedom to carry out your research. Otherwise, you'll never be able to find the answer.". However, P4 also adopted a more cautious position, particularly where potential impacts remain uncertain, "Are you really going to launch something like this research onto the market all at once, when we're not actually sure yet whether it's safe?". However, progressing beyond the pilot stage remains challenging, "In the Netherlands it is difficult to grow from start-up to commercial scale." (P1). According to both P1 and P3, cost is one of the primary barriers to scaling, with P1 stating,

"Ultimately, price determines whether credits are generated." and P3 stating, "CDR is the most expensive approach." and "Few buyers operate in the market currently." (P3). P5 also observed that the market faces difficulties in expanding, stating, "We have made substantial progress in the past 5 years, but we expected much more and much more speed, and actually far too little is being bought and far too little is being invested.".

These findings suggest that scaling up CDR requires two key conditions: funding from buyers and the regulatory space for piloting. P3 noted that currently supply exceeds demand, but "Demand may exceed supply in 2035 because of regulation." (P3), P3 argued that this may occur because many companies are not yet participating in the market, and will likely only do so when it is required. As P2 said, "You must accept risk; pilots should be able to demonstrate failure." This creates challenges for policymakers, as the risks associated with novel technologies may not yet be fully understood. This is especially difficult for regulators because of previous failures highlighted by P1, "In Barendrecht, CCS plans were cancelled early on." and P2, "Large-scale experiments like wood sinking faced societal opposition and were halted.". P4 also highlights this difficulty, "It does make things more difficult at times. It's also a challenge for those responsible for implementing the scheme: how are we going to assess a project like this?".

The importance of government support in facilitating investment and market creation was frequently highlighted, while cautioning on the importance of its role as an impulse and the risk of uneven subsidisation of different methods. This support can come in the form of subsidies, as P1 notes, "It makes sense to temporarily subsidise this to allow scaling.". Similarly, P3 noted, "Everything financial helps with scaling of removals". P4 expects the need for incentives to exist for a longer period, "But I do expect that, for the first 10 to 15 years or so, we'll need some sort of support to help with implementation, and in that case, for example, an SDE is actually quite a good tool." (P4). P5 also sees this need for subsidisation, "The government will have to continue taking a substantial leading role there." but also emphasises the market impact of subsidies, "then people start relying on the fact that there is all kinds of subsidisation, so subsidies should be short and should have the purpose of saying: this is only meant as an impulse." (P5). P4 also sees this when a mandate gets introduced, "Of course, you must also ensure that his mandate keeps the playing field as level as possible.". So even though there are risks to subsidies, there appears to be no credible pathway for scaling CDR without either sustained policy support, subsidies, or some form of removal mandate.

To summarise, the interviews reinforced the importance of continued R&D and innovation to enable the scale-up of CDR. Participants highlighted that successful development depends on both sufficient regulatory space for piloting and experimentation, and adequate funding to move technologies from research to commercial deployment. A recurring theme was that high costs, limited demand, and investment challenges currently constrain market growth. There was broad agreement that government support through subsidies, market creation measures, or mandates will be necessary to accelerate deployment and reduce costs. Overall, the discussions suggest that large-scale CDR deployment is unlikely to occur without policy and financial support and opportunities for continued learning through experimentation.

6.5 Public participation and perceptions

These methods do not happen in a vacuum but are developed within the wider society, the public view and discussion on CDR was thus also touched upon within the interviews.

The use of Biomass is a politically sensitive topic. A theme that emerged regarding this is the practical feasibility of BECCS and the question of how this technology should be deployed. For example, P1 states, "Biomass is likely more needed elsewhere in practice." and that, "Reducing natural stocks for BECCS may yield little net benefit.". This view was consistent with the concerns raised by P2, "My concern lies with raw materials, especially for BECCS.", and also with P3 stating, "By the way, I am against BECCS subsidy, now that I see it that way, because it maintains a market that is actually undesirable in the long term.". While P4 has a pragmatic view, "I also think we need to remain realistic about what capacity we're actually going to need over the next 15 years." and that, "we will always have residual biomass streams that we cannot put to good use.", while also realising the difficulties with BECCS, "Of course, you wouldn't want to put A-grade timber or any other high value material into the furnace". These differing perspectives contribute to the current uncertainty surrounding the future role of BECCS, as P4 highlights, "We don't yet know which direction we want to go in, so not much is happening yet, and I think that's partly the case with BECCS as well.".

The use of BECCS remains a contentious issue between undesirability for long-term use, the issue of raw material sourcing, and the practical use for CCS on current bioenergy production. P1 highlighted, "Biomass burning has a negative image, for good reason.". While P2 stated, "'Bio' can have positive connotations in public discourse." and "Biomass is often judged negatively, there is very little nuance.". As stated above, P3 doesn't prefer a route utilising BECCS, however also adopted a pragmatic position, stating, "At the same time, I'd rather they burn it and capture it.". This tension was also displayed by P4 stating, "Of course, you don't want to create a lock-in. You don't want things to get bogged down or drag on longer than necessary." and highlighting the role that bioenergy currently plays, "Ultimately, the main purpose of a bioenergy power station is, of course, to supply energy. And I think that's what you should focus on above all else.".

Another question that arose concerned how the CDR market could be implemented in a socially acceptable manner, mainly highlighting the need for social acceptance and the general acceptance of NbS without regard for specific implementation. P1 doesn't see much of a public discussion on CDR, "The public does not have strong opinions on most carbon removal techniques.". However, P1 noted that, "Biomass burning has a negative image, for good reason."(P1). P4 also recognised the positive connotations of natural solutions, "Natural routes always feel a bit more appealing. They feel a bit safer, even though they might not always have a high degree of permanence.". P4 further emphasised the importance of social acceptance, "You also need that social acceptance, and I think that's a key priority."(P4). P5 provided an example of how social acceptance and stakeholder engagement could be strengthened, "For example, I personally created a chain contract with everyone in that chain. It was not an exact obligation, but I considered it important to show how we do this.".

The use of Biomass is a complicated and political question which is often viewed nega-

tively, while BECCS likely will be implemented. P1 highlights, "Biomass burning has a negative image, for good reason." While P2 says, "'Bio' can have positive connotations in public discourse." and "Biomass is often judged negatively, there is very little nuance.". As stated above, P3 doesn't prefer a route utilising BECCS, however also displays pragmatism with, "At the same time, I'd rather they burn it and capture it.". This tension was also displayed by P4 stating, "Of course, you don't want to create a lock-in. You don't want things to get bogged down or drag on longer than necessary." and showing the different role BE currently has, "Ultimately, the main purpose of a bioenergy power station is, of course, to supply energy. And I think that's what you should focus on above all else."

The implementation of the CDR market in a social acceptable way was discussed, highlighting a lack of public discussion and the need for a transparent overview of CDR processes. P1 doesn't see much of a public discussion on CDR, "The public does not have strong opinions on most carbon removal techniques.". But does note that, "Biomass burning has a negative image, for good reason."(P1). P4 also recognises the positive connotations of natural solutions, "Natural routes always feel a bit more appealing. They feel a bit safer, even though they might not always have a high degree of permanence.". While also pointing out the social acceptance, "You also need that social acceptance, and I think that's a key priority."(P4). While P5 demonstrates how one could build social acceptance, "For example, I personally created a chain contract with everyone in that chain. It was not an exact obligation, but I considered it important to show how we do this."

To sum up, the interviews indicate that BECCS's function and social acceptance are significant public-facing issues for CDR. Participants expressed significant concerns about BECCS, particularly regarding biomass availability, sustainability, and the risk of creating long-term dependence on an undesirable system. However, some interviewees acknowledged that residual biomass streams might still be useful for CDR deployment or future energy generation. More generally, interviewees emphasised that the acceptability of CDR methods has been significantly influenced by public perceptions in the past. Biomass and BECCS are frequently viewed negatively and remain politically contentious, whereas nature-based solutions enjoy greater public appeal and trust, regardless of whether this is warranted. Several participants stressed that achieving social acceptance through transparency, stakeholder engagement, and clear governance will be essential for successful CDR implementation.

6.6 On the use of DAPP and framing

The use of the DAPP approach was also discussed during several interviews. P2 argued that DAPP might be more effective when applied at a different level of aggregation, "You might be able to take it a step further when summarising CDR. Comparing it to nuclear energy and the phasing out of fossil fuels.". While P4 also highlighted factors which could influence the decision in the scale of CDR required, "It is indeed a question of how quickly we are moving towards renewables.", "Livestock reduction is an option." and lastly, "So, on the one hand, you might have the potential to sequester that carbon within the economy, but even that will be limited.". These observations highlight the importance of the broader context within which CDR operates. Although CDR is designed to reduce the effects of climate change, alternative mitigation strategies may also contribute to this goal in the short term.

Another point of discussion concerned the geographical scope of the pathway framing, which focused on the deployment of CDR methods within the Netherlands. However, many carbon credits are currently generated outside the Netherlands. P5 highlighted, "They purchase internationally, and that is because we have agreed that a number of conditions must be met. One of those is the social component, and that is not present in the Netherlands. We are too wealthy a country.". P5 also recognised that, "an industrial party in the Netherlands will say: from an economic perspective I have always purchased abroad. I have no incentive whatsoever to do otherwise.". A sole focus on credits generated within the Netherlands therefore does not reflect the current reality of the voluntary carbon market.

In conclusion, the interviews revealed that CDR pathways may benefit from being considered in a broader climate policy context, as the need for removals is dependent on advancements in mitigation measures such as the speed with which renewable energy is deployed and livestock reduction. Participants also mentioned that the current carbon removal market is highly international, implying that a solely domestic focus may not fully reflect how CDR will develop in practice.

7 Discussion and limitations

Within this discussion, the aspects highlighted are the dependence of actions on previous actions, the impact of identifiable constraints and how these factors combined impact the applicability of the DAPP approach for the CDR sector. The early adopter pathway approach was the archetypical pathway approach that was followed, as identified in Di Fant et al. (2025). This means that the results are not intended to identify exact timings or an actionable pathway plans. Instead, the goal would be to find constraints and the dependencies between actions.

7.1 Dependence of actions

Within the development of these pathways, it became clear that while some actions are dependent on previous actions, others rely more on policy implementation.

7.1.1 Dependence on R&D

In the pathway maps, the dependence of DACCS and mineralization on additional R&D was already evident. Some interviewees were asked about their opinions on R&D and pilots. The current situation already has some research subsidies in place, but some argue that it is not enough. P2 highlighted not only the need for funding for pilot projects but also that there needs to be space for piloting, “You must accept risk; pilots should be able to demonstrate failure.”. While piloting is an issue for more technological solutions, the NbS are less dependent on pilots as these practices have been widely implemented. The main issues for these methods are competition for land and financing.

7.1.2 The development of CCS hubs

As a precursor for the use of CCS-based DACCS or BECCS, adequate storage and transport infrastructure must be available. The Netherlands has recognised this within the roadmap, and there are some projects in the works. P4 highlighted that Aramis might have space available for removals, while Porthos has full planning capacity already in place for industrial emitters. But if storage development at scale is required, additional projects need to be included in planning. This would be a precursor before the large-scale implementation of DACCS or BECCS could become possible, and therefore represents a dependency between actions. It would also become more relevant if other European countries, such as Germany and Belgium, are connected to the Netherlands as planned. Due to the increased competition for storage space caused by the stored emissions from these nations, the Netherlands would need to look for more storage space.

7.1.3 BCR as a CDR method

The use of biochar as a carbon removal method was categorised under soil carbon sequestration for this project. This was done for a few reasons. Firstly, this is one of the ways in which biochar is used, so it’s not a misrepresentation to mention biochar under soil carbon sequestration. Secondly, a course was previously taken in which biochar was presented as a byproduct of sustainable fuels, meaning that this raised questions regarding the additionality in the production of biochar for CDR. Although

P4 does note that, "Because of the whole carbon removal scene that has arisen, people are actually preferring to make biochar, or at least trying to produce it as their main product.". Lastly, biochar has a relatively small potential listed in the roadmap of 0.05 MtPA (KGG, 2025). A combination of these factors resulted in biochar playing a less prominent role, than might be warranted given the rapid growth of the global market for biochar-based removal credits. Alongside conventional NbS such as afforestation and reforestation (somewhere between 1,800 MtPA CO₂ to 2,600 MtPA CO₂), BCR (0.97 MtCO₂) presented the largest volume of novel CDR in 2025 (Smith et al., 2026). The dominance of BCR among novel CDR methods can be seen in Figure 11 from 'The State of Carbon Dioxide Removal, 3rd Edition' below.

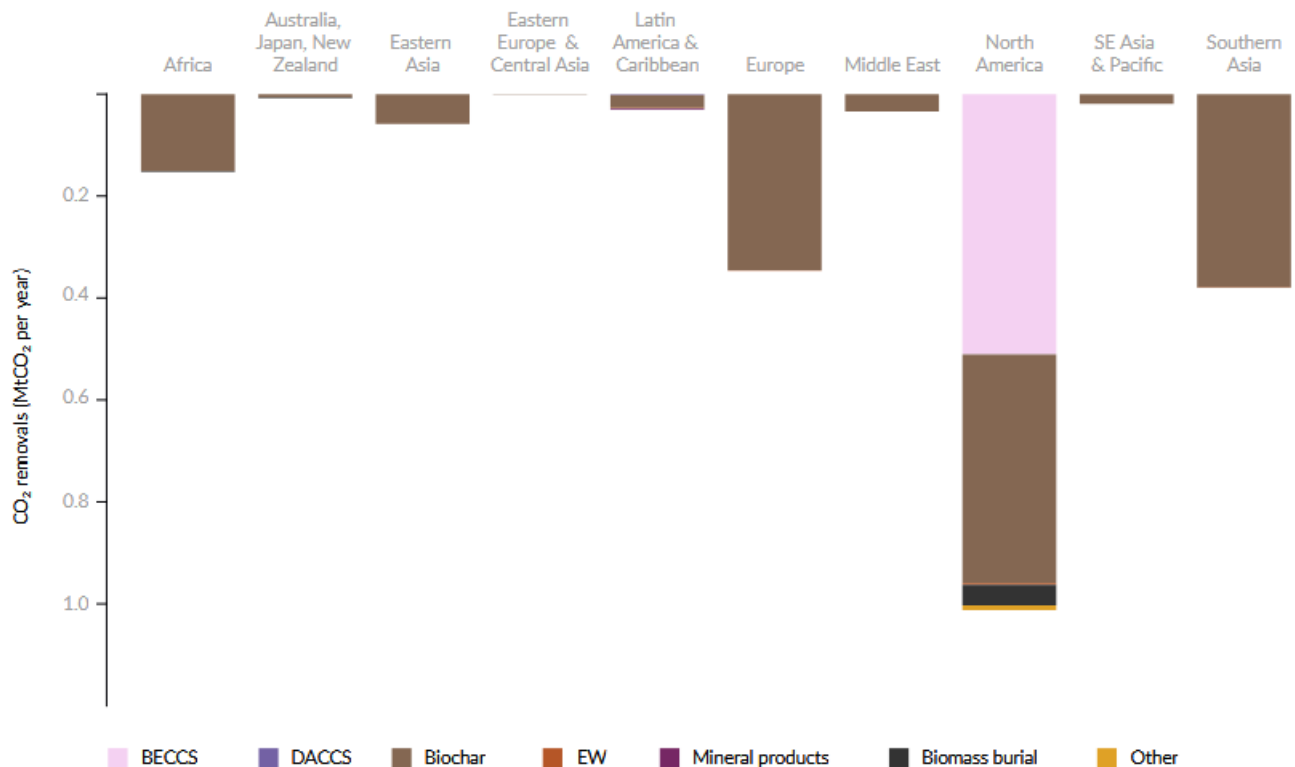


Figure 11: Figure 7.2(b) Rates of novel CDR, rates by year and location. Region-specific global CDR in 2025 from Smith et al. (2026), 'The State of Carbon Dioxide Removal, 3rd Edition'.

Based on the prevalence of BCR in real-world credits, its role in the application of these pathways should likely have been amplified more and would have warranted its own technological category. This point was also emphasized in the interviews with P3 and P4. The report by Kampman et al. (2023) also notes that, while the annual removal rate may not be significant, BCR's cumulative potential is estimated at 114 Mt by 2050 in the Netherlands. However, its realistic cumulative potential is estimated at roughly 0.5 Mt by 2050 mainly due to constraints associated with the availability of sustainable biomass. This constraint was not emphasised to the same extent in the pathways for BECCS, although this constraint applies equally to this method.

7.1.4 Dependence on finance

One of the main points of contention in developing this sector is how to finance the removals. In the DAPP approach as designed during this project, the dependence on financing is understated in the final maps. The options of subsidising, introducing an ETS tax and a carbon bank are present. These are the primary financial methods that were discussed during the interviews; however, the manner in which the pathways are presented suggests that they are in competition with CDR methods. In reality, these are underlying financial decisions which can be used to fund the subsidies for the various methods of CDR. The decision to include both technologies and financing methods, is because both the technical and financial aspects are important when deciding how to shape policy. However, as a result the final pathways do not provide as clear a picture for developing financial policy as the pathway development process and the subsequent discussions provided.

7.1.5 On the inclusion of CDR in EU ETS

The option to utilise ETS for the funding of CDR was discussed and recommended. The Dutch government indicated being for the eventual implementation of permanent CDR within the EU ETS (Carbon Gap, 2025; KGG, 2025). This has been considered problematic in the literature for the primary objective of the ETS, namely reducing emissions. Because this allows the substitution of emissions with removals. However, this changes when a mandate is introduced. The Netherlands is also in favour of creating separate temporary and permanent removal goals next to existing mitigation mandates (Carbon Gap, 2025). Some interviewees were in favour of using ETS revenue (P1, P2) while others (P3, P5) favoured incorporation of CDR in ETS. The main difference in view was that from one side the exchange of removals and reduction was considered a risk and would allow for longer use of fossil fuels. On the other hand, some argued that removals are more expensive and recurring payments compared to decreasing emissions; thus there is an inherent value to utilising reductions over removals. P5 did also provide the background that this would need to come with certification methods which would reach the same standards as what is currently accepted by ETS companies, so these companies can use it within their for use within their reporting and compliance systems.

A small note on the implementation of this decision should be that the Netherlands does not view the creation of mandates or decisions regarding the inclusion of temporary CDR as a national responsibility. For example, the Netherlands does choose where the funds generated by the ETS are used (SDE++), but not on the inclusion of removals within the ETS because these decisions are taken at the EU level.

7.2 Implications of Constraints

Given the constraints present in the Netherlands, certain aspects are reflected within the pathways, while others are not. In some cases, constraints are incorporated into the pathways or their underlying timeline assumptions but are not represented as explicitly as necessary.

7.2.1 Storage Capacity

When considering long-term planning on this scale, several challenges emerge that may become more or less important depending on future implementation choices. The primary long-term constraint identified is the availability of CCS storage capacity. Current documents suggest that sufficient storage capacity is likely to be available for at least several decades. However, existing plans allocate much of this capacity to fossil-based CCS rather than the storage of biogenic or atmospheric CO₂. Consequently, the faster the transition away from fossil fuels occurs, the greater the remaining capacity available for CDR applications. Nevertheless, many storage contracts have already been agreed upon, meaning that portions of this capacity are effectively reserved. Furthermore, substantial interest exists among industrial actors in Germany and other EU Member States. This issue becomes particularly significant if large-scale CCS deployment is required while the current political resistance to onshore storage, including the possible use of the Groningen gas field, remains unchanged.

Current fossil CCS scenarios in the Netherlands are expected to use a substantial share of available offshore storage capacity, with estimates suggesting that capacity would remain sufficient until approximately 2060 under these scenarios EBN and Gasunie (2022). This does not necessarily imply that existing capacity should not be used for fossil-emission mitigation. However, careful evaluation is required regarding whether these emissions should genuinely be regarded as residual emissions and how, when, and to what extent a transition towards the removal of atmospheric or biogenic CO₂ should occur.

7.2.2 Sustainable Biomass

Based on the interviews and the roadmap, the current treatment of BECCS within the pathways reflects a relatively optimistic perspective regarding its implementation. It highlights the considerable potential that BECCS could theoretically provide if several assumptions hold, namely the continued availability of sustainable biomass imports, the achievement of net-negative emissions, and the replenishment of biomass resources following extraction. These assumptions were adopted primarily to present policy pathways capable of achieving the required scale of removals.

The framing of BECCS could also be further differentiated, for example by distinguishing between waste-based removals, bioenergy based on dedicated feedstocks, and Bio-CCS applications. Such distinctions may better represent the trade-offs involved. The central question regarding bioenergy is whether high-quality biomass has more valuable alternative applications, whether CCS represents the most desirable use of biomass resources, or whether promoting BECCS creates a long-term dependence on the technology.

There is no definitive answer whether bioenergy-based carbon removal should play a significant role in future climate policy. However, there appears to be a broad consensus that biomass should only be used where no preferable alternative application exists, such as fuel production. This preference is particularly evident for domestic waste streams, as such resources are expected to remain available beyond 2050.

Dutch policymakers will likely need to decide sooner rather than later whether BECCS should form part of the country's long-term CDR portfolio. They would also need to determine how such deployment should be incentivised or mandated, given that

under current policy frameworks BECCS is unlikely to be economically competitive with conventional bioenergy. Alternative approaches involving the capture of biogenic CO₂ without combustion would require the conversion of biomass into fuels or other storage pathways. While these approaches may achieve higher capture rates, they may lack some associated co-benefits of conventional bioenergy systems and could therefore prove more difficult to implement.

7.2.3 Land use and area

The Netherlands is a country with limited available space, as virtually all land has already been allocated to specific purposes (van Oort & Hospers, 2024). Because of the legislative background of land designations, it is exceedingly challenging and takes a long time to change a piece of land’s designation from agricultural to industrial use. Therefore, the issue is not whether there is space available, but rather what we are willing to give up in order to utilise the available space. Large-scale removals will only intensify competition for different land appropriation decisions beyond what is already the case. The pathways implicitly incorporate this trade-off, which contributes to the fact that, for instance, forests in the Netherlands have a limited capacity for removal. However, some interviewees thought it had too little presence on the pathway maps.

7.3 The applicability of DAPP for CDR

The use of the DAPP approach for the CDR sector has shown some drawbacks while proving useful in other aspects. It is useful for creating a thought process as a framing tool for identifying dependencies between actions. It requires consideration of whether an action works, requires a previous action or is itself an action that needs to occur before another. However, within the CDR sector there is a non-uniformity of methods, which means that even though the general technology is often presented as DACCS, BECCS or mineralisation, the technologies which fall under this often don’t have the same trade-offs or problems attached. For example, there are a whole variety of technologies which can be classified under BECCS or Bio-CCS. And even when there is some degree of uniformity, feedstocks and carbon accounting can differ for different implementations of the same technology. This makes it very difficult to accurately predict the potential and trade-offs which occur for each subsection of the removal methods. This implies that each framing choice is accompanied by an asterisk, such as the creation of a forest being advantageous for the nature environmentalist, provided that it is achieved in a manner that prevents the production of monocultures and promotes biodiversity. In practice, some environmentalists support the use of CDR for the creation of forests, while others are against it.

7.3.1 The setting of a goal

The CDR sector has a disadvantage when the DAPP approach is applied. Namely, the need to set a goal and the subjectivity and impact this introduces for CDR. I purposely framed the goal as needing to reach a certain temperature minimum (IPCC AR6 1.5-2 °C for 2100). This is because the goal is not to reach a certain number of removals, but to decrease the warming of the planet. Nevertheless, in order for this to occur in practice, a specific amount of CDR must occur, which is contingent upon the mitigation efforts of other countries and the values associated with responsibility. This means in practice there will be a shifting goalpost, where the required amount of CDR shifts over

time and shifts with changing values. The amount of 5 Gt CO₂e by 2100 (cumulative) was too high in the view of some interviewees and unrealistic, but it falls within the range predicted by the EU (1.17-18.58 Gt CO₂e) (Sunny et al., 2021). During the interview with the NGO, they stated that 25 MtPA CO₂e was considered the maximum realistic potential for 2050-2100. This would equate to roughly the lowest estimate of requirement in the EU predicted range. When speaking with various people at KIN, most did not believe the possible range of 20-25 MtPA by 2040-2050 in the roadmap for the Netherlands (KGG, 2025) was realistic or even desirable. The consensus is that removals should not lessen mitigation measures. But with the setting of this goal at 5 Gt CO₂e this results in a situation where the scalability of the method becomes more important than it would be when setting a lower goal. This means that in the later half of the 21st century a focus on CCS- and mineralisation-based options becomes nearly inevitable because these are the only methods with sufficient scalability in the Netherlands. There is virtually no chance that, for example, the creation of forests can acquire the same scale of removals in the Netherlands. This creates a challenge in presenting these methods as a sustainable long-term option, as they necessitate a scale-up of the multiple tens of MtPA.

Another difficulty in applying the DAPP approach to the CDR sector is dealing with uncertainty regarding the effectiveness and costs of different actions. Within DAPP, this uncertainty is primarily addressed through the development of multiple scenarios. However, the outcomes remain highly dependent on how actions and scenarios are framed. For example, BECCS could become both prevalent and competitive if sufficient sustainable biomass can be sourced. In this project, it was assumed that biomass could be imported from outside the Netherlands. While this is currently permitted for bioenergy facilities under certain conditions, it introduces the risk that negative environmental impacts and forest-management burdens are shifted to other countries. In addition, there is the question whether biomass will remain competitive as an energy source, which depends on developments in the wider energy sector. Consequently, its future cost trajectory, as well as its economic and societal value proposition, may change over time.

Dealing with costs is particularly challenging because any assessment is necessarily based on current cost estimates, which may either increase or decrease in the future. In practice, when developing the pathway maps, costs functioned more as a back-of-the-mind consideration than as an explicit trade-off. For example, both mineralisation and DACCS were assigned R&D-related actions because they will likely require substantial technological progress before becoming commercially competitive. Similarly, the inclusion of retrofitting existing BE facilities before subsidising BECCS reflects the presence of current bioenergy facilities, and potentially coal-fired power plants, that could be converted to BECCS more cost-effectively than constructing entirely new facilities.

7.3.2 Value-based approach

The difficulty in accounting for costs is one of the reasons to shift towards a value-based approach. However, this value-based approach has its challenges. Firstly, it is difficult to address or discuss the values surrounding an implementation of a method when it has not yet been implemented. The best example is the creation of forests, or reforestation as a CDR method. Within the KIN workshop, someone felt it was a fail-safe option for the removal of carbon in the atmosphere. They saw its co-benefits of

biodiversity, resilience and adaptability, and well-established removal method as strong incentives. However, during this research a different view has also been encountered which shows reforestation as an expensive, highly reversible method with uncertain net removal effect. What this shows is not that the values differ between these opinions, but that the actual implementation of the method, the framework surrounding risk management for a certain method, and the knowledge of the risks are more important in determining whether an option aligns with someone’s values. This is consistent with the results of Honegger et al. (2022), which determined that the performance of policy options is dependent on their feasibility, while public acceptability is contingent upon the (perceived) contribution of the policy to mitigation and the social perception of fairness. Consequently, it is argued that a discussion is necessary regarding the manner in which trade-offs will be resolved at different institutional levels.

The importance of framing for the desirability of a particular action was an inherent limitation of this thesis and approach. The expectation from the interviews was that the interviewees would address aspects of the framing with which they disagreed. From the NGO side, for example, this concerned the framing of the amount of CDR taking place, and to a lesser extent, the framing of afforestation. From discussions at KIN, I gained the impression that NGOs are, in general, optimistic about forests as a CDR measure, but this was challenged during the interview. Following this, the pathway in Figure 9 was iterated to illustrate the trade-off that could occur between forest management, wood building, and NbS in general.

7.3.3 Timeframe

Three factors came into play when deciding how to frame the issue of removals over the period 2026-2100. Firstly, the DAPP approach was created to develop action pathways for longer timeframes, and has often been used for longer timeframes (Di Fant et al., 2025). Secondly, climate goals have been anchored around limiting warming by 2100. And lastly, the carbon removal roadmap considered the period up to 2050 for its estimations (KGG, 2025). The combination of these three factors led to the decision for 2100. However, the further one moves from the present the more uncertain possibilities, risks and opportunities become. In practice, this meant that beyond 2050 choices regarding methods and realistic pathways become increasingly subjective and dependent on framing. This effectively left three technological pathways, CCS-based methods, mineralisation or a new technology which has not yet become part of the main discussion. However, even with all the current options combined, there is a real possibility that they could not collectively achieve 5 Gt CO₂e by 2100. The development of the maps beyond 2050 thus became more a question of what could theoretically achieve such a potential and only then of how values might differ between these methods. Thus, the method shaped the value comparison instead of the value comparison shaping the choices for certain methods.

7.4 Scientific contributions

This study adds to the current understanding of the CDR sector by incorporating the evaluation of decisions not only by their technological potential, but also by the values driving and shaping those decisions. This work builds on the recommendations of Harvey et al. (2023), by developing value-based approaches for CDR policy development and combining them with the local context of the Netherlands.

One issue that this research has shown is that there is not one way to evaluate the potential of different CDR methods. Of course, the technical potential, theoretical potential and size constraints play a role when considering the question of reaching a certain number of removals. However, if the goal is not to reach a certain number of removals, but rather to achieve this in a responsible and sustainable manner, the challenge and value proposition changes. This is because perceptions of implementation risk differ between stakeholders. During the KIN workshop, there was a subset of participants which felt that the risks associated with relying on technological solutions, CCS, or CDR in general was a bad strategy. In the scenario in which the endeavour is to avoid the use of CDR, the perception was that the incentive to reduce emissions would be stronger. On the other hand, there were views which showed more technical optimism. The outlook was more aligned with the view that a certain level of removals must be achieved, and what is the way we could achieve this. This view aligned more with the initial framing of the DAPP approach, because of the decision to adopt a specific removal target. The most prominent view encountered during this research was one which recognised the problems of CDR, but still thought that an amount of CDR would likely be required to meet the goals of the Paris Agreement.

Another aspect that this work has shown is that the evaluation of a CDR method does not occur at the conceptual level, but at the implementation level. Every technique carries some inherent risks, and how well they are implemented is the most important factor in determining how they are ultimately evaluated.

The Dynamic Adaptive Policy Pathways (DAPP) approach's most significant contribution to this research was not the production of pathway maps themselves, as was initially predicted, but rather the structured process of developing them. The iterative process of identifying uncertainties, defining objectives, and constructing pathways provided a useful framework for discussing and analysing the key challenges within the CDR sector. This framing helped to capture many prominent issues, including technological uncertainty, market development, and regulatory complexity. However, the findings also highlight an important limitation of the approach: the outcomes are highly dependent on the initial framing of the problem and the assumptions embedded within it. In this study, the influence of these framing choices on the resulting pathways only became fully apparent after the pathway maps had been completed and evaluated with stakeholders. As a result, the value of DAPP for the CDR sector seems to be less in the final pathway maps and more in its capacity to facilitate structured analysis of the sector, reveal implicit assumptions, and support discussion among stakeholders. At the same time, this dependence on framing underscores the need for careful consideration of how goals, actions, and scope are defined at the outset, as different framings may lead to substantially different policy pathways and conclusions.

8 Conclusion

The goal of this thesis was to answer the following research question and sub-questions: **What contribution can Dynamic Adaptive Policy Pathways make to the development of carbon dioxide removal in the Netherlands?**

Sub-questions:

1. What is the current policy and regulatory context for CDR in the Netherlands?
2. What are plausible policy pathways for CDR deployment in the Netherlands?
3. How do stakeholders evaluate these pathways?

This thesis addressed the first sub-question through a policy document and literature review. Subsequently, question two was addressed by iteratively creating pathways in light of design directions and stereotypical actors. Question three was addressed by conducting semi-structured interviews. First, the sub-questions will be addressed, after which policy advice and recommendations for future research will be presented.

8.1 Answer to the research questions

8.1.1 SQ1: CDR in the Netherlands

The goal of this sub-question was to understand the context of CDR in the Netherlands. This was accomplished through a policy and literature review aimed at determining what the possibilities are for CDR in the Netherlands, where the discussion is taking place, and what goals might be appropriate.

The current regulatory context in the Netherlands, as reflected in the roadmap, focuses on financing R&D in the short term, exploring possibilities for CDR deployment, and facilitating market creation. However, the rules governing these markets are largely left to market participants and European legislation. Furthermore, the direction and mechanisms of support for scaling the CDR market beyond the R&D phase have not yet been determined and, consequently, remain absent from formal policy.

The result of this review led to the goal being defined as 5 Gt CO₂e of cumulative CDR by 2100 in the Netherlands, the identification of two scenario axes, and the available actions as framed in Table 2. With an overview of these aspects, the regulatory and policy context for the Netherlands was identified. Together, these elements provided an overview from which the process of developing pathways could begin.

8.1.2 SQ2: Development of Pathways

The objective of this sub-question was to establish stereotypical pathways for achieving the objective in various contextual scenarios. This was accomplished through the iterative creation of pathways while considering the four stereotypical actors: the nature environmentalist, the tech optimist, the economist, and the framework architect perspectives.

Subsequently, four pathway maps were developed, with the highlighted pathways in each map reflecting the perspectives of the stereotypical actors. Unless a new carbon removal technology that does not require CCS infrastructure is developed, the analysis showed that pathways that could reach the scale needed for this study in the

Netherlands would probably need to rely on some kind of CCS-based storage. This finding was primarily driven by the high land requirements associated with NbS and the limited availability of suitable minerals in the Netherlands. However, even CCS-based approaches may struggle to achieve the removal target considered in this thesis. DACCS remains at an early stage of development, while the large-scale deployment of BECCS would depend heavily on both the availability and sustainability of biomass supplies. Alongside the pathway maps showing the plausible pathways, an interview protocol was developed to structure questions and discussion topics around the identified pathways. Following the completion of the pathway maps and interview protocol, the evaluation phase could commence.

8.1.3 SQ3: Evaluation of Pathways

The goal of this sub-question was to evaluate the pathways developed using stakeholder insights. Five interviews were conducted to examine how stakeholders evaluated both the framing embedded within the pathway decisions and how the perspectives differed to other stakeholders. The quotations from these interviews were subsequently coded and grouped, allowing for comparison across various aspects of the CDR sector.

This resulted in an overview of several key themes, including the lack of a clear definition of permanence, the incorporation of CDR within the EU ETS, the need for mandates, social acceptability, debates regarding the required scale of removals, questions concerning responsibility for emissions, and the usefulness of the DAPP approach. These discussions showed that there is considerable diversity in stakeholder perspectives. However, the differences generally stemmed not from fundamental disagreements in principle, but from differing interpretations of the risks associated with practical implementation of CDR methods.

The evaluation of these pathways demonstrated that, although they were effective in highlighting several contentious aspects of the CDR sector, a different scope may be more appropriate for informing CDR policy development. The deployment of CDR does not occur in isolation but is embedded within the broader context of the energy transition and the wider challenge of reducing GHG emissions in the Netherlands. Furthermore, a purely domestic perspective overlooks the possibility some part of the required carbon removals could be achieved outside of Dutch borders, thereby disregarding some potential approaches available to policymakers.

8.1.4 Answer to the research question

Dynamic Adaptive Policy Pathways can contribute to the development of carbon dioxide removal in the Netherlands by providing a structured approach for exploring policy options under conditions of high uncertainty. The approach proved useful for facilitating interviews with stakeholders and providing a framing through which many of the issues present within the sector could be discussed. At the same time, the application of DAPP to the CDR sector revealed important limitations. The strong dependence on pathway framing, uncertainty regarding future technological development, uncertainty surrounding a quantified goal, and the heterogeneity of CDR methods reduce the usefulness of DAPP as a tool for the CDR sector. As a result, the pathway maps themselves were not the most valuable component. Rather, their primary value lay in their creation, helping to identify limitations, and making underlying assumptions and value-based decisions explicit. Therefore, the main contribution of DAPP to the

development of CDR in the Netherlands is not the identification of a single preferred pathway, but the provision of a framing through which policymakers and stakeholders can explore alternative pathway designs, evaluate trade-offs, and discuss the conditions under which different CDR methods may become desirable or feasible.

8.2 Policy advice

The policy advice which can reasonably be derived from the current iteration and evaluation of the pathways will be divided into two parts. The first part will focus on advice on short-term actions until 2050. The second part will address more uncertain, longer-term actions beyond 2050 until 2100. This distinction is made under the assumption that the goal of reaching net-zero GHG emissions before 2050 remains in place.

The short-term actions recommended mainly relate to how and under what circumstances the removals are allowed to be used in compensation versus as a stand-alone removal. The trade-off here is that the sector needs to be developed to such a scale that it can remove a significant amount of emissions while not undermining emissions reduction efforts. The utilisation of temporary CDR as a way of compensation for, for example, short-term GHG emissions, should only occur when a definition is made on what level of residual emissions is considered acceptable. The time between the decision to allow removals as compensation and the scaling-up of removals can be significant in the Netherlands. It is therefore important to define residuals as quickly as possible, as this definition of residual emissions would allow the aiming for removal targets while keeping the main goal of emission reduction in place. There is a risk of setting the target too high or too low, as setting it too high would allow the removals to compete with mitigation while setting it too low would not create enough incentive to scale up to the required amount.

In the short term, additional efforts are also required to improve the financing of removals. Removals are currently overly dependent on a limited number of buyers. If the goal is to help the sector grow and mature, some form of financial support will likely be required. This can be achieved through government financing for the removal of its own residual emissions, subsidies through the SDE++, or alternative mechanisms such as carbon contracts for difference. In the short term, the specific form of financial support is less important than the availability of financial support itself. Additionally, the regulatory environment for pilot projects was identified as a constraining factor in the development of certain technologies, particularly DOCCS. However, no recommendation is made regarding the improvement of this regulatory environment, as this thesis neither focused on this issue nor identified a clear means of addressing it.

Developing policy recommendations for the longer term involves considerably greater uncertainty. Consequently, the recommendations presented here are less specific. Policymakers should recognise that greater use of existing storage capacity for fossil-based emissions will reduce the storage capacity available in the future. This could significantly limit the potential of several CDR methods unless alternative storage locations become available or CDR is required only at a limited scale. In the Netherlands, technological pathways will almost certainly be necessary if substantial levels of CDR are required beyond 2050. These pathways require investments in R&D today and also

require reflection on how companies can be supported within the framework of the precautionary principle.

8.3 Future research

The current iteration of pathway maps still leaves room for improvement. It is insufficient in terms of specificity of the various methods because the scope of the overview necessitates some level of simplification in order to compare the various methods without making the maps unreadable. However, this means that some nuance inherent in the method is lost. Meanwhile, rather than broad terms such as DACCS or BECCS, the argument for the method's choice and desirability frequently boils down to its specific implementation.

Future research might thus benefit from pursuing one of two directions, either adopting a broader perspective on CDR in relation to other available policy actions. For example, a focus on the integration of CDR with emission reduction measures, or different land use practices. The goal would then be to place CDR within a broader societal context rather than treating it as a separate niche of CDR-specific methods as was done for this thesis. The other direction would be to focus on individual methods or specific subsets of methods. For example, focusing exclusively on DACCS, would provide a more nuanced understanding of challenges laid out and would allow greater differentiation between technologies being developed under the umbrella term of DACCS. This could also improve alignment with the DAPP approach by accounting for method heterogeneity, or alternatively facilitate the definition of broader, more clearly specified goals.

References

- Babin, A., Vaneeckhaute, C., & Iliuta, M. C. (2021). Potential and challenges of bioenergy with carbon capture and storage as a carbon-negative energy source: A review. *Biomass and Bioenergy*, 146, 105968. <https://doi.org/10.1016/j.biombioe.2021.105968>
- Bednar, J., Obersteiner, M., Baklanov, A., Thomson, M., Wagner, F., Geden, O., Allen, M., & Hall, J. W. (2021). Operationalizing the net-negative carbon economy. *Nature*, 596(7872), 377–383. <https://doi.org/10.1038/s41586-021-03723-9>
- Blanchard, O., Gollier, C., & Tirole, J. (2023). The portfolio of economic policies needed to fight climate change. *Annual Review of Economics*, 15, 689–722. <https://doi.org/10.1146/annurev-economics-051520-015113>
- Brad, A., & Schneider, E. (2023). Carbon dioxide removal and mitigation deterrence in EU climate policy: Towards a research approach. *Environmental Science & Policy*, 150, 103591. <https://doi.org/10.1016/j.envsci.2023.103591>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Campbell, J. S., Foteinis, S., Furey, V., Hawrot, O., Pike, D., Aeschlimann, S., Maesano, C. N., Reginato, P. L., Goodwin, D. R., Looger, L. L., Boyden, E. S., & Renforth, P. (2022). Geochemical negative emissions technologies: Part i. review. *Frontiers in Climate*, 4. <https://doi.org/10.3389/fclim.2022.879133>
- Carbon Gap. (2025). *Carbon removal in the netherlands – national policy overview* [Carbon gap - policy tracker]. Retrieved February 24, 2026, from <https://tracker.carbongap.org/regional-analysis/national/netherlands/>
- Carbon Gap. (2026a). *The different types of carbon removal technologies*. Retrieved June 8, 2026, from <https://carbongap.org/infographics/>
- Carbon Gap. (2026b, January 27). *Carbon removals and carbon farming regulation (crcf)*. Retrieved June 8, 2026, from <https://tracker.carbongap.org/policy/crcf/>
- Chiaramonti, D., Lotti, G., Vaccari, F. P., & Sanei, H. (2024). Assessment of long-lived Carbon permanence in agricultural soil: Unearthing 15 years-old biochar from long-term field experiment in vineyard. *Biomass and Bioenergy*, 191, 107484. <https://doi.org/10.1016/j.biombioe.2024.107484>
- Climate Action Tracker. (2024, October 21). *Net zero targets: Eu*. Retrieved April 8, 2026, from <https://climateactiontracker.org/countries/eu/net-zero-targets/>
- Cradock-Henry, N. A., Frame, B., Preston, B. L., Reisinger, A., & Rothman, D. S. (2018). Dynamic adaptive pathways in downscaled climate change scenarios. *Climatic Change*, 150(3), 333–341. <https://doi.org/10.1007/s10584-018-2270-7>
- Damen, K., Faaij, A., & Turkenburg, W. (2009). Pathways towards large-scale implementation of co2 capture and storage: A case study for the netherlands. *International Journal of Greenhouse Gas Control*, 3(2), 217–236. <https://doi.org/10.1016/j.ijggc.2008.09.005>
- de Perthuis, C., & Trotignon, R. (2014). Governance of co2 markets: Lessons from the eu ets. *Energy Policy*, 75, 100–106. <https://doi.org/10.1016/j.enpol.2014.05.033>
- Di Fant, V., Middelkoop, H., Dunn, F. E., & Haasnoot, M. (2025). Supporting adaptive pathways planning using archetypes for climate adaptation. *Regional Environmental Change*, 25(1), 31. <https://doi.org/10.1007/s10113-024-02349-7>
- Di Maria, A., Snellings, R., Alaerts, L., Quaghebeur, M., & Van Acker, K. (2020). Environmental assessment of CO2 mineralisation for sustainable construction

- materials. *International Journal of Greenhouse Gas Control*, 93, 102882. <https://doi.org/10.1016/j.ijggc.2019.102882>
- Directorate-General for Climate Action. (2025). *Carbon removals and carbon farming - climate action - european commission*. Retrieved February 10, 2026, from https://climate.ec.europa.eu/eu-action/carbon-removals-and-carbon-farming_en
- Directorate-General for Climate Action (European Commission) & Ramboll Management Consulting. (2025). *Carbon removals in the EU: Review of current carbon removal projects and early stage financing*. Publications Office of the European Union. Retrieved February 10, 2026, from <https://data.europa.eu/doi/10.2834/0004994>
- Dooley, N., de Respinis, M., de Klerk, I., Wurpel, G., & Koornneef, J. (2025). *Empowering & decarbonizing the netherlands: A national north sea energy compass* (Report). Netherlands Organisation for Applied Scientific Research (TNO). Retrieved May 1, 2026, from <https://publications.tno.nl/publication/34644374/PrBK7Gtx/koornneef-2025-empowering.pdf>
- EBN & Gasunie. (2022). *Studie transport en opslag van CO2 in Nederland* (Report). Energie Beheer Nederland (EBN) and Gasunie. Retrieved May 1, 2026, from <https://www.ebn.nl/wp-content/uploads/2022/10/Studie-Transport-en-opslag-van-CO2-in-Nederland-EBN-en-Gasunie-1.pdf>
- Erbach, G., & Dewulf, N. (2024, December). *The netherlands' climate action strategy* (EPRS Briefing No. PE 767.176). European Parliamentary Research Service. Retrieved February 16, 2026, from [https://www.europarl.europa.eu/RegData/etudes/BRIE/2024/767176/EPRS_BRI\(2024\)767176_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2024/767176/EPRS_BRI(2024)767176_EN.pdf)
- European Commission. (2025a). *2050 long-term strategy*. European Commission. Retrieved January 28, 2026, from https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en
- European Commission. (2025b). *Eu's 2030 carbon storage target*. European Commission. Retrieved January 28, 2026, from https://climate.ec.europa.eu/eu-action/industrial-carbon-management/eus-2030-carbon-storage-target_en
- European Environment Agency. (2025). *Netherlands use of ets auctioning revenues*. Retrieved June 7, 2026, from <https://reportnet.europa.eu/public/dataflow/1527>
- Regulation (EU) 2024/3012 of the European Parliament and of the Council of 27 November 2024 establishing a Union certification framework for permanent carbon removals, carbon farming and carbon storage in products (2024, November 27). Retrieved February 5, 2026, from <http://data.europa.eu/eli/reg/2024/3012/oj>
- Franks, M., Gruner, F., Kalkuhl, M., Lessmann, K., & Edenhofer, O. (2026). Pigou's Advice and Sisyphus' Warning: Carbon Pricing with Non-Permanent Carbon Dioxide Removal. *Environmental and Resource Economics*, 89(2), 11. <https://doi.org/10.1007/s10640-025-01060-3>
- Gerres, T., & Linares, P. (2022, June). *Carbon contracts for differences (ccfds) in a european context*. Office of Henrike Hahn, Member of the European Parliament. Retrieved June 24, 2026, from https://henrike-hahn.eu/files/upload/aktuelles/dateien/Study_CCfD_Henrike-Hahn_6.2022.pdf
- Gidden, M. J., Brutschin, E., Ganti, G., Unlu, G., Zakeri, B., Fricko, O., Mitterrutzner, B., Lovat, F., & Riahi, K. (2023). Fairness and feasibility in deep mitigation pathways with novel carbon dioxide removal considering institutional capacity to mitigate. *Environmental Research Letters*, 18(7), 074006. <https://doi.org/10.1088/1748-9326/acd8d5>

- Günther, P., Garske, B., Heyl, K., & Ekardt, F. (2024). Carbon farming, overestimated negative emissions and the limits to emissions trading in land-use governance: The EU carbon removal certification proposal. *Environmental Sciences Europe*, 36(1), 72. <https://doi.org/10.1186/s12302-024-00892-y>
- Haasnoot, M., Kwakkel, J. H., Walker, W. E., & ter Maat, J. (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. *Global Environmental Change*, 23(2), 485–498. <https://doi.org/10.1016/j.gloenvcha.2012.12.006>
- Harvey, V., Workman, M., & Heap, R. (2023). Developing carbon dioxide removal policy and anticipatory perspectives in the United Kingdom and United States. *Energy Research & Social Science*, 102, 103185. <https://doi.org/10.1016/j.erss.2023.103185>
- Honegger, M., Baatz, C., Eberenz, S., Holland-Cunz, A., Michaelowa, A., Pokorný, B., Poralla, M., & Winkler, M. (2022). The ABC of Governance Principles for Carbon Dioxide Removal Policy. *Frontiers in Climate*, 4. <https://doi.org/10.3389/fclim.2022.884163>
- Huan, Q., Wibowo, H., Yan, M., & Song, M. (2024). A review of CO₂ mineral storage: Current processes, typical applications, and life cycle assessment. *Journal of Environmental Chemical Engineering*, 12(6), 114785. <https://doi.org/10.1016/j.jece.2024.114785>
- Kallio, A. M. I., & Garvik, E. (2026). Eu policy on forest carbon sinks revisited. *Environmental Science & Policy*, 177, 104332. <https://doi.org/10.1016/j.envsci.2026.104332>
- Kampman, B., Kruit, K., Van den Toorn, E., De Vries, M., Van Grinsven, A., Voulis, N., Groenewegen, H., Van der Veen, R., Rycroft, L., & Neele, F. (2023, June). *Koolstofverwijdering voor klimaatbeleid: Analyse van behoefte, aanbod en beleid voor negatieve emissies in nederland*. CE Delft. Retrieved June 29, 2026, from https://ce.nl/wp-content/uploads/2023/07/CE_Delft_220460_Koolstofverwijdering_voor_klimaatbeleid_DEF-gecorrigeerd.pdf
- KG. (2025, March). *Netherlands carbon dioxide removal roadmap* (Report). Government of the Netherlands, Ministry of Climate Policy and Green Growth. Retrieved January 28, 2026, from <https://www.government.nl/binaries/government/documenten/reports/2025/03/14/netherlands-carbon-dioxide-removal-roadmap/2025-Netherlands+Roadmap+on+carbon+dioxide+removals.pdf>
- KIN. (n.d.). *Workshop on responsible carbon removal*. Retrieved June 11, 2026, from <https://hetkin.nl/en/workshop-on-responsible-carbon-removal/>
- Lamb, W. F., Low, S., Gordon, L.-M., & Mattila, M. (2025). How are oil and gas firms integrating carbon dioxide removal into their climate strategies? *Energy Research & Social Science*, 127, 104237. <https://doi.org/10.1016/j.erss.2025.104237>
- Lamb, W. F., Schleussner, C.-F., Grassi, G., Smith, S. M., Gidden, M. J., Geden, O., Runge-Metzger, A., Vaughan, N. E., Nemet, G., Johnstone, I., Schulte, I., & Minx, J. C. (2024). Countries need to provide clarity on the role of carbon dioxide removal in their climate pledges. *Environmental Research Letters*, 19(12), 121001. <https://doi.org/10.1088/1748-9326/ad91c7>
- Lawrence, J., Haasnoot, M., McKim, L., Atapattu, D., Campbell, G., & Stroombergen, A. (2019). Dynamic adaptive policy pathways (DAPP): From theory to practice. In V. A. W. J. Marchau, W. E. Walker, P. J. T. M. Bloemen, & S. W.

- Popper (Eds.), *Decision making under deep uncertainty: From theory to practice* (pp. 187–199). Springer International Publishing. https://doi.org/10.1007/978-3-030-05252-2_9
- Ma, J., Zhou, Y., He, L., Liu, X., & Wang, H. (2026). A systematic review of carbon sink pathways and deployment strategies. *Earth-Science Reviews*, 278, 105517. <https://doi.org/10.1016/j.earscirev.2026.105517>
- McDonald, H., Siemons, A., Fallasch, F., Gardiner, J., Scheid, A., Scheffler, M., & Wiegmann, K. (2025). *Temporary carbon units from carbon farming and eu agri-food climate policy: Assessment of risks, opportunities, and alternatives for promoting carbon farming* (Report). Ecologic Institute and Oeko-Institut. Retrieved May 29, 2026, from <https://www.ecologic.eu/sites/default/files/publication/2025/Temporary-carbon-units-from-carbon-farming-and-EU-agri-food-climate-policy-50216.pdf>
- Meckling, J., & Biber, E. (2021). A policy roadmap for negative emissions using direct air capture. *Nature Communications*, 12(1). <https://doi.org/10.1038/s41467-021-22347-1>
- Nascimento, L., Kuramochi, T., Iacobuta, G., den Elzen, M., Fekete, H., Weishaupt, M., van Soest, H. L., Roelfsema, M., Vivero-Serrano, G. D., Lui, S., Hans, F., Jose de Villafranca Casas, M., & Höhne, N. (2021). Twenty years of climate policy: G20 coverage and gaps. *Climate Policy*, 22(2), 158–174. <https://doi.org/10.1080/14693062.2021.1993776>
- NEGEM Consortium. (2024, July). NEGEM final booklet [Horizon 2020 Grant Agreement no. 869192]. <https://www.negemproject.eu/wp-content/uploads/2024/07/NEGEM-Final-Booklet.pdf>
- Paebbl. (2026). *Technology*. Paebbl. Retrieved June 6, 2026, from <https://paebbl.com/technology>
- Ritchie, H., & Roser, M. (2020). CO2 emissions. *Our World in Data*. Retrieved January 28, 2026, from <https://ourworldindata.org/co2-emissions>
- Rosa, L., Becattini, V., Gabrielli, P., Andreotti, A., & Mazzotti, M. (2022). Carbon dioxide mineralization in recycled concrete aggregates can contribute immediately to carbon-neutrality. *Resources, Conservation and Recycling*, 184, 106436. <https://doi.org/10.1016/j.resconrec.2022.106436>
- Schenuit, F., Brutschin, E., Geden, O., Guo, F., Mohan, A., Oliveira Fiorini, A. C., Saluja, S., Schaeffer, R., & Riahi, K. (2025). Taking stock of carbon dioxide removal policy in emerging economies: Developments in Brazil, China, and India. *Climate Policy*, 25(1), 89–108. <https://doi.org/10.1080/14693062.2024.2353148>
- Schreyer, F., Luderer, G., Rodrigues, R., Pietzcker, R. C., Baumstark, L., Sugiyama, M., Brecha, R. J., & Ueckerdt, F. (2020). Common but differentiated leadership: Strategies and challenges for carbon neutrality by 2050 across industrialized economies. *Environmental Research Letters*, 15(11), 114016. <https://doi.org/10.1088/1748-9326/abb852>
- Smith, S. M., Grassi, G., Gupta, S., Schwingshackl, C., Harrington, K. J., Pilli, R., & Rink, A. (2026). Chapter 7: Current levels of cdr. In *The state of carbon dioxide removal: 3rd edition 2026*. <https://doi.org/10.17605/OSF.IO/VH7U6>
- Sovacool, B. K., Baum, C. M., Fritz, L., & Low, S. (2025). Exploring global climate intervention experiments: Sociotechnical promises, innovation dynamics, and perceived co-impacts across 20 projects and pilots. *Sustainability Science*, 20(6), 2195–2216. <https://doi.org/10.1007/s11625-025-01696-6>

- Sunny, N., Chiquier, S., Patrizio, P., & Mac Dowell, N. (2021, October). *Identify member state targets for CDR* (Deliverable No. D4.3) (Version 3.0; Horizon 2020 Grant Agreement no. 869192). NEGEM Consortium. <https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5e95f4c99&appId=PPGMS>
- Taillardat, P., Thompson, B. S., Garneau, M., Trottier, K., & Friess, D. A. (2020). Climate change mitigation potential of wetlands and the cost-effectiveness of their restoration. *Interface Focus*, 10(5). <https://doi.org/10.1098/rsfs.2019.0129>
- Tanzer, S. E., Alvarado Cummings, S. C., Valenti, O. M., Junginger, M., & Duden, A. S. (2025). So you want to build a BECCS plant: The patchwork policy context for bioelectricity with carbon capture and storage in Europe. *Environmental Research Communications*, 7(5), 051008. <https://doi.org/10.1088/2515-7620/add3d5>
- Tanzer, S. E., & Ramírez, A. (2019). When are negative emissions negative emissions? *Energy & Environmental Science*, 12(4), 1210–1218. <https://doi.org/10.1039/c8ee03338b>
- van Oort, F., & Hospers, G.-J. (2024, September 25). *Ruimtelijke economische verkenning 2024*. Ministerie van Economische Zaken. Den Haag. Retrieved July 7, 2026, from https://www.tweedekamer.nl/kamerstukken/brieven_regering/detail?id=2024Z14318&did=2024D35077
- Viloria, E., & Mäkelä, A. (2025, May 7). *The case for carbon removal in the eu industrial decarbonisation bank: Pragmatic, possible and pivotal*. Carbon Gap. Retrieved June 24, 2026, from <https://carbongap.org/insights/the-case-for-carbon-removal-in-the-eu-decarbonisation-bank>
- Vistarte, L., Kubule, A., Rozentale, L., & Pubule, J. (2024). Carbon farming: A systematic literature review on sustainable practices. *Environmental and Climate Technologies*, 28(1). <https://doi.org/10.2478/rtuct-2024-0068>
- WKR. (2024, July). *Clearing the air* (Report). Netherlands Scientific Climate Council. Retrieved February 18, 2026, from <https://english.wkr.nl/site/binaries/site-content/collections/documents/2024/07/18/wkr-report-002-clearing-the-air/Translated+Report+-+Clearing+the+air+-+updated+colophon.pdf>
- Xodus Group. (2023). *Ccus white paper* (White paper). Xodus Group. Retrieved May 1, 2026, from <https://www.xodusgroup.com/media/gsepgyhl/xodus-ccus-whitepaper.pdf>

AI-statement

The BibTeX for source implementation in LaTeX have been made utilising Zotero. However, in case of doubt about accuracy, ChatGPT was provided with a link or citation and the task of ensuring that the source was APA 7 compliant. I have reviewed the resulting BibTeX and citation for accuracy. An overview of how ChatGPT was used in the general preparation of this proposal is shown in Table 5. This table might not be entirely accurate (percentages) but gives a good overview of how AI was used within this thesis.

Table 7, 8, 9 and 11 were created with the use of Copilot utilising the university account, the input consisted of Dutch quotes, and their attribution, the AI translated the quotes and added an explanation of attribution which were both manually edited to ensure no errors were present. Table 10, was generated using Copilot, but the translations and filling in were performed manually due to Copilot hallucinating. It was ensured that no personally or organisationally identifiable data was included in the statements sent to Copilot; the combination of university account, lack of identification, and the fact that these quotes would be made public made me feel comfortable using Gen-AI to accelerate the process. Table 3, was also created with the use of Copilot, the categories and methods were given as input and subsequently changed with the help of sources after a table was generated.

A spelling and grammar review was conducted using Microsoft Copilot to identify sections of text requiring revision. The LanguageTool AI paraphrasing tool was subsequently employed to enhance the overall readability and refine sentence structure. All suggestions from Copilot and LanguageTool were reviewed and edited before being implemented.

Table 5: Overview of AI-assisted tasks utilising ChatGPT during thesis preparation (>93 prompts) created using ChatGPT.

Category of Use	Description of Assistance
Citation and Reference Formatting (38%)	Generation and verification of APA 7 references and BibTeX entries. Assistance included converting source information into correct APA 7th edition formatting and preparing references compatible with <code>biblatex-apa</code> .
LaTeX Formatting and Troubleshooting (29%)	Support with LaTeX and Overleaf formatting. Assistance included resolving formatting issues such as incorrect appendix references, table alignment, and document structure.
Writing and Language Clarification (6%)	Minor assistance with academic writing, terminology clarification.
Conceptual Clarification and Literature Support (13%)	High-level explanations and contextual support related to carbon dioxide removal pathways and climate policy and identifying market parties.
Programming and Technical Assistance (8%)	Support with Python-based audio transcription workflows using Whisper, FFmpeg installation and troubleshooting.(Not used in the end)
Miscellaneous / Organisation (6%)	Assistance with organising thesis-related information, extracting prompts from ChatGPT conversations, preparing an overview of AI usage.

Appendix A: Interview protocol

The interview protocol was used a guide rail for the interviews. However, because the intention was to find out what different stakeholders find important, it was not used strictly but more of a way to steer the conversation towards what could potentially be interesting for this research.

Interview Protocol

The EU is currently not on track to hit its climate emission reduction goals. And even rapid emissions reduction cannot help in achieving net-zero greenhouse gas emissions, carbon dioxide removal (CDR) will be required to remove hard-to-abate residual emissions and capture historical emissions. However, the development of CDR is in its infancies both on a technological readiness level and a policymaking perspective. This causes a lot of uncertainty to be in place on how to effectively use CDR policies. There are a variety of CDR-technologies available and there is no single golden bullet, the implementation of technology and policies should thus be done in the local or regional context. To further explore the requirements for the Netherlands, the following research question was developed: **What could policy pathways for carbon dioxide removal look like in the Netherlands while achieving the goals of the Paris climate agreement (i.e. 1.5-2 °C for 2100 IPCC AR6)?**

The Goal of this interview is to evaluate example pathways keeping in mind stereotypical examples with the goal of finding out?

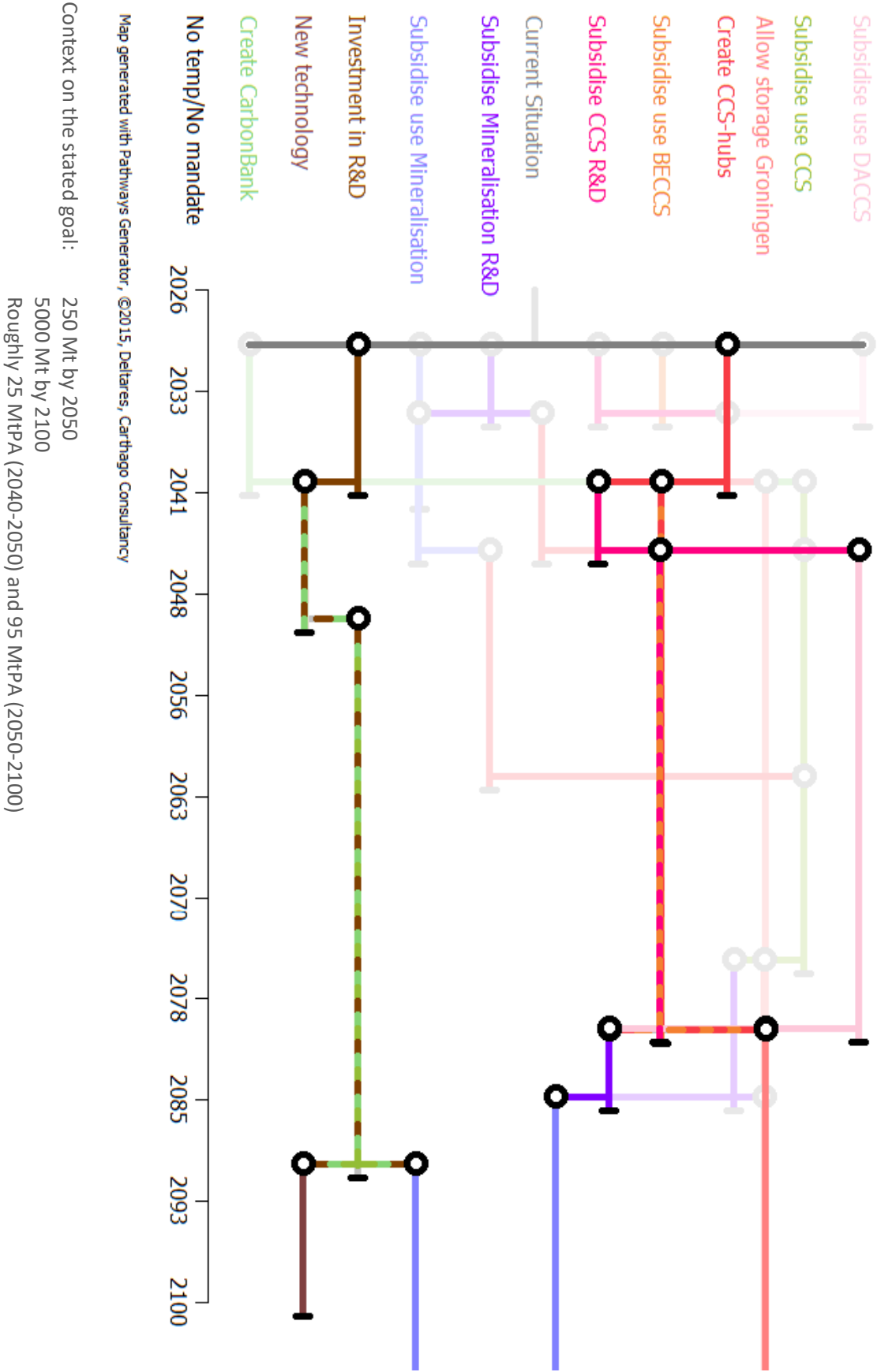
- Conditions under which policies fail.
- Dependence on previous actions
- Various value perspectives on trade-offs

First some general questions about how you view CDR.

After this we will look at maps for the 4 specific **scenarios**

QUESTION	SITUATION	FOLLOW-UPS	RESULT
WHAT IS YOUR EXPERIENCE WITH CDR?	Describe the situation, context, and background	What type of organisation? What is your/organisations view on CDR?	The view expressed
HOW DO YOU LOOK AT THE USE OF TEMPORARY SOLUTIONS?	NBS or temporary solutions can help achieve short-term results more favourably	Do you think they should be allowed to count as CDR?	
DO YOU THINK WE NEED A SEPARATE MANDATED GOAL? WHY/WHY NOT?	Currently, there exists a voluntary market, there were some plans for separate CDR goals	What are conditions which such a goal should reach? Do you think it would be helpful?	

Pathway map 1: No temporary removals, No mandated removals



QUESTION	SITUATION	FOLLOW-UPS	RESULT
HOW DO WE CREATE AN INCENTIVE TO INVEST?	Describe the situation, context, and background Currently, there only exists an incentive to invest to reduce/substitute emissions and for marketing.	Should we pay fossil companies for removals? View on incorporation ETS, risks? Public funding for CDR?	The view expressed
SHOULD WE SUBSIDIZE DEPLOYMENT?	Currently, only emissions reduction and R&D get subsidized.	Should we subsidize the infrastructure? When does the shift need to be from subsidizing research to subsidizing deployment?	
IS THERE A POLICY ON THIS PATHWAY MAP WHICH YOU FEEL WOULD FAIL?		What is the condition under which it fails?	

Pathway map 2: Temporary removals, No mandated removals

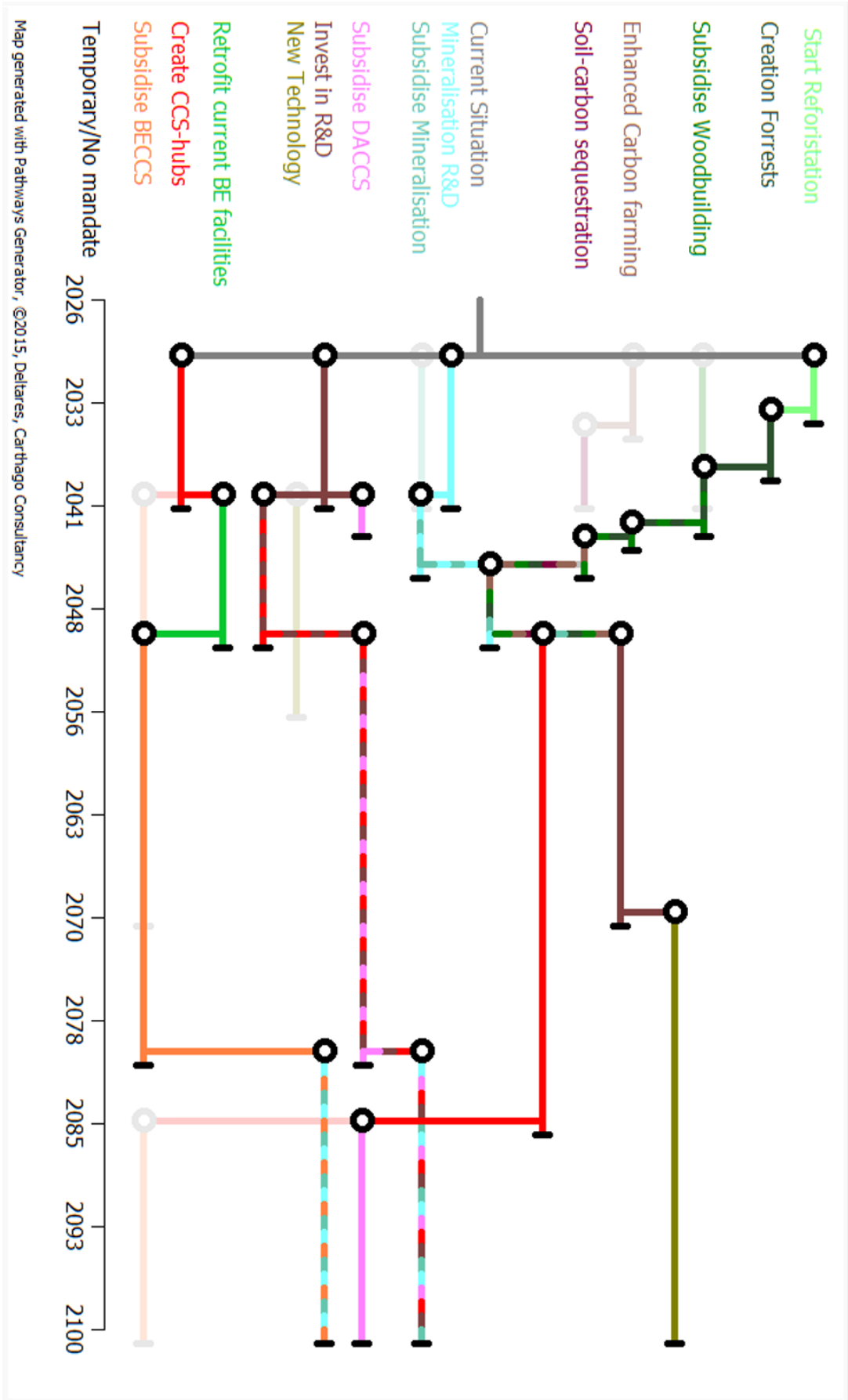
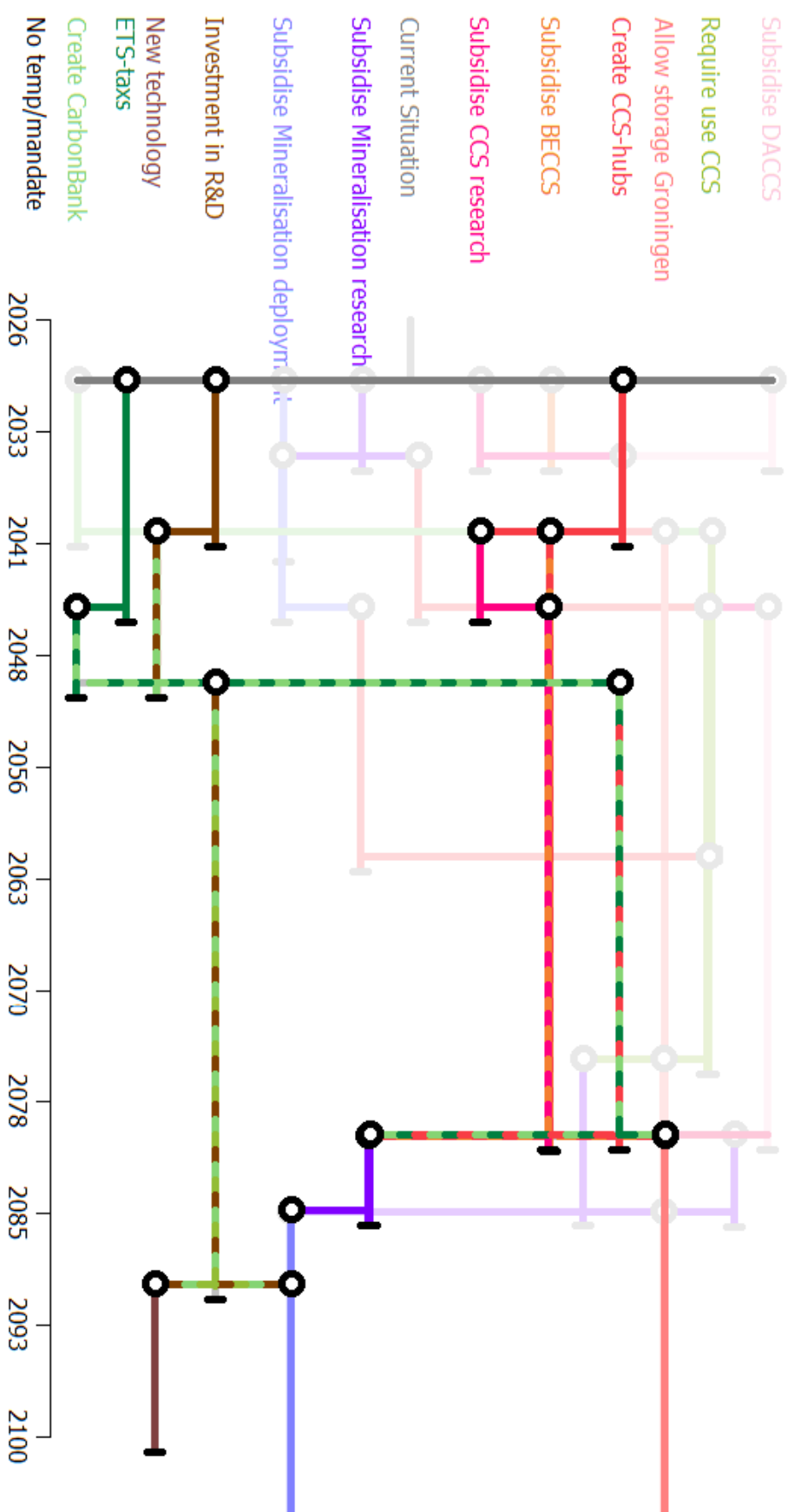


Table pathway 2:

QUESTION	SITUATION	FOLLOW-UPS	RESULT
	Describe the situation, context, and background		The view expressed
IS THERE A CORRECT TIME TO START UTILISING CCS?	In this map I decided to show CCS-hubs after 2050, with the idea of needing to reach net-zero by 2050.	Do you think we can use CCS without the moral hazard of continuation of fossil fuels? Under which conditions?	
WHAT DO YOU THINK OF THE POTENTIAL FOR BECCS?	The use of BECCS can be controversial due to competition for biomass	How do we ensure that BECCS deployment happens responsible?	
DO YOU FEEL NATURE BASED SOLUTIONS AS MORE VIABLE OPTIONS SHORT TERM?	NBS are often seen as more favourable due to co-benefits and perception, regardless of the wider context.	How should we use NBS? (For example, separate goals, do you have another idea?)	
IS THERE A POLICY ON THIS PATHWAY MAP WHICH YOU FEEL WOULD FAIL?		Is there for example an option which is more dependent on another choice?	

Pathway 3: No temporary removals, with a mandate

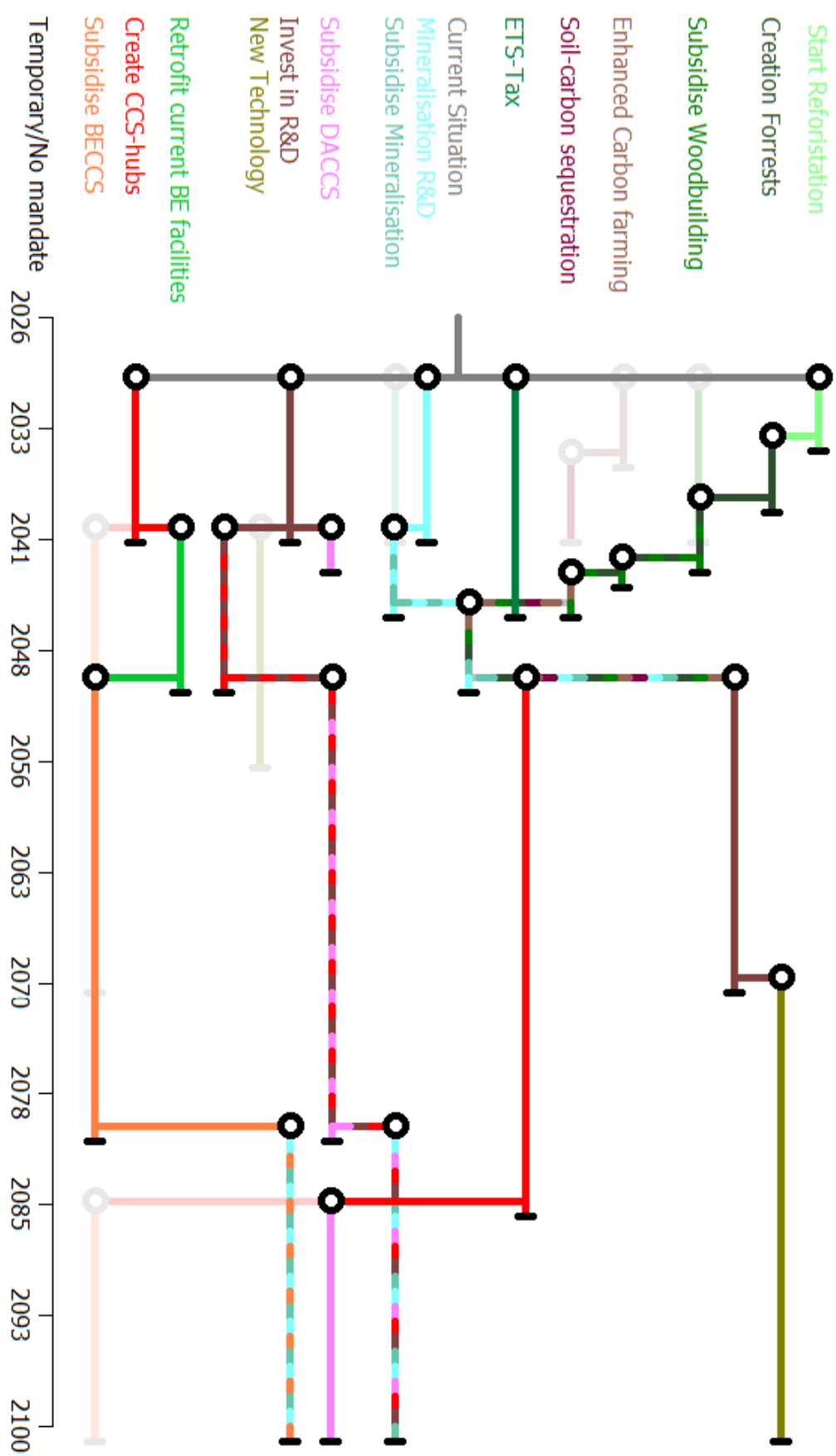


Map generated with Pathways Generator, ©2015, Deltares, Carthago Consultancy

Table P3:

QUESTION	SITUATION	FOLLOW-UPS	RESULT
	Describe the situation, context, and background		The view expressed
IF A MANDATE GETS INTRODUCED, WHAT DO YOU THINK WOULD CHANGE?	Different investment decision		
AT WHAT LEVEL DO YOU THINK A MANDATE MAKES SENSE?	Can mandate at point of extraction, or at use (ETS/ carbon tax)		
SHOULD WE MANDATE THE DEPLOYMENT?	For example, require the use of ccs with BE.	Should we subsidize the infrastructure?	
IS THERE A POLICY ON THIS PATHWAY MAP WHICH YOU FEEL WOULD FAIL?		What is the condition under which it fails?	

Pathway map 4: Temporary with mandate



Map generated with Pathways Generator, ©2015, Deltares, Carthago Consultancy

Table map 4: Temporary and mandate

QUESTION	SITUATION	FOLLOW-UPS	RESULT
	Describe the situation, context, and background		The view expressed
IF A MANDATE GETS INTRODUCED, WHAT DO YOU THINK WOULD CHANGE WHEN TEMPORARY REMOVALS ARE ALLOWED?	Different investment decision		
SHOULD WE MANDATE THE DEPLOYMENT?	For example, require the use of CCS with BE.	Should we subsidize the infrastructure?	
IS THERE A POLICY ON THIS PATHWAY MAP WHICH YOU FEEL WOULD FAIL?		What is the condition under which it fails?	

Final questions/ Remarks/ questions.

QUESTION	SITUATION	FOLLOW-UPS	RESULT
	Describe the situation, context, and background		The view expressed
DO YOU FEEL LIKE I MISSED A METHOD WHICH SHOULD HAVE BEEN INCLUDED?	Like OCCDR approaches, blue carbon, ocean alkalinity enhancement etc. Or another financing method	Why should this method/policy be included?	
VALUE TRADE OFFS FRAMING		Scalability vs Sustainability Moral hazard versus the risk of in-action.	
(FOR WITH KIN)		Was there a trade of that you saw occurring terms of values?	
ANY OTHER QUESTIONS/REMARKS			

Appendix B: Informed consent and HREC

Delft University of Technology
HUMAN RESEARCH ETHICS
INFORMED CONSENT FORM
MSc Complex Systems Engineering and Management
(English Version: May 2026)

You are being invited to participate in a research study titled **What will carbon dioxide removal look like in the Netherlands?** This study is being done by Nathan Jager from the TU Delft supervised by Samantha Tanzer, BinBin Pearce and Jan Kwakkel.

The purpose of this research study is to create policy pathways (series of actions) for the development of carbon dioxide removal in the Netherlands. The interview will take approximately 30-45 minutes to complete. The data will be used for the development of a master's thesis. We will be asking you to evaluate the scenarios, goals and actions available to policymakers; and subsequently help co-develop the pathways based on your professional expertise and values.

To the best of our ability your answers in this study will remain confidential. We will minimize any risks by only stating the type of organisation which you are associated with.

Your participation in this study is entirely voluntary, **and you can withdraw at any time**. You are free to omit any questions. The answers given will be recorded, transcribed and reported back to you with the possibility of clarification or removal.

Corresponding researcher: Nathan Jager
Responsible researcher: Samantha Tanzer

Explicit Consent points PLEASE TICK THE APPROPRIATE BOXES	Yes
1. I have read and understood the study information above, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions, and I can withdraw from the study at any time, without having to give a reason.	☐
3. I understand that taking part in the study involves: • Having my answers recorded (deleted after transcription and response is completed). • Having my answers transcribed.	☐
4. The transcript will be sent to you for rebuttal. We'll create an anonymous summary, which can be included in the final MSc thesis which will be public.	☐
5. I understand that personal information collected about me that can identify me, such as contact information will be stored on the TU delft OneDrive only accessible to the project team mentioned above.	☐
6. I understand that the (identifiable) personal data I provide will be destroyed after the completion of the thesis (expected august 2026).	☐
7. I agree that my responses, views or other input can be quoted anonymously in research outputs	☐

Signatures

Name of participant [printed]

Signature

Date

Delft University of Technology
HUMAN RESEARCH ETHICS
CHECKLIST FOR HUMAN RESEARCH

Applicant Information

PROJECT TITLE:	What will CDR look like in the Netherlands?
Research period:	Calendar week 16-23
Faculty:	Technology, Policy and Management
Department:	-
Type of the research project:	Master's thesis
Funder of research:	Internal
Name of Corresponding Researcher:	Nathan Jager
E-mail Corresponding Researcher:	[redacted]
Position of Corresponding Researcher:	Master's student
Name of Responsible Researcher:	Samantha Tanzer
E-mail of Responsible Researcher:	[redacted]
Position of Responsible Researcher:	Assistant Professor

I. Research Overview

a) Please summarise your research very briefly (100-200 words)

What are you looking into, who is involved, how many participants there will be, how they will be recruited and what are they expected to do?

<i>Add your text here – (please avoid jargon and abbreviations)</i>
I'm going to be looking into carbon dioxide removal policies and trying to use values to try to find policy adoption pathways over a period of now till 2100. The goal is to get at least 3 participants, someone from the policy sector, the industrial sector and from a climate activism NGO. The industrial sector and policy sector will be contacted through my first supervisor, as she has potential contacts. For the climate NGO, I will contact the person through my own network and

try to get an interview this way. The goal is that they evaluate the scenarios, policy actions and goals I've identified, and subsequently try to co-develop pathways (series of actions) based on their values and views of the role/developing carbon dioxide removal sector.

III. Risk Assessment and Mitigation Plan

Please complete the following table in full for all points to which your answer is “yes”. Bear in mind that the vast majority of projects involving human participants as Research Subjects also involve the collection of **Personally Identifiable Information (PII)** and/or **Personally Identifiable Research Data (PIRD)** which may pose potential risks to participants as detailed in Section G: Data Processing and Privacy below.

To ensure alignment between your risk assessment, data management and what you agree with your Research Subjects you can use the last two columns in the table below to refer to specific points in your Data Management Plan (DMP) and Informed Consent Form (ICF) – **but this is not compulsory**.

It's worth noting that **you're much more likely to need to resubmit your application if you neglect to identify potential risks**, than if you identify a potential risk and demonstrate how you will mitigate it. If necessary, the HREC will always work with you and colleagues in the Privacy Team and Data Management Services to see how, if at all possible, your research can be conducted.

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		Please provide the relevant reference #	
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? <i>Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!</i>	MITIGATION PLAN – what mitigating steps will you take? <i>Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.</i>	DMP	ICF
A: Partners and collaboration						
1. Will the research be carried out in collaboration with additional organisational partners such as: - One or more collaborating research and/or commercial organisations - Either a research, or a work experience internship provider¹ ¹ If yes, please include the graduation agreement in this application		X				
2. Is this research dependent on a Data Transfer or Processing Agreement with a collaborating partner or third party supplier? <i>If yes please provide a copy of the signed DTA/DPA</i>		X				
3. Has this research been approved by another (external) research ethics committee (e.g.: HREC and/or MREC/METC)?		X				

			<i>If YES please complete the Risk Assessment and Mitigation Plan columns below.</i>		<i>Please provide the relevant reference #</i>	
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? <i>Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!</i>	MITIGATION PLAN – what mitigating steps will you take? <i>Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.</i>	DMP	ICF
<i>If yes, please provide a copy of the approval (if possible) and summarise any key points in your Risk Management section below</i>						
B: Location						
4. Will the research take place in a country or countries, other than the Netherlands, within the EU?		X				
5. Will the research take place in a country or countries outside the EU?		X				
6. Will the research take place in a place/region or of higher risk – including known dangerous locations (in any country) or locations with non-democratic regimes?		X				
C: Participants						
7. Will the study involve participants who may be vulnerable and possibly (legally) unable to give informed consent? (e.g., children below the legal age for giving consent, people with learning difficulties, people living in care or nursing homes,).		X				
8. Will the study involve participants who may be vulnerable under specific circumstances and in specific contexts, such as victims and witnesses of violence, including domestic violence; sex workers; members of minority groups, refugees, irregular migrants or dissidents?		X				
9. Are the participants, outside the context of the research, in a dependent or subordinate position to the investigator (such as own children, own students or employees of either TU Delft and/or a collaborating partner organisation)? <i>It is essential that you safeguard against possible adverse consequences of this situation (such as allowing a student's failure to participate to your satisfaction to affect your evaluation of their coursework).</i>		X				
10. Is there a high possibility of re-identification for your participants? (e.g., do they have a very specialist job of which there are only a small number in a given country, are they members of a small community, or employees from a partner company collaborating in the research? Or are they one of only a handful of (expert) participants in the study?	X		The person from the NGO might be identifiable based on the relatively small team of this organization.	I will not disclose the position of the person within the organization, nor will I mention the name of this person or organisation. Only the type of organisation in which the interviewees operate will be disclosed.		
D: Recruiting Participants						
11. Will your participants be recruited through your own, professional, channels such as conference attendance lists, or through specific network/s such as self-help groups	X		Both the use of private and public networks might be used. Risk: losing the list of participants	In the final thesis I will only note the specific sectors/types of organisation the participants belong too. The recruitment methods used will not be disclosed.		

			<i>If YES please complete the Risk Assessment and Mitigation Plan columns below.</i>		<i>Please provide the relevant reference #</i>	
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? <i>Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!</i>	MITIGATION PLAN – what mitigating steps will you take? <i>Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.</i>	DMP	ICF
				All personal data including the list of participant and organisation will be stored at TUD OneDrive, accessible only to the TUD research team.		
12. Will the participants be recruited or accessed in the longer term by a (legal or customary) gatekeeper? (e.g., an adult professional working with children; a community leader or family member who has this customary role – within or outside the EU; the data producer of a long-term cohort study)		X				
13. Will you be recruiting your participants through a crowd-sourcing service and/or involve a third-party data-gathering service, such as a survey platform?		X				
14. Will you be offering any financial, or other, remuneration to participants, and might this induce or bias participation?		X				
E: Subject Matter <i>Research related to medical questions/health may require special attention. See also the website of the CCMO before contacting the HREC.</i>						
15. Will your research involve any of the following: - Medical research and/or clinical trials - Invasive sampling and/or medical imaging - Medical and <i>In Vitro Diagnostic Medical Devices</i> Research		X				
16. Will drugs, placebos, or other substances (e.g., drinks, foods, food or drink constituents, dietary supplements) be administered to the study participants? <i>If yes see here to determine whether medical ethical approval is required</i>		X				
17. Will blood or tissue samples be obtained from participants? <i>If yes see here to determine whether medical ethical approval is required</i>		X				
18. Does the study risk causing psychological stress or anxiety beyond that normally encountered by the participants in their life outside research?		X				
19. Will the study involve discussion of personal sensitive data which could put participants at increased legal, financial, reputational, security or other risk? (e.g., financial data, location data, data relating to children or other vulnerable groups) <i>Definitions of sensitive personal data, and special cases are provided on the TUD Privacy Team website.</i>		X				
20. Will the study involve disclosing commercially or professionally sensitive, or confidential information? (e.g., relating to decision-making processes or business strategies which might, for example, be of interest to competitors)	X		There is a chance that some questions asked from the industrial sector actor might relate to their business strategy or decision-making process.	The interviewee will retain the right to have anything stricken from the record; the transcribed of the interview will be sent to the interviewee to check their own words. It will also be made explicitly clear that any		

			<i>If YES please complete the Risk Assessment and Mitigation Plan columns below.</i>		<i>Please provide the relevant reference #</i>	
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? <i>Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!</i>	MITIGATION PLAN – what mitigating steps will you take? <i>Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.</i>	DMP	ICF
				information provided must be publishable for this thesis.		
21. Has your study been identified by the TU Delft Privacy Team as requiring a Data Processing Impact Assessment (DPIA)? <i>If yes please attach the advice/ approval from the Privacy Team to this application</i>		X				
22. Does your research investigate causes or areas of conflict? <i>If yes please confirm that your fieldwork has been discussed with the appropriate safety/security advisors and approved by your Department/Faculty.</i>		X				
23. Does your research involve observing illegal activities or data processed or provided by authorities responsible for preventing, investigating, detecting or prosecuting criminal offences <i>If so please confirm that your work has been discussed with the appropriate legal advisors and approved by your Department/Faculty.</i>		X				
F: Research Methods						
24. Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g., covert observation of people in non-public places).		X				
25. Will the study involve actively deceiving the participants? (For example, will participants be deliberately falsely informed, will information be withheld from them or will they be misled in such a way that they are likely to object or show unease when debriefed about the study).		X				
26. Is pain or more than mild discomfort likely to result from the study? And/or could your research activity cause an accident involving (non-) participants?		X				
27. Will the experiment involve the use of devices that are not 'CE' certified? <i>Only, if 'yes': continue with the following questions:</i>		X				
• Was the device built in-house?		X				
• Was it inspected by a safety expert at TU Delft? <i>If yes, please provide a signed device report</i>		X				
• If it was not built in-house and not CE-certified, was it inspected by some other, qualified authority in safety and approved? <i>If yes, please provide records of the inspection</i>		X				
28. Will your research involve face-to-face encounters with your participants and if so how will you assess and address Covid considerations?	X			Reschedule or switch to online in case of sickness/ symptoms		

			<i>If YES please complete the Risk Assessment and Mitigation Plan columns below.</i>		<i>Please provide the relevant reference #</i>	
ISSUE	Yes	No	RISK ASSESSMENT – what risks could arise? <i>Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!</i>	MITIGATION PLAN – what mitigating steps will you take? <i>Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.</i>	DMP	ICF
29. Will your research involve either : a) “big data”, combined datasets, new data-gathering or new data-merging techniques which might lead to re-identification of your participants and/or b) artificial intelligence or algorithm training where, for example biased datasets could lead to biased outcomes?		X				
G: Data Processing and Privacy						
30. Will the research involve collecting, processing and/or storing any directly identifiable PII (Personally Identifiable Information) including name or email address that will be used for administrative purposes only? (eg: obtaining Informed Consent or disbursing remuneration)	X		Losing informed consent or participant list	Storing at TUD OneDrive		
31. Will the research involve collecting, processing and/or storing any directly or indirectly identifiable PIRD (Personally Identifiable Research Data) including videos, pictures, IP address, gender, age etc and what other Personal Research Data (including personal or professional views) will you be collecting?	X		Losing the audio recording and transcribed	Storing at TUD OneDrive		
32. Will this research involve collecting data from the internet, social media and/or publicly available datasets which have been originally contributed by human participants		X				
33. Will your research findings be published in one or more forms in the public domain, as e.g., Masters thesis, journal publication, conference presentation or wider public dissemination?	X		Master thesis	The interviewees are made aware of it through informed consent. Thesis will only use anonymised quotes and aggregated results		
34. Will your research data be archived for re-use and/or teaching in an open, private or semi-open archive?	X		Risk of revealing personal data in the appendixes	In case of doubt of a summaries anonymity we will not publish it.		

Appendix C: Thematic analysis

The thematic analysis occurred through firstly the creation of a codebook. This is the framework by which the decision taken in the making of the codes gets elaborated. For this, a theoretical thematic approach was initiated. During the conducting of these interviews the goal was to evaluate the assumptions made on the specific views and how the sector was framed utilising DAPP. Initially, the statements were divided over 7 initial themes which were important for this project. These themes are: Goal framing, funding decisions, mandate, sustainability, additionality, permanence, and uncertainty. The coding was conducted with a focus surrounding these seven themes. The basis for the coding method used was written by Braun and Clarke (2006).

Firstly, individual statements were selected out of the interviews and laid out under the seven different themes for each interview before stating the initial coding. Then these different statements were given a code, the codes, an explanation and an example are shown in table 6.

Table 6: Coding scheme with explanations and examples, text between () are context added to make clear where the quotes stand for, the quotes were translated from Dutch

Codes	Explanation	Example
Emissions accounting	Relates to experiences of lack of accounting, or how something should be attributed	There are a lot of emissions there. These are now seen as unavoidable. But if you adopt a sustainable agricultural system, this will become less. (P1)
Failed experiment	The impact of failed experiments	Of course you saw Barendrecht, where plans were (CCS), and that was already stopped at the time. (P1)
Market conditions	The country specific conditions in the Netherlands, both economic and land use	Because in the Netherlands it is quite difficult to go from start-up to scale-up to ultimately just a commercial company. (P1)
Moral hazard	The risk of continuation of fossil fuels	You don't want to lock in on fossil CCS. Under the ETS, if you emit and capture and store fossils, you can continue to use them. (P1)
Policy regarding pilots	How to deal with the risks and developing of pilots	You must accept that this puts you at risk of damage; a pilot should allow you to conclude whether this was not a convenient route. (P2)
Public support	Representation of public views on methods/actions according to interviewees	I don't think the public thinks much of most carbon removal techniques. (P1)
Raw material sourcing	Risk in sourcing of raw materials, mainly biomass	My concern is actually on the raw materials side for BECCS. (P2)
Scaling issues	Views expressing difficulties encountered when scaling up or needing to scale up	A financier will not easily accept an increase in scale of more than a factor of 10 because it involves financial risks. (P2)
Setting of goals	Reaction on the goal set for DAPP, or own organisational goal	We don't think it will be much more than 25 megatons per year (by 2100). (P1)
Shifting definitions	Definitions change over time/per field of study	Only in our water models is mineralization the production of organic matter. (P2)
Theory versus practice	Some solutions are theoretically very favourable, but are practically not applicable yet	(DOCCS company) They have some very big technical questions to answer. (P2)

Codes	Explanation	Example
Undecided choice	Uncertainty regarding how to approach a certain method/how to support it	(Are temporary removals desirable) We are still discussing this; we do a lot with mangroves. (P2)
Unjustified method	A view that the potential attributed to a method is unjustified	It has the greatest theoretical potential, but they do not really see that BECCS makes sense in the Netherlands. (P1)
Value nature processes	Expressions of support for current natural NbS	You ensure that it happens and prevent natural processes from being slowed down. (P1)
Whose emissions	Lack of attributing emissions to a certain country	From a legislative perspective, emissions outside the eight miles are not ours. (P2)
Economic trade off	To highlight when the trade off being made is economical	Governments should prioritise green transition investments over other temporary emission reductions. (P3)
Mandate	This code highlights the impact of mandates or the need for mandates	So if you set out a mandate that involves integrating the ETS or, for example, incorporating it into the ETS, the narrative there should still remain clear. (P4)
Financing	Highlights difficulties and opportunities regarding the financing of removals	And they'll have to get their business case sorted in the end, and aiming for 25 million tonnes with subsidies seems a bit much to me. (P4)
Reaction on framing of DAPP	Relates to statements made on the use of DAPP	You might be able to take it a step further when summarising CDR. Comparing it to nuclear energy and the phasing out of fossil fuels. (P2)
Definition	What is a certain definition used, or that should be used	If it happens in 14 or 15 per cent of cases or more often, it becomes an industry standard and is no longer considered an additional feature. (P3)

An overview of all quotes per interview and their attribution will be shown in Table 7, Table 8, Table 9, Table 10 and Table 11. Some filler words or repetition of words might have been removed from the quotes, however the meaning or context is the same to the best of my ability. These tables were made with the help of GenAI, see the AI-statement for an explanation.

The first interview happened with a person from an NGO, they have their own vision document on the development of CDR.

Table 7: Coding for interview P1, displaying the Dutch and English

Codes	Dutch quote	English quote	Explanation of attribution
Setting of goals	Wij vinden 5 Gt wel echt te veel binnen onze eigen visie op koolstofverwijdering.	We consider 5 Gt to be far too high within our own vision of carbon removal.	Sets organisational benchmark.
Setting of goals	Dus wij denken niet dat het veel meer zal worden dan 25 megaton per jaar.	We do not expect it to exceed 25 megatons per year.	Quantifies expected target.

Codes		Dutch quote	English quote	Explanation of attribution
Setting of goals		Daarom willen we ook uiteindelijk geen afbouwpad voor fossiel, om te voorkomen dat je uiteindelijk toch fossiele CO ₂ moet blijven opslaan.	Therefore, we ultimately do not want a fossil phase-down pathway that still requires ongoing storage of fossil CO ₂ .	Links targets to fossil phase-out.
Setting of goals		Richting 2100 wordt het wel wat onduidelijker wat je daar daadwerkelijk over kan zeggen.	Towards 2100 it becomes more uncertain what can realistically be said.	Highlights long-term uncertainty.
Whose emissions		Ook al staan land-use emissies op de rekening van een ander land, wij zeggen dat je in klimaatbeleid ook moet kijken naar scope 2 en 3 effecten, ook al staan die niet op jouw rekening richting het IPCC.	Even if land-use emissions are accounted for in another country, policymakers should consider scope 2 and 3 effects as well.	Expands responsibility beyond territorial accounting.
Emissions counting	ac-	En sowieso moet je in je totale massabalans meenemen dat een deel niet is afgevangen, net zoals dat je ketenemissies en de energy penalty in het geval van BECCS moet meenemen.	You must include in your total mass balance that part is not captured, as well as supply-chain emissions and the energy penalty of BECCS.	Emphasises full accounting.
Emissions counting	ac-	Het complete plaatje bekijken om te beoordelen hoe je negatieve emissies inschat ten opzichte van andere opties.	You need to consider the full picture when assessing negative emissions relative to alternatives.	Holistic comparison between methods.
Emissions counting	ac-	Daar zijn heel veel emissies die nu als onvermijdbaar worden gezien, maar als je een duurzaam landbouwsysteem invoert, wordt dat wel minder.	Many emissions are currently considered unavoidable, but they can decrease with sustainable agriculture.	Shows dynamic accounting.
Emissions counting	ac-	Wij zijn nu aan het kijken wat je vastlegging wordt als je inzet op mineraliserend cement, bio-based bouwmaterialen en alternatieven vanuit de biochemie.	We are examining the combination of sequestration from mineralising cement, bio-based materials, and biochemical alternatives.	Alternative accounting pathways.
Funding choice		Je kan er natuurlijk een prijs op zetten, zoals bij ETS	You can put a price on it, as in the ETS.	Pricing mechanism.
Funding choice		Je kan koolstofverwijderingsveilingen organiseren, dus wie het meeste kan realiseren tegen de laagste prijs.	You can organise auctions to identify who can deliver the most at the lowest price.	Market-based mechanism.
Funding choice		Het blijft de vraag waar die publieke Financiering vandaan komt.	The question remains where public funding will come from.	Funding uncertainty.
Funding choice		Inkomsten van ETS-veilingen daarvoor gebruiken is op zich een prima manier.	Using ETS-auctionrevenues is a reasonable approach.	Suggested funding source.
Market conditions		Nog steeds is het uiteindelijk de prijs die ervoor zorgt dat er daadwerkelijk credits worden gegenereerd.	Ultimately, price determines whether credits are generated.	Market dependency for creating current price.

Codes	Dutch quote	English quote	Explanation of attribution
Market conditions	In Nederland is het best lastig om van start-up naar scale-up en uiteindelijk naar een commercieel bedrijf te groeien.	In the Netherlands it is difficult to grow from start-up to commercial scale.	Structural barrier for growing in the Dutch market.
Scaling issues	Het is logisch dat je dat tijdelijk ook subsidieert om het nu de kans te geven om schaal te maken.	It makes sense to temporarily subsidise this to allow scaling.	Supports subsidies.
Scaling issues	Wij staan niet negatief tegenover subsidies op deployments.	We are not opposed to deployment subsidies.	Positive stance towards scaling with subsidies on deployment
Policy choice	Bij DACCS en DOCCS is het ingewikkelder om te zeggen dat je verplicht bent dit toe te passen in een bepaalde situatie.	For DACCS and DOCCS it is harder to impose mandates.	Policy complexity for uncertain technologies.
Policy choice	(Incentive + mandate) Dat is eigenlijk wel. Is heel logisch, Ja	(Incentive + mandate) Actually it is. Makes a lot of sense. Yes	Policy mix concept of shifting from free market to mandate.
Policy choice	Wij zijn geen voorstander van volledige integratie met het ETS, omdat dat de incentive voor emissiereductie verlaagt.	We are not in favour of fully integrating it into the ETS because it reduces reduction incentives.	Critique of possible integration in ETS.
Policy choice	En niet dan nog een aparte subsidie voor een afvanginstallatie op iets wat je al subsidieert.	No additional subsidy should be given for something already subsidised.	Avoids double counting.
Policy choice	Het is belangrijk hoe binnen een systeem van koolstofverwijdering ook nature-based solutions meegenomen kunnen worden.	It is important how nature-based solutions can be included in a carbon removal system.	Inclusion of NbS should be done in a way.
Policy choice	Een tijdelijke afvang die die periode overbruggt zou je kunnen wegstrepen tegen methaan-effecten.	Temporary capture could be balanced against methane effects.	For a temporary mechanism.
Moral hazard	Je houdt dan een vorm van fossiele compensatie, terwijl je op lange termijn netto negatieve emissies wil.	This maintains fossil compensation while long-term goals require net negative emissions.	Moral hazard risk when trying to bind fossil with removals.
Moral hazard	In onze visie moet je fossiele emissies zo snel mogelijk naar nul reduceren.	In our view, fossil emissions should be reduced to zero as quickly as possible.	Strong mitigation stance.
Moral hazard	Het moet echt natuur zijn en niet puur snelgroeiend plantagebos.	It should be real nature, not fast-growing plantation forests.	Strong view on how sustainable forests should be.
Moral hazard	Je wilt geen lock-in op fossiele CCS; onder het huidige ETS kan je anders blijven uitstoten en opslaan.	You want to avoid fossil CCS lock-in; under current ETS, emissions can continue if captured.	Lock-in concern with current ETS-framework.
Value nature	Je doet dit niet alleen voor koolstofverwijdering, maar ook voor biodiversiteit en andere co-benefits.	This is done not only for carbon removal but also for biodiversity and co-benefits.	Co-benefits.

Codes	Dutch quote	English quote	Explanation of attribution
Value nature	Je kan het meer borgen en moet voorkomen dat natuurlijke processen worden afgeremd.	You should safeguard and avoid slowing natural processes.	Protect natural systems.
Value nature	Zowel in de landbouwsector als natuurversterking en rustgebieden op de Noordzee waar blauwe koolstof kan ontstaan.	In agriculture, nature restoration, and North Sea areas enabling blue carbon.	Broad NbS role, how it should be treasured more.
Theory versus practice	Historisch gezien is alle koolstofverwijdering eigenlijk een nature-based solution.	Historically, carbon removal has mainly been nature-based.	Historical framing, in light of technical focussed pathway developed.
Unjustified method	Het heeft het grootste theoretische potentieel, maar tegelijkertijd zien ze niet dat BECCS logisch is in Nederland.	It has the largest theoretical potential but is not considered logical in the Netherlands.	Feasibility critique for framing of BECCS.
Unjustified method	Als het een bioplastic is dat binnen een jaar weer wordt verbrand, dan levert dat geen bijdrage.	If bioplastics are burned within a year, they do not contribute.	Ineffective application, should not count as a removal.
Unjustified method	Als je natuurlijke voorraden vermindert voor bio-energie met afvang, loop je het risico op weinig netto winst.	Reducing natural stocks for BECCS may yield little net benefit.	Net-effect concern for utilising BECCS.
Unjustified method	In de praktijk heb je biograndstoffen waarschijnlijk elders harder nodig waar geen alternatieven zijn.	Biomass is likely more needed elsewhere in practice.	Competing demand for finite resource.
Failed experiment	Je zag natuurlijk Barendrecht, waar plannen waren voor CCS en dat destijds al is stopgezet.	In Barendrecht, CCS plans were cancelled early on.	Failed implementation example of CCS under land.
Public support	Ik denk dat het publiek niet zo veel vindt van de meeste koolstofverwijderingstechnieken.	The public does not have strong opinions on most carbon removal techniques.	Low knowledge of removals.
Public support	Het verbranden van biomassa heeft wel een negatief imago, en terecht.	Biomass burning has a negative image, for good reason.	Negative perception of biomass burning.
Public support	Als je biobrandstoffen maakt met koolstofverwijdering, ligt dat minder gevoelig bij het publiek.	Biofuels with carbon removal are less sensitive in public debate.	Likely no/limited public concern.
Public support	Europese collega-organisaties zijn erg sceptisch over het meenemen van nature-based solutions in beleid voor koolstofverwijdering.	European collega-organisations are very sceptical about including NbS in CDR policy.	Institutional scepticism from a sustainability perspective, monoculture forrests.

The second interview was conducted with someone from a knowledge institute who formerly worked on a project about DOCCS, and later a more sector wide project.

Table 8: Coding for interview P2, displaying the Dutch and English

Codes	Dutch quote	English quote	Explanation of attribution
Setting of goals	Nee, ik heb daar niet zo heel veel verstand van (5 Gt in 2100).	No, I do not have much expertise on that (5 Gt in 2100).	Indicates uncertainty about target setting.
Setting of goals	We hebben de afgelopen weken gezegd dat het niet verstandig is om een minimumdoel te stellen, als je tegelijkertijd zegt dat je het tot het minimum moet beperken dat nodig is om klimaatdoelen te halen.	In recent weeks, we have said it is not wise to set a minimum target if you also aim to minimise it to what is strictly necessary.	Critique of minimum targets.
Setting of goals	In al onze modellen werkt het alleen als er een bepaalde hoeveelheid CDR wordt ingezet; dat moet je uitgangspunt zijn.	In our models, they only work if a certain amount of CDR is included; that should be your baseline.	Model-driven target setting, displays a requirement of CDR.
Setting of goals	En in die zin moet je er juist een maximum op zetten, want je loopt niet het risico om eroverheen te schieten, maar je zou moeten voorkomen dat je dat doet.	In that sense, you should strive for a maximum, as the real risk is not overshooting what is desirable.	Argument for full commitment, while not overcommitment.
Setting of goals	Hoeveel geld willen wij uitgeven in de komende periode om terug te gaan naar 1.5–2 graden?	How much are we willing to spend in the coming period to return to 1.5–2 degrees?	Links targets to economic constraints of willingness to spend.
Setting of goals	Je kunt als land een doel bereiken door ook in gesprek te gaan met je bedrijfsleven.	As a country, you can reach targets by engaging with industry.	Governance through collaboration, instead of attribution of a target to a country/company.
Whose emissions	De emissies die daaruit voortkomen, bijvoorbeeld op de Noordzee, zou je moeten beschouwen als door de mens beïnvloed en dus ook moeten doorberekenen.	Emissions from systems like the North Sea should be considered anthropogenic and included in accounting.	Expands accounting boundaries beyond current requirements.
Whose emissions	Vanuit wetgeving zijn emissies buiten de acht mijl niet van ons; als je de RVO belt, zeggen ze hetzelfde.	Legally, emissions beyond eight miles are not attributed domestically; authorities confirm this.	Legal attribution boundary.
Whose emissions	Je hebt daar een duidelijke grensdiscussie, bijvoorbeeld rond de Noordzee.	There is a clear boundary debate, for example around the North Sea.	Highlights ambiguity of responsibility in the North Sea.
Emissions accounting	Als je CO ₂ uitstoot die ouder is dan een bepaald aantal jaren en dus niet kortcyclisch is, zien wij dat als een probleem (rond de 200 jaar).	CO ₂ that is older and no longer part of a short cycle (around 200 years) is considered problematic.	Differentiates carbon cycles, emissions before industrial revolution are non short cycle.

Codes		Dutch quote	English quote	Explanation of attribution
Emissions counting	ac-	CO ₂ die kortcyclisch is en terug de lucht in komt door jouw acties, wordt minder problematisch gezien; dan help je een natuurlijke cyclus.	Changing short-cycle CO ₂ emissions are considered less problematic, as they support natural cycles.	Distinguishes emission types, and their preceived impact.
Emissions counting	ac-	Tegelijkertijd zijn er grote blinde vlekken over wat daar gebeurt; er zijn bijvoorbeeld lawaai-getallen van 5% van de emissie in Nederland die niet goed worden meegeteld.	There are major blind spots, for example around unknown and unaccounted emission sources.	Identifies accounting gaps of emissions from the North Sea.
Emissions counting	ac-	Er zijn discussies over de opnamecapaciteit van bijvoorbeeld de Waddenzee en de bijbehorende kosten.	There are debates about the absorption capacity of systems like the Wadden Sea and associated costs.	Natural sink uncertainty, and if or if not to account them within removals
Emissions counting	ac-	Additionality komt vaak terug bij credits en daar moet je voorzichtig mee omgaan vanwege de risico's.	Additionality often arises in credits and requires careful handling due to risks.	Addresses credit integrity and additionality risk.
Emissions counting	ac-	Het LULUCF-domein omvat veel emissies en is een van de moeilijkste om mee te werken.	The LULUCF domain includes many emissions and is difficult to operationalise.	Complexity of land-use accounting.
Value nature		Het groeit in de Noordzee en wordt opgeslagen in de Waddenzee, wat natuurlijk prachtig is.	It grows in the North Sea and is stored in the Wadden Sea, which is amazing.	Positive view on natural sequestration, value existing approaches.
Market conditions		Voor bewezen methoden moet je meenemen dat landgebruiksverandering in Nederland lastig is en lange doorlooptijden heeft.	For proven methods, land-use change in the Netherlands is difficult and has long lead times.	Structural constraint of the Dutch market, felt missing in the DAPP.
Policy pilots	regarding	Je moet accepteren dat je risico loopt op schade; een pilot moet kunnen aantonen dat een route niet werkt.	You must accept risk; pilots should be able to demonstrate failure.	Role of experimentation, and that there are inherent risks to piloting a technology.
Policy pilots	regarding	Het gaat vaak om technologische doorbraken, dus experimenteren is noodzakelijk.	These involve technological breakthroughs, so experimentation is necessary.	Innovation logic, requirement for DACCS/DOCCS.
Policy pilots	regarding	Ze zijn ook al een half jaar bezig om pilots die Financing hadden In de haven van Rotterdam voor elkaar te krijgen. Dat vindt men gewoon heel erg lastig bij Rijkswaterstaat.	They have also been working for six months to arrange pilots that had financing in the port of Rotterdam. People at Rijkswaterstaat simply find that very difficult.	Institutional barrier for conducting piloting plants in the Netherlands.
Policy pilots	regarding	Onderzoeksexcepties zijn gevoelig maar noodzakelijk, omdat je anders niet kunt leren schalen.	Research exemptions are sensitive but necessary to enable scaling.	Regulatory tension for research with possible negative effects(DOCCS).
Policy pilots	regarding	Als je het voorzorgsprincipe te strikt toepast, begin je nooit aan nieuwe technologie.	Strict application of the precautionary principle can block innovation.	Critique of the strict precaution policy.

Codes	Dutch quote	English quote	Explanation of attribution
Policy regarding pilots	De discussie over impact van demo-projecten op de oceaan staat nog in de kinderschoenen. De vergunningverleners hebben geen flauw idee wat ze ermee moeten.	The discussion on ocean impacts of demo projects is still in its infancy. The licensing authorities have no idea what to do with it.	Immature governance field, lack of knowledge.
Policy regarding pilots	Uiteindelijk moet iemand het gewoon gaan doen; ondanks onzekerheid moet actie worden genomen.	Ultimately, someone has to act despite uncertainty.	Call for action in terms of setting up pilots.
Scaling issues	Vanuit technologieontwikkeling zou je CCS moeten behandelen zoals elektrische auto's nu.	CCS development should follow a pathway similar to electric vehicles.	Analogy for scaling, some less sustainable removals (grey electricity) for now, to future (green electricity) sustainable removals.
Scaling issues	Implementatie kan alleen als je kunt piloten en experimenteren.	Implementation requires piloting and experimentation.	Learning-by-doing is a requirement for scaling.
Scaling issues	Dat kost tijd en zonder leren leidt het tot kapitaalvernietiging.	This takes time, otherwise it leads to wasted investment.	Time requirement of scaling up.
Scaling issues	Financiers accepteren meestal geen schaalvergroting groter dan een factor tien vanwege risico's.	Financiers rarely accept scaling beyond a factor of ten due to risks.	Financial constraint of scaling up to mton scale.
Scaling issues	Bedrijven zoals RWE hebben eerder een gebrek aan subsidie dan last van regelgeving.	Companies like RWE face lack of subsidies rather than regulatory barriers.	Identifies main bottleneck for adding BECCS based on their own research.
Moral hazard	Je moet nadenken over maximumdoelen om te voorkomen dat fossiele uitstoot blijft doorgaan.	Maximum targets may be needed to prevent continued fossil emissions.	Prevents dependency on fossil due to the potential of removal in the future.
Moral hazard	Het koppelen van CDR aan fossiele uitstoot is gevaarlijk omdat het als aflat of afkoop kan worden gezien.	Linking CDR to fossil emissions is risky as it legitimises continuation.	Offset critique if attempted to couple fossil with removals.
Raw material sourcing	Mijn zorg zit aan de grondstofenkant, vooral voor BECCS.	My concern lies with raw materials, especially for BECCS.	Resource concern in terms of sustainability.
Raw material sourcing	BECCS is vaak afhankelijk van biomassa zoals houtpellets; afvalstromen hebben een heel veel positievere connotatie.	BECCS depends on biomass like pellets; waste feedstocks are preferable.	Resource quality distinction, sourcing local waste versus biomass outside the country.
Undecided choice	We hebben nog discussie of tijdelijke verwijdering wenselijk is; we doen veel met mangroves.	We are still debating temporary removals and working with mangroves.	Ongoing debate on how to deal with temporary methods, while working to research such a method.
Undecided choice	Als we dit willen doen, moeten we processen op geologische schaal begrijpen.	We need to understand processes at geological scale.	Knowledge uncertainty which is required to make the choice for temporary removals on such a scale.
Unjustified method	Ik vind farming geen geschikte methode voor koolstofverwijdering.	I do not consider farming a valid removal method.	Rejects method, does not believe it to be done for the goal of removal.

Codes		Dutch quote	English quote	Explanation of attribution
Theory practice	versus	(Niche onderwerp) Daarom worden DACCS en DOCCS vaak samengenomen, maar er zijn belangrijke verschillen in effecten.	DACCS and DOCCS are often grouped (because of DOCCS being a Niche topic), but differ in impacts.	Conceptual nuance in how to account for the effects in practice.
Theory practice	versus	(DOCCS Bedrijf) hebben nog grote technische vragen openstaan.	(DOCCS Company) still face major technical questions.	Practical limitations of moving large amount of water through a membrane, proposed scale of Gt versus the current reality.
Shifting tions	defini-	Jarenlang werd iets BECCS genoemd terwijl dat nu eigenlijk niet meer klopt.	Something was labelled BECCS for years, but would no longer fall under that definition.	Changing terminology, related to a form of algae farming +10 years ago.
Shifting tions	defini-	Economische definities van 'lange termijn' zoals 50 jaar zijn discutabel.	Economic definitions of long-term, like 50 years, are questionable.	Temporal ambiguity, also in relation to what long-term means in CRCF.
Shifting tions	defini-	In watermodellen is mineralisatie het maken van organische stof.	In water models, mineralisation means producing organic matter.	Field-specific definition, deviates from the same one used in CDR.
Shifting tions	defini-	Bedoel je met dat functies voor de natuur, is het natuurbouw of moet er ook nog echt technische functies aan vastzitten?	Do mean with NbS functions for nature, is it natural construction or do you also have to have technical functions attached to it?	Conceptual boundary definition of NbS is unclear.
Failed experiment		Grootschalige experimenten zoals het zinken van hout leidden tot maatschappelijke weerstand en zijn gestopt.	Large-scale experiments like wood sinking faced societal opposition and were halted.	Social rejection of a method due to failed experiments.
Public support		Bio heeft ook een positieve connotaties in het publieke debat.	"Bio" can has positive connotations in public discourse.	The good perception of Bio.
Public support		Biomassa wordt vaak negatief beoordeeld, erg ongenueanceerd.	Biomass is often judged negatively, there is very little nuance.	Public framing is often simplified.
Reaction on framing of DAPP		Je zou misschien op een iets hoger niveau nog kunnen doen, als je CDR gaat samenvatten. Ze gaan vergelijken met kernenergie en Uit fasering van fossiele brandstoffen.	You might be able to take it a step further when summarising CDR. Comparing it to nuclear energy and the phasing out of fossil fuels.	Other level of aggregation.

The third interview happened with a market party which uses a wood building method and will position themselves under temporary removals within CRCF, but they state their method could reach the time span required for permanence, due to differentiating from normal wood building.

Table 9: Coding for interview P3, displaying the Dutch and English, additions between () are context added for readability, some clean up was performed on the Dutch text.

Codes	Dutch quote	English quote	Explanation of attribution
Definition	Als het 14 of 15% van de gevallen of vaker gebeurt, dan wordt het een industrie standaard en dan is het niet meer additioneel.	If it happens in 14 or 15 per cent of cases or more often, it becomes an industry standard and is no longer considered an additional feature.	Definition boundary.
Definition	Je kunt nu additioneel zijn om dat in een toekomst te verliezen	You can operate additional now only to lose that in a future	The ability to lose it is part of the definition of additionality.
Economic trade-off	de Mensen die opereren in deze markt of de bedrijven die opereren in deze markt, die zijn vaak ook al aan het reduceren waar mogelijk, want die weten wat de werkelijke kosten zijn van compenseren.	Companies in the removal market already reduce, because they know the cost of compensation.	Cost-driven behaviour.
Economic trade-off	Het is ook de duurste aanpak (CDR)	CDR is the most expensive approach.	Cost barrier to use instead of mitigation.
Economic trade-off	Ik vind dat de overheid eerder meer moet investeren in de shift (naar groene energie) bewerkstelligen dan een subsidie gaan doen, zodat we langer op een minder duurzamere manier kunnen blijven werken.	Governments should prioritise green transition investments over other temporary emission reductions.	Policy priority argument.
Emissions accounting	Ik hoor gemixte informatie stromen in de markt vanwege verschillende plekken. Er zijn wetenschappers die zeggen, We hebben al 1,5 graad warming, dus we gaan een overshoot in.	There are mixed information flows; some scientists argue we already face a carbon overshoot.	Conflicting scientific and market inputs about size setting.
Emissions accounting	het kan zo zijn dat je veel meer uitstoot als je ook veel meer verwijdert en die kwaliteit is gewaarborgd. Dan zou dat in theorie niet uitmaken. De praktijk is dat een investering in reductie 100 keer rendabeler is. 100 even een willekeurig nummer, dan investeren in een verwijdering, omdat je dat ieder jaar moet doen.	In theory emissions can be balanced by removals, but reduction is more efficient in practice.	Prioritises reduction.

Codes	Dutch quote	English quote	Explanation of attribution
Financing	Dat moet een beetje divers zijn. Daar waar je niet afhankelijk wil zijn van één of twee grote partijen. Het is nog zo'n jonge markt. Zorg dat je zowel de grote als de kleinere spelers fund.	Funding should be diversified to small and big removal operations.	Market concentration.
Financing	Hoe? Maakt mij niet zoveel uit. Dat kun je doen door legislation en een verplichting te stellen, want dan weet je dat de vraag gaat toenemen. Dat kan zijn door subsidies, dat kan zijn door gecoördineerde aankopen.	I don't care how; tools like mandates, subsidies, and pricing can stimulate demand.	No preference for financing policy.
Mandate	Maar dat we inderdaad tot een piek komen en dat weer kunnen gaan afbouwen, dan lijkt het me zeer waarschijnlijk dat we daar wetgeving voor nodig hebben.	Legislation will likely be needed if we need to utilise removals.	Regulatory need of a mandate.
Market conditions	We willen wel binnen die CRCF vallen; daarom zullen we dat wel verkopen als een tijdelijke oplossing.	We want to fall within the CRCF.	The desire to work within the CRCF
Market conditions	Als je kijkt naar de bedrijven die handelen, zijn dat de bedrijven die gigantisch veel geld verdienen en in de vrijwillige markt gewoon hoge marges hebben.	Companies currently participating in the market are high margins companies.	Market conditions of buyers.
Market conditions	Verwerken in ETS helpt, want dan kun je ervoor zorgen dat niet alleen de vaste emissierechten, maar ook carbon removal werkt. Subsidies kunnen helpen met belangrijke projecten.	ETS integration helps create demand for removals.	Policy-market link.
Market conditions	Nou is biochar denk ik by far de grootste CDR op dit moment in Nature-based Solutions in carbon removals.	Biochar dominates current CDR markets.	Market dominance.
Market conditions	Je hebt betrekkelijk weinig kopers die acteren in de markt.	Few buyers operate in the market currently.	Limited demand in the current market.
Market conditions	Als ik eigenlijk vooruitkijk, Ik denk dat we in 2035 een vraagoverschot gaan hebben, omdat dan de net-zero-doelstellingen er wel zijn	Demand may exceed supply in 2035 because of regulation.	Market evolution, from too much supply to too little.
Moral hazard	We weten ongeveer hoeveel CO2 we kunnen permitteren. Gelieerd aan de warming, dus dat is een fixed nummer en om dat nummer te halen heb je de CO2 die je uitstoot, min CO2 die je verwijdert. Als je ervan uitgaat dat het getal dat je wenst te hebben accuraat is. Dan maakt het niet uit.	Utilising removals or mitigation for meeting the target doesn't matter, as long as you are accounting correctly	Fixed budget framing.

Codes	Dutch quote	English quote	Explanation of attribution
Moral hazard	Als je qua kwaliteit hoog genoeg zit In de credits die je aanschaft om je uitstoot te compenseren (Dan is dat prima).	High-quality credits acceptable as compensation for emissions.	Conditional acceptance for compensation.
Public support	In de praktijk gaat dat argument vaak niet op. Van Mensen die zeggen, sceptici, over de vrijwillige carbonmarkt: dit is afkopen van je uitstoot.	Utilising removals as compensation is seen as indulgence of responsibility.	Sceptical people over the use as compensation.
Scaling issues	We hebben nog wat uitstoot over. Dan ga je die compenseren met betrekkelijk goedkope credits, dan ga je je verder verdiepen en denk je: oh, maar die permanentie is hartstikke kort. Maar we willen dit wel echt op een goede manier doen. En op die manier groeien mensen naar CDR.	Companies transition from low quality to high quality credits by participating in the market.	Behavioural up-scaling in terms of quality.
Scaling issues	Mijn baseline is alles, alles helpt. Alles helpt, zolang we stimuleren dat er geld naar carbon removal vloeit.	Everything financial helps with scaling of removals.	Pragmatic view on how to financially support scaling.
Setting of goals	De meeste wetenschappers die met mij daarover vertellen, die zeggen: we gaan overshooten. De vraag is of het doel dat jij hier stelt überhaupt een kans van halen heeft.	In an overshoot scenario, the targets set may be unrealistic.	Feasibility concern on limiting temperature to 1.5 degrees.
Setting of goals	Ik denk dat wetgeving nodig is en anders gaan we voor een grotere overshoot, een veel grotere overshoot.	Policy goals needed to avoid overshoot.	The need for extra reduction goals.
Setting of goals	Daar kan ik je niet echt mee helpen, om eerlijk te zijn. Omdat die schaal zo groot is en de tijdsperiode zo lang, dat vind ik heel moeilijk te voorspellen. Maar ik zou niet bij default zeggen dat 5 gigaton onhaalbaar is.	I am unable to help with what is a realistic goal, but belief 5 Gt is plausible.	Uncertainty in framing a goal.
Setting of goals	Om de korte termijn doelen te gaan halen, hebben we een versnelling nodig.	Acceleration needed for reaching short-term removal goals.	The need for additional actions.
Shifting definitions	Permanentie zou een element kunnen kunnen zijn, maar daar is ook in mijn weten niet een definitief antwoord.	No clear permanence definition.	Definition ambiguity in the free market.
Shifting definitions	Permanent voor mij betekent permanent. Als ik er persoonlijk naar kijk, dan moet het definitief weg zijn.	Personal definition of permanence is really permanent removal.	Subjective framing.

Codes		Dutch quote	English quote	Explanation of attribution
Shifting definitions	defini-	Ik denk dat er een soort ondergrens zou moeten komen (qua kwaliteit) van OK, maar dit is wat we wel accepteren, dit niet. En dat gaat CRCF hopelijk doen.	There is a need for minimal definition; hopefully CRCF will help.	Standardisation is required for defining removals.
Shifting definitions	defini-	(additionality): dat onderwerp komt vaak naar boven en ook hier heb je verschillende definities.	Multiple definitions of additionality exist.	Free market allows for multiple definitions.
Theory practice	versus	Ik ben wel benieuwd waar die definitie is (van permanent), want die markt definitie loopt nogal uiteen.	Practical definition of permanence differs between parties.	The theoretical need for permanence comes with the practical question what this is.
Theory practice	versus	Dus zij kunnen de wetten die ze dan instellen eigenlijk zelf bijna niet naleven.	They nearly can't follow the law (if a carbon price gets introduced)	The high amount of emissions the government has itself limit their practical implementation.
Theory practice	versus	Tegelijkertijd heb ik liever dat ze het verbranden en afvangen.	At the same time, I'd rather they burn it and capture it.	Theoretical no BECCS but in practice preference over BE.
Unjustified method		Daar kom je wel in een bepaald schouwspel, want je hebt ook tonnen CO2 als avoidens bijvoorbeeld: die heel goedkoop zijn. En daar vind ik dan weer wel dat het als afkoop geldt, dus er is een soort omslagpunt over.	There you come across a certain spectacle, because you also have tons of CO2 as avoidances, for example: which are very cheap. And then I think that it counts as indulgence	Validity concern of certain removals in the current market.
Unjustified method		Ik ben trouwens wel tegen subsidie van BECCS, nu ik dat zo zie staan, omdat dat dus een markt in stand houdt die eigenlijk op termijn onwenselijk is.	By the way, I am against BECCS subsidy, now that I see it that way, because it maintains a market that is actually undesirable in the long term.	Critique on BECCS, would rather see other methods.
Whose emissions		Tegelijkertijd heb ik 100 keer liever dat iemand zijn uitstoot afkoopt dan dat hij niks doet.	At the same time, I would 100 times rather have someone buy off their emissions than do nothing.	Stance on lack of players in the market.

The fourth interview was conducted with a person from a policymaking organisation, with a focus on technological methods.

Table 10: Coding for interview P4, displaying the Dutch and English, additions between () are context added for readability, some clean up was performed on the Dutch text.

Codes	Dutch quote	English quote	Explanation of attribution
Definition	Uiteindelijk heeft een bio energiecentrale Natuurlijk als hoofddoelenergie leveren. En, Ik denk dat dat wel ook hetgeen is waar je het dan vooral Aan moet koppelen.	Ultimately, the main purpose of a bioenergy power station is, of course, to supply energy. And I think that's what you should focus on above all else.	Definition for goal of BECCS
Definition	je kan natuurlijk ook ervoor kiezen om het via mineralisatie te doen. Dat is ook wel redelijk permanent al kan je daar ook een hele discussie over voeren?	Of course, you could also choose to do it through mineralisation. That's also fairly permanent, although you could have quite a discussion about that, couldn't you?	Permanence ambiguity.
Definition	Of in hoeverre het echt permanent is een hè. Het is een enhanced wheathering oftewel, je doet het versneld dus uiteindelijk over tijd zal het ook wel een keer gebeuren.	Or to what extent it's actually permanent, isn't it? It's a form of accelerated weathering – in other words, you're speeding up the process, so eventually, over time, it'll happen anyway,	Discussion on definition permanence nuance.
Economic trade-off	daarnaast dus ook te kijken naar ontwikkelingen waar technologie, het kan natuurlijk iets doen, maar het kan ook voor meerdere zaken worden ingezet du sook het stukje economisch intresant.	In addition, we should also look at developments where technology – whilst it can, of course, achieve certain things – can also be used for a variety of purposes, which makes it economically attractive as well.	Show the need for multi-purpose.
Economic trade-off	Maar er komt inderdaad ook een fractie die ik kan toepassen als energiedrager of als brandstof wat wel ook weer ingezet kan worden in de markt.	But there is indeed also a fraction that I can use as an energy carrier or as fuel, which in turn can be put to use in the market.	Market for the co-product of Biochar.
Economic trade-off	De winst eruit halen als een installatie nog 15 jaar moet draaien. Waarom zouden we dan wachten met zo'n investering doen en niet gewoon gelijk ervoor zorgen dat in ieder geval het klimaat effect tegengaan	Making the most of it when a plant still has 15 years left to run. So why should we wait to make such an investment, rather than simply ensuring straight away that we at least counteract the impact on the climate?	Trade-off decision between climate and financial.

Codes	Dutch quote	English quote	Explanation of attribution
Economic trade-off	je wilt natuurlijk geen lock in creëren. Je wilt niet dat dingen vast gaan lopen of langer blijven dan nodig. Dat is zeker waar, maar ik denk ook wel dat we realistisch moeten blijven in wat gaan we de komende 15 jaar nog toch aan aan capaciteit nodig hebben?	Of course, you don't want to create a lock-in. You don't want things to get bogged down or drag on longer than necessary. That's certainly true, but I also think we need to remain realistic about what capacity we're actually going to need over the next 15 years.	Trade-off tension climate/financial.
Emissions accounting	De lucht klaren (Raport) en geeft daarin het advies om eigenlijk kortdurende vastlegging tegenover kortdurende emissies te zetten en permanente vastlegging tegen langdurige emissies. de blik is om de WKR daarin te volgen.	The report 'Clearing the Air' recommends matching short-term sequestration against short-term emissions and permanent sequestration against long-term emissions. The aim is to follow the WKR's approach in this regard.	View on how to account.
Emissions accounting	Natuurlijk want anders dat je een soort van waterbedeffect krijgt dat je misschien nu het uitspaart, maar straks in één keer vrijkomt.	Of course, because otherwise you end up with a sort of 'waterbed effect' where you might be saving it now, but it'll all come flooding out at once later on.	Accounting risk of temporary removals
Emissions accounting	met Energy Innovatie, dus hernieuwbare Energy is een thema, wat heel sterk in de regeling staat, het hoofdproduct moet niet Biochar zijn, want dat is niet hetgeen wat we als brandstof willen hebben. We willen juist bio olies of biogas.	With Energy Innovation, renewable energy is a key theme that features very prominently in the scheme; the main product should not be biochar, as that is not what we want to use as a fuel. Instead, we want bio-oils or biogas.	Additionality of biochar in current legislation.
Financing	Uiteindelijk om een investeringsbesluit te maken Heb je een een sluitende businesscase nodig? Dus ook al komt er een mandaat. Dat moet wel dan een mandaat zijn wat realistisch uit te voeren is.	Ultimately, to make an investment decision, do you need a sound business case? So even if a mandate is granted, it must be one that is realistic to implement.	Financially a mandate must be possible.
Financing	En moeten ze wel hun businesscase uiteindelijk rond krijgen en om 25 miljoen ton met subsidies te gaan doen, lijkt me een beetje veel.	And they'll have to get their business case sorted in the end, and aiming for 25 million tonnes with subsidies seems a bit much to me.	Not everything can be done with subsidies, there must be some market demand.

Codes	Dutch quote	English quote	Explanation of attribution
Financing	Ik wel merk bijvoorbeeld bij Biobased bouwmaterialen en duurzame teelt dat men dus denkt aan credits. En daarvoor ook eens een inkoopprogramma op te starten. Dat is wel een beetje de ook volgens mij de de General tendens.	I do notice, for example, that when it comes to bio-based building materials and sustainable cultivation, people are thinking in terms of credits. And they're also looking to launch a procurement programme for this. I think that's more or less the general trend.	Idea for financing removals
Financing	We zijn nog niet zover dat we dat zeg, maar nu al zouden willen uitrollen en zeker voor technologische routes zitten daar nog voor ons haak en ogen aan. (Carbonbank)	We're not quite there yet, but we'd like to roll this out now, and there are certainly still a few snags to sort out, particularly when it comes to technological routes. (Carbonbank)	There are difficulties with implementation of tenders for technological routes.
Financing	Het dan best lastig is om die stimulans constant te houden (Incentive+mandate)	It is then quite difficult to maintain that incentive consistently (incentive + mandate)	Difficulty with a program such as ETS
Financing	dus Economisch rendabel is wel op de korte termijn absoluut niet zijn en Ik denk zeker in een combinatie met CCS dat daar ondersteuning voor nodig is.	So it is certainly not economically viable in the short term, and I definitely think that, particularly when combined with CCS, it will require support.	Financial support needed for technical routes
Financing	Maar ik verwacht wel dat voor implementatie we daar de eerste 10 15 jaar, een soort ondersteuning voor nodig hebben en dan is bijvoorbeeld een SDE best een goed instrument	But I do expect that, for the first 10 to 15 years or so, we'll need some sort of support to help with implementation, and in that case, for example, an SDE is actually quite a good tool	Financial support needed
Financing	Ik denk dat we nu In de R&D fase zitten voor de meeste technologieën of in ieder geval dat het belangrijk is dat we daar in ieder geval geld in stoppen.	I think we're currently in the R&D phase for most technologies, or at the very least, that it's important we invest in them.	Financing is necessary for R&D
Financing	(Subsidie) Het is eigenlijk een soort van contract for difference, een soort van opex met ook een klein stukje capex regeling dat als een installatie staat en draait dat. Men een soort van ja afhankelijk ook van hoeveel hoeveel de stroom kost en hoeveel ze daadwerkelijk kunnen afvangen.	(Subsidy) It's actually a sort of contract for difference, a sort of OPEX arrangement with a small element of CAPEX, which comes into play once a plant is up and running. It depends, of course, on how much the electricity costs and how much they can actually capture.	Implementation of a carbonbank CfD.

Codes	Dutch quote	English quote	Explanation of attribution
Financing	(SDE) Dat is inderdaad zo'n methode om te zeggen, nou nu kunnen we in ieder geval DACC ontwikkelen en ook op wat grotere projecten als Nederland zijnde Alleen Het is Natuurlijk nog geen koolstofverwijdering, dat zal dan op termijn moeten.	(SDE) That is indeed one way of putting it: well, at least we can now develop DACC and apply it to somewhat larger projects as a country. However, it is, of course, not yet carbon removal; that will have to be addressed in due course.	Financing of related technologies will help scaling up removals.
Market conditions	Als we bijvoorbeeld kijken naar het kolstof credits verhaal, dan zitten we natuurlijk nu op het punt dat die vrijwillige koolstofmarkten er is.	If, for example, we look at the issue of carbon credits, we are, of course, now at the stage of these voluntary carbon markets.	Current market context.
Market conditions	Je wilt natuurlijk dat zo'n markt legitiem wordt, dus daarom natuurlijk ook het CRCF	Of course, you want a market like that to be legitimate, so that's why, of course, the CRCF is being developed.	Regulation to mature the market.
Market conditions	(temporary credits) dus we daar toch een soort van meer vrije markt, met wel een stukje stimulans vanuit de overheid, maar dan meer vanuit zo'n inkoopprogramma	(temporary credits) so we'd have a sort of freer market there, with a bit of government support, but more in the form of a procurement programme	View on development of subsection of the market
Market conditions	door dat hele kost verwijderings scene die ontstaan is, gaan mensen toch liever Biochar maken, of in ieder geval dat als als hoofdproduct proberen te te produceren.	Because of the whole carbon removal scene that has arisen, people are actually preferring to make biochar, or at least trying to produce it as their main product.	Market change of biofuels and char as co-products.
Market conditions	het is wel dus iets wat (Biochar/bio-olie) synergieën kan opleveren, dus ik denk dat we daar dat daar ook wel een beetje de winst te behalen is.	It is, after all, something (biochar/bio-oil) that can yield synergies, so I think there's a bit of a benefit to be gained there as well.	Economics on development
Market conditions	Ik denk dat we ook op het punt zijn dat alle beetjes helpen.	I think we've also reached the point where every little bit helps	All additions to the market are welcome.
Market conditions	zo'n mandaat is inderdaad een kan een goed middel zijn, maar wel pas als er een in ieder geval een markt is die in ieder geval op zijn minst een beetje is ontstaan.	Such a mandate could indeed be a useful tool, but only once a market has, at the very least, begun to take shape.	Need for a developed market
Market conditions	Je kan niet mandaat opleggen zonder dat er een markt is.	You cannot impose a mandate without there being a market.	Market maturity for mandate.
Market conditions	de natuurlijke methodes wat een heel groot stuk beslaat, maar daarvan is het altijd onduidelijk. Volgens mij wat wat precies additioneel is of wat niet additioneel is	natural methods, which cover a very large area in the market, but it is not always clear what is considered 'additional' and what isn't.	Condition of current market.

Codes	Dutch quote	English quote	Explanation of attribution
Market conditions	Alleen maar koolstof verwijderen dat een hele lastige is om een goed verdienmodel op te maken, je zult een soort van synergie nodig moeten hebben.	Just removing carbon is a real challenge when it comes to developing a viable business model; you'll need some sort of synergy.	Market constraint and co-benefits.
Moral hazard	Dat is altijd een beetje de afweging, is het realistisch om dat effect nauw al scherp te hebben, of is het vooral iets wat we gewoon als achterhoofd moeten houden met als dit over de tijd toeneemt	That's always a bit of a balancing act: is it realistic to expect that effect to be clearly defined right now, or is it mainly something we simply need to bear in mind in case it becomes more pronounced over time?	Moral hazard of unknown technologies.
Moral hazard	dat snap ik ook wel (Huiverig connectie fossil enremoval)	I can see that too (wariness of the link between fossil fuels and removal)	legitimacy of fossil extraction.
Moral hazard	We willen natuurlijk het liefst voorkomen dat men het gaat inzetten om langer te kunnen uitstoten. Het moet Natuurlijk nog steeds zo zijn reductie eerst	Of course, we'd prefer to avoid people using it to continue emitting for longer. Of course, the priority must still be on reduction first	Core moral hazard.
Moral hazard	Dan moet eerst reductie plaatsvinden en dan koolstofverwijdering. Het moet niet zo zijn dat kostenverwijdering straks in op grote schale wordt geïmplementeerd, zodat we gewoon vrolijk door kunnen gaan met het fossiele stukje.	First, emissions must be reduced, and then carbon removal must take place. We must not end up in a situation where carbon removal is implemented at great scale, while simply relying on fossil fuels.	Hierarchy between reduction and removal.
Moral hazard	(towards 2100) Stel, we zouden op die periode nog steeds dat (CCS) nodig hebben. Wat gebeurt daarna? Dan hebben we dan daarna niks meer nodig of hebben we dan nog steeds iets nodig?	(towards 2100) Suppose we were still to need that (CCS) during that period. What happens after that? Will we no longer need anything after that, or will we still need something?	Risk of setting a goal at a point and difficulties after achieving this.
Moral hazard	Mits het natuurlijk niet teveel negatieve gevolgen aan (de R&D) hangen of in ieder geval die gaan bestuderen	Provided, of course, that it does not have too many negative consequences (R&D), or that, at the very least, these are investigated.	Risk of allowing pilots.
Public support	Natuurlijke routes voelen toch altijd wat meer knuffelbaar voelen toch wat veiliger, Ook al hebben ze Misschien niet altijd een een hoge permanentie.	Natural routes always feel a bit more appealing. They feel a bit safer, even though they might not always have a high degree of permanence.	Perception bias in public debate.
Public support	Ik denk op het moment dat je ook maar ETS je noemt met koolstofverwijdering dat je dan toch al snel ja, de wind van voren krijgt.	reckon that the moment you even mention ETS in the same breath as carbon removal, you're bound to come in for some flak.	Criticism when removal/reductions are in the same framework.

Codes	Dutch quote	English quote	Explanation of attribution
Public support	Je moet ook die sociale acceptatie hebben en Ik denk dat het dat dat een belangrijk speerpunt is.	You also need that social acceptance, and I think that's a key priority.	Legitimacy.
Public support	(BE) het ook een heel erg politiek gedreven onderwerp is in die zin dat het ook echt wel politiek speelt.	(BE) it is also a highly politically driven issue in the sense that it does indeed play a political role.	Sourcing debate.
Public support	Je moet ook die sociale acceptatie hebben en het is een belangrijk speerpunt. Dus synergie, maar ook stukje sociale acceptatie en dat we daar ook goed over nadenken.	You also need that social acceptance, and it's a key priority. So synergy, but also a degree of social acceptance, and we need to give that careful consideration.	The need for social and co-benefits.
Public support	We moeten mensen meenemen, We moeten ze informeren en dat gaat niet pers altijd om de technische details, maar gewoon al om we gaan dit doen en dit levert het voor jou op.	We need to get people on board. We need to keep them informed, and that doesn't necessarily always mean going into the technical details, but simply explaining what we're going to do and how it will benefit you.	Explain benefit
Public support	We moeten niet alleen denken aan techniek en oplossing, maar ook, hoe gaan we die oplossing uiteindelijk inzetten? En hoe zorgen we dat dat ja op een juiste manier gebeurt?	We mustn't just think about technology and solutions, but also: how are we ultimately going to implement that solution? And how do we ensure that it is done properly?	Explain implementation
Public support	zo vroeg mogelijk mensen meekrijgen, want uiteindelijk moet je die CDR op grote schaal gaan uitrollen, dus hoe eerder je mee begint met die mensen meekrijgen des te groter de kans van slagen.	Get people on board as early as possible, because for large scale CDR, the sooner you start getting people on board, the greater the chance of success	Scaling requires support.
Raw material sourcing	je wilt natuurlijk niet a-hout of materiaal wat van hoge waarde is in de verbranding zouden moeten stoppen	Of course, you wouldn't want to put A-grade timber or any other high-value material into the furnace	Applicability of biomass.
Raw material sourcing	Maar anderzijds zullen we altijd wel reststromen van biomassa hebben die we niet goed kunnen toepassen.	On the other hand, however, we will always have residual biomass streams that we cannot put to good use.	Availability of waste.
Raw material sourcing	hoeveel brandstof hebben we dan straks nog als we alleen aan die reststromen krijgen en is dat voldoende volume om een bio energiecentrale draaiende te krijgen dus?	So how much fuel will we have left if we rely solely on those waste streams, and is that enough to keep a bioenergy plant running?	Resource limits in the future.

Codes	Dutch quote	English quote	Explanation of attribution
Raw material sourcing	(BE) Maar vanuit cyclaire economie perspectief. Ja voelt het toch niet zo als een logische keuze.	(BE) But from a circular economy perspective, it doesn't really feel like a logical choice.	Better use of biomass.
Raw material sourcing	Omdat we gewoon nog een heleboel afval hebben, wat gewoon nog de verbrandingsoven in moeten.	Because we still have a lot of waste that simply has to go into the incinerator	Residual biomass is there and you must do something with it.
Setting of goals	Het is nog geen hard doel. Het is wel iets waar we naartoe willen (20-25MtPA)	It's not a firm target yet. It is, however, something we're aiming for (20-25 MtPA)	Goal framing roadmap.
Setting of goals	De routekaart zit nu vooral met de focus op de eerste 5 jaar eigenlijk.	The roadmap is actually mainly focused on the first five years at the moment.	Current planning horizon.
Setting of goals	Ik verwacht inderdaad ook wel tegen de tijd dat 2030 2040 begint, we een herijking moeten krijgen, waarin ook misschien wat meer directie wordt gegeven, welke technologieën wel niet.	I do indeed expect that, as we approach the turn of the decade from 2030 to 2040, we will need to carry out a reassessment, which may also involve providing a bit more guidance on which technologies to adopt and which to avoid.	Revising goals.
Setting of goals	Ik denk dat het gevaar ontstaat. Dat als je dit onder dezelfde doelen, gaat scharen als CO2 reductie doelen, dat je dan eigenlijk zeker die technologische routes gewoon tekort doet en zo dadelijk gewoon een soort van tegenwerkt	Grouping objectives, CDR and CO reduction targets, you'll actually be doing those technological pathways a disservice and, in the long run, will simply working against them.	Need for separate goals.
Setting of goals	En Als ik zie naar het grote gat wat We hebben tussen wat we nodig hebben aan removals en wat we dadelijk beschikbaar hebben, dan is dat best wel een groot gat.	The gap between availability and of removals and current capacity is quite big.	Feasibility of current goals and requirements.
Setting of goals	(Framed Goal) het laat in ieder geval goed zien wat we al je tijd aan Overshoot hebben gedaan	(Framed Goal) In any case, it really shows what we've been up to with overshoot all this time	Showcase of the challenge with goal framing.
Setting of goals	Ik denk dat voor Nederland als we alles hier zouden moeten uitvoeren als project het het niet mogelijk gaat zijn, of in ieder geval We gaan behoorlijk wat ruimtegebrek ervaren om dit te kunnen doen.	I think that, as far as the Netherlands is concerned, if we were to carry out everything here as a project, it wouldn't be possible, or at the very least we would face a significant shortage of space to do so.	Feasibility.

Codes	Dutch quote	English quote	Explanation of attribution
Setting of goals	het (fossiel) moet dan terug naar waar het vandaan komt en daarvoor zullen we toch moeten uitzoeken hoe we dat gaan doen.	The (fossil emissions) will then have to be returned to where it came from, and to do that we'll have to work out how we're going to go about it.	What the final goal should be.
Setting of goals	Als we zo een doelstelling zouden moeten uitvoeren dat we dan toch echt wel op mondiaal niveau uitwisseling zouden moeten kunnen hebben van die carbon credits Dit is anders gewoon niet haalbaar.	If we were to implement a target like that, we would really need to be able to trade those carbon credits on a global scale. Otherwise, it simply isn't feasible.	Feasibility without exchange.
Setting of goals	Er zijn Natuurlijk nog nog veel meer andere CO2 equivalenten waar mogelijk iets tegen gedaan kan worden.	Of course, there are many other CO2 equivalents where something could potentially be done to tackle them.	Goals next to CO2.
Setting of goals	Ik denk ook dat dat belangrijk is en dat geldt dus ook weer opnieuw voor dat stukje ETS. Je moet er echt gewoon twee separate doelen van maken en het gewoon toch in een hokje stoppen, ook doen we dat liever niet en houden we het liever, globaal en compleet.	I also think that's important, and so that applies once again to that part about the ETS. You really do need to treat them as two separate objectives and simply pigeonhole them; although we'd rather not do that and would prefer to keep things broad and comprehensive.	Separate removal and reductions goals.
Mandate	Het is iets wat inderdaad ook al vanuit ons, ergens een logische stap lijkt, maar het moet niet zo zijn dat we ETS en CO2 reductie op een hoop gooien met kostenverwijdering.	CDR should not be mixed with ETS reduction.	Separation principle when mandating.
Mandate	Als je dus een mandaat stelt waarbij integratie van ETS doet of het bijvoorbeeld in het ETS doet, dat het narratief daar ook nog steeds gewoon helder blijft	So if you set out a mandate that involves integrating the ETS or, for example, incorporating it into the ETS, the narrative there should still remain clear	Clear story when mandating.
Mandate	(BE) Als je Natuurlijk net een nieuwe fabriek hebt neergezet, dan is het voor een ondernemer lastig om te zeggen van nou, we gaan nu dat ding sluiten	(BE) If you've only just set up a new factory, it's difficult for an entrepreneur to say, 'Right, we're going to shut that place down now'	Transition difficulty with current facilities.

Codes	Dutch quote	English quote	Explanation of attribution
Mandate	Er zit nog economische waarde in het in het en die fabriek. En dan zou je bijvoorbeeld wel kunnen zeggen als die er dus nog niet zo lang is koppel het dan op zijn minst of verplicht het dan in ieder geval die negatieve emissies mee te doen.	There is still economic value in that factory. And so, for example, you could say that if it hasn't been there for very long, then at the very least link it to the scheme or, in any case, make it compulsory for it to contribute to offsetting those negative emissions.	Conditional obligation for mandating CCS.
Mandate	De verplichting bij de efuals nu daar zie je dus inderdaad echt wel een push naar de productie van bio brandstoffen.	The requirement under the E-fuels well, there you can certainly see a real push towards the production of biofuels.	Mandate effect.
Mandate	Dus ik verwacht wel dat als wij een mandaat gaan stellen dat we dan ook die implementatie wat kunnen versnellen.	So I do expect that if we set out a mandate, we'll be able to speed up the implementation a bit.	Policy impact of a mandate.
Mandate	Dus ik denk dat het belangrijkste is dat zo'n mandaat op het juiste moment wordt ingevoerd.	So I think the most important thing is that such a mandate is introduced at the right time.	Policy timing is crucial.
Mandate	zo'n mandaat moet je wel, denk ik ook opstellen met oog voor de sector	I think you do need to draw up a mandate like that with the sector in mind	Context awareness of developing sector.
Mandate	Ik denk ook wel dat Als je zo een mandaat stelt het sowieso op Europees niveau op zijn minst moet zijn.	I also think that if you're going to set a mandate like that, it should at least be at European level.	Effectiveness of the mandate.
Mandate	Je moet Natuurlijk ook zorgen dat zijn mandaat, het het speelveld zo gelijk mogelijk houdt.	Of course, you must also ensure that his mandate keeps the playing field as level as possible.	Fairness between technologies.
Mandate	Het is dus ook altijd dan de vraag van, wat doet de politieke vervolgens mee?	So the question is always: what role does politics then play?	Dependence and uncertainty on effectiveness of mandate due to politics.
Mandate	Dat je in ieder geval op zijn minst inderdaad eerst de de carrot voorhoudt voordat je met de stick aan komt zetten.	That, at the very least, you do indeed dangle the carrot first before bringing out the stick.	Policy sequencing of a mandate in a developing sector.
Policy regarding Pilots	Je moet als onderzoeker wel de ruimte en de vrijheid hebben om te kunnen onderzoeken. Anders kan je het antwoord nooit achterhalen.	As a researcher, you do need to have the space and freedom to carry out your research. Otherwise, you'll never be able to find the answer.	Innovation condition.
Policy regarding Pilots	tot hoe groot zijn installatie nog onderzoek? Wanneer kom je op het punt dat het geen onderzoek meer te noemen is?	Up to what point is research into his installation still considered research? At what point does it cease to be called research?	Governance challenge when giving permits for research.

Codes		Dutch quote	English quote	Explanation of attribution
Policy Pilots	regarding	Nu zijn de impacts Misschien nog klein, lijkt het nog niet zo spannend? Is het cumulatieve effect van deze technologie nu niet zo groot, maar over 50 jaar komen we er ineens achter dat het misschien toch veel groter is.	At the moment, the impacts may still be small; it may not seem all that significant yet; the cumulative effect of this technology may not be that great right now, but in 50 years' time we may suddenly realise that it is, in fact, much greater after all.	Pilot risks with giving exemptions.
Policy Pilots	regarding	ga je, zoiets als onderzoek in eens in één keer toch op de markt brengen, terwijl we eigenlijk nog niet zeker weten of het veilig is.	Are you really going to launch something like this research onto the market all at once, when we're not actually sure yet whether it's safe?	Governance challenge when the risks are unknown.
Policy Pilots	regarding	je ziet vaak toch in een pilot fase dat energieverbruik nog hoger is dat de foodprint nog niet duidelijk is. Dan ja, dan is het lastig om d'r al credits voor te vragen.	You often find, after all, that during the pilot phase energy consumption is even higher and the food footprint isn't yet clear. In that case, yes, it's difficult to apply for credits for it just yet.	Behind on the actual risks with accounting for scale.
Policy Pilots	regarding	(Low TRL subsidies) Ik zou ook zeggen dat het een soort van grijs gebied of transitie is waar je daar dan inderdaad in terecht komt.	(Low TRL grants) I'd also say that it's a sort of grey area or transition phase that you do indeed find yourself in.	SDE requires TRL, but subsidies are given earlier for certain deployments.
Policy Pilots	regarding	Het maakt het soms wel moeilijker. Ook voor degene die de regeling uitvoeren van hoe gaan we zo'n project toetsen?	It does make things more difficult at times. It's also a challenge for those responsible for implementing the scheme: how are we going to assess a project like this?	Difficulty on judging new technological pilots.
Policy Pilots	regarding	Het is toch wel een heel andere nieuwe technologie, dus dat maakt het soms wel. Ook inderdaad voor de uitvoering best lastig Als we dat soort dingen inderdaad Toepassen. (SDE voor lagere TRL)	It is, after all, a completely different new technology, so that does make a difference sometimes. It's also quite tricky to implement, if we do apply that sort of thing. (SDE for lower TRL)	Institutional difficulty.
Policy Pilots	regarding	Dus in die zin zou ik zeggen dat innovatie daarin echt wel een belangrijke rol speelt, dus daar wil je graag wel op tijd in ieder geval iets aan beschikbaar hebben, waarbij dus ook nog geen keuze maakt in de richting die je wilt ondersteunen.	So in that sense, I'd say that innovation really does play an important role in this, so you'd certainly want to set aside some time for it, without having to make a choice just yet about which direction you want to support.	Importance of supporting all methodologies at this point.

Codes		Dutch quote	English quote	Explanation of attribution
Policy Pilots	regarding	(BECCS) niet per se iets wat we nou zeggen van nou, de (afvalverbranding) moet nu volle bak zeggen dat we die energiecentrales gaan neerzetten en meteen een capture plaats erachter zetten.	(BECCS) isn't necessarily something where we just say, 'Right, we need to go full steam ahead with (waste incineration) and build those power stations straight away, with a capture facility right behind them.'	Hesitancy on incentivise for BECCS (even though there might be economic worth)
Policy Pilots	regarding	je wilt wel ondernemer dan in ieder geval de optie bieden van Ga dan inderdaad die investering doen (in BECCS).	You want an entrepreneur to at least have the option of go ahead and make that investment (in BECCS).	Allow the option, even though issues remain.
Policy Pilots	regarding	(BECCS) En al is het maar om een groot project neer te zetten en eens te kijken van wat leren we hier nou van?	(BECCS) And even if it's just to get a major project off the ground and see what we can learn from it?	Allow the option, even though issues remain.
Policy Pilots	regarding	(mCDR) is het goed om dat gewoon te ondersteunen en of in ieder geval het onderzoek daarnaar te ondersteunen, zodat we in ieder geval zeker weten wat er mis kan gaan.	(mCDR) it would be a good idea to simply support this, or at least to support research into it, so that we can at least be certain of what could go wrong.	Risk understanding.
Policy Pilots	regarding	bij zo'n startup ja, een hele bestaansrecht staat of valt met hun technologie, dus Ik denk ook dat dat landschap ervoor zorgt dat we toch ook nu al moeten inzetten op dit soort technologie om om gewoon al te zorgen dat die kennis niet zomaar verloren gaat.	With a start-up, its exists depends on its technology, in this landscape we need to start investing in this sort of technology right now, simply to ensure that this knowledge isn't lost.	Innovation ecosystem requires current investment.
Scaling Issues		wij zelf zijn daar altijd een beetje voorzichtig mee, eigenlijk met elke technologie wel, Omdat we zeker willen weten dat de eerste milieu pack bepalen voordat we iets echt willen opschalen.	We're always a bit cautious about that ourselves – about every technology, really – because we want to be sure we've assessed the environmental impact before we actually scale anything up.	Risks to environment when scaling, and the consequence for policy.
Scaling Issues		Denk bijvoorbeeld aan CCU, maar dan met biogenen of atmosferische CO2 en kunnen we dan niet inderdaad zorgen dat zo technologieën op de markt terecht kunnen komen?	Take CCU, for example, but using biogenic or atmospheric CO2 couldn't we then indeed ensure that such technologies reach the market?	Scaling through non-CDR use of technologies.
Scaling Issues		Technologieontwikkeling ondersteunen met als doel dat het uiteindelijk kostenverwijdering doet, maar op korte termijn wat meer zoeken naar iets wat verkoopbaar is.	Support technology development with the aim of ultimately reducing costs, but in the short term focus more on finding something that can be sold.	Scaling strategy of utilising CCU/co-benefits.

Codes		Dutch quote	English quote	Explanation of attribution
Scaling Issues		Het is wel weer (SDE) een manier om implementatie op grote schaal toe te passen.	It is, after all, (SDE) one way of implementing it on a large scale.	Financial instrument role.
Scaling Issues		Ik denk dat Als je het inderdaad enkel op CCS zou moeten Laten terugvallen, dan wordt het inderdaad een hele lastige.	I think that if you really had to rely solely on CCS, it would indeed be quite a challenge.	Technology limitation in storage.
Scaling Issues		Het toch nodig is om zo'n stappen te maken om in ieder geval die uitrol te krijgen op grote schaal	It is, after all, necessary to take such steps in order to ensure that the roll-out goes ahead on a large scale	Scaling requires the deployment during less sustainable approaches, transition approach.
Scaling Issues		Je wilt gewoon wel die technologie van de grond krijgen en als je pas wacht totdat alles al verduurzaamd is, dan heb je het of niet meer nodig of je bent inderdaad te laat.	You just want to get that technology off the ground, and if you wait until everything has already been made sustainable, then either you won't need it anymore or you'll indeed be too late.	Timing argument for scaling CDR.
Theory practice	versus	wat dan dus lastig is en waar ik dan zelf ook nog geen duidelijkheid op heb is hoe dat er gaat gebeuren. Stel, je krijgt integratie met ETS. Hoe gaan we dan nog zorgen dat het toch nog gewoon twee losse doelstellingen blijven?	So what's tricky – and something I'm not entirely clear on myself – is how that's going to happen. Suppose we do achieve integration with ETS. How are we then going to ensure that they still remain two separate targets?	Policy gap.
Theory practice	versus	Er zijn Natuurlijk ook andere broeikasgassen die een negatieve impact hebben op het klimaat. Methaan is bijvoorbeeld, al Ik ben zelf altijd een beetje sceptisch over methaan filteren uit de lucht Omdat het over parts per billion gaat, maar ook daar zie je best wel wat tractie in ontwikkelingen in ontstaan.	Of course, there are other greenhouse gases that have a negative impact on the climate. Methane, for example – although I'm always a bit sceptical about filtering methane out of the air, as we're talking about parts per billion – but even there, you can see quite a bit of momentum building in developments.	Practical limitation of methane filtering.
Reaction on framing of DAPP		Veestapel verkleinen zou een mogelijkheid kunnen zijn om rest emissies bijvoorbeeld te verminderen.	Livestock reduction option.	Alternative inclusion in framing.
Reaction on framing of DAPP		Het is ook de vraag inderdaad hoe snel we naar renewables gaan.	It is indeed a question of how quickly we are moving towards renewables.	Uncertainty on how that impacts the framing.
Reaction on framing of DAPP		je hebt ook een stukje koolstof in je economie zitten, ligt er ook aan hoe groot die koolstof economie straks nog is.	There's also a bit of carbon in your economy; it also depends on how big that carbon economy will be in the future.	Structural factor on the need of DAPP.

Codes	Dutch quote	English quote	Explanation of attribution
Reaction on framing of DAPP	We gaan er toch wel vanuit dat onze koolstof economie gaat krimpen.	We think the carbon economy will shrink.	Transition expectation.
Reaction on framing of DAPP	Zou je dus aan de ene kant potentieel hebben om die koolstof in die economie vast te leggen, maar ook dat zal beperkt zijn.	So, on the one hand, you might have the potential to sequester that carbon within the economy, but even that will be limited,	Constraint view on alternative inclusion.
Reaction on framing of DAPP	(Koolstofeconomie) Aan de andere kant dat doen we nu Natuurlijk als mens ook al dus Wat voor winst is daar te behalen?	(Carbon economy) On the other hand, we're already doing that as humans, of course, so what sort of benefits is there to be had?	Uncertain gains in sequestering in the economy.
Undecided choice	Daarvoor zijn we ook wel bezig met zoeken van wat zou nou eigenlijk de de randvoorwaarden, die technologieën en voor Nederland toepasbaar kunnen maken?	To that end, we are also looking into what the pre-conditions might be that would make technologies applicable in the Netherlands.	Open question on requirements .
Undecided choice	Je zit toch wel een beetje met de vraag van, wat is het economische verdienvermogen met deze technologieën en dat soort vragen proberen we dus nu ook wel als (organisatie) te stellen.	You do find yourself wondering a bit about the economic potential of these technologies, and as (organisation) we're now trying to ask questions like that too.	Open question on the ability to make it work economically.
Undecided choice	Hebben we niet juist soms ook de tijdelijke oplossingen nodig die bijvoorbeeld de koolstof vastleggen in de menselijke economie.	Don't we sometimes also need temporary solutions that, for example, sequester carbon within the human economy?	Strategic uncertainty on how to best approach temporary CDR.
Undecided choice	Integratie ETS dat wordt voornamelijk Natuurlijk ook op Europees niveau uitgezocht of we dat willen gaan doen.	Integration of the ETS – this is, of course, being examined primarily at European level to determine whether we wish to proceed with it.	Governance uncertainty, although done at a different level.
Undecided choice	We weten nog niet welke richting we op willen, dus er gebeurt ook nog niet zoveel en ik denk dat dat ook een beetje met BECCS is.	We don't yet know which direction we want to go in, so not much is happening yet, and I think that's partly the case with BECCS as well.	Early-stage indecision.
Undecided choice	maar ze zijn ook een verwerker van afval, en zolang we nog gewoon afval hebben is het misschien lastig om ze te zeggen, We gaan ze niet meer gebruiken.	But they're also a waste processing company, and as long as we still have ordinary waste, it might be difficult to tell them, 'We're not going to use them any more.'	Transition challenge in use of BECCS or BE.

Coding Table for interview of P5, a person from a voluntary market party focusing on carbon farming and bio-based building.

Table 11: Coding for interview P5, displaying the Dutch and English, additions between () are context added for readability, some clean up was performed on the Dutch text.

Codes	Dutch quote	English quote	Explanation of attribution
Definition	Daar zijn allemaal modellen voor en aan die methodes, daar moeten wij ook voldoen.	There are all kinds of models for that and we also have to comply with those methods.	References formal definitions and methodological requirements.
Definition	dan zeggen ze eigenlijk, Als het in een gebouw is, zien we dat wel als permanentie op dit moment.	then they basically say, if it is in a building, we currently see that as permanence.	Defines permanence within existing methodologies.
Definition	Je moet berekenen tot aan het feit dat het de fabriek verlaat.	You have to calculate up to the point that it leaves the factory.	Defines accounting boundaries.
Economic trade-off	Technologische oplossingen of onder de grond, dat zijn zulke andere industrieën eigenlijk weer met hele andere belangen en ook investeringsvormen	Technological solutions or underground storage, those are really different industries again with very different interests and investment structures.	Highlights competing investment considerations.
Economic trade-off	commerciële bedrijven die trekken zich terug, want die gaan zeggen, dan zeggen de aandeelhouders, daar is geen rendement te behalen. Dat zie ik als een groot gevaar en we zitten best wel op zo'n kantelpunt.	commercial companies withdraw, because shareholders will say there is no return to be achieved there. I see that as a major danger and we are quite at a tipping point.	Economic viability influences participation.
Economic trade-off	Dan is er een markt ontstaan en die CSRD is een hele goed instrument, Maar door de politieke druk en door geopolitiek is dat teruggetrokken.	Then a market emerged and the CSRD is a very good instrument, but due to political pressure and geopolitics it has been scaled back.	Political developments affect economic incentives.
Economic trade-off	dan kom je nog op prijsniveau. De prijs is veel hoger dan alle internationale projecten, vaak wel factor 10.	then you also come to price levels. The price is much higher than all international projects, often by a factor of 10.	Cost differences shape decisions.
Economic trade-off	Dat is realistisch omdat de grond hier duurder is en alles is hier duurder en het zijn ook andere soortige projecten dan in het buitenland, ook binnen Europa.	That is realistic because land is more expensive here and everything is more expensive here and they are also different kinds of projects than abroad, even within Europe.	Explains higher costs.
Economic trade-off	Als je bedrijf economisch onder druk staat, dan koop je niet Omdat die prijsverschillen te groot zijn.	If your company is under economic pressure, then you do not buy because those price differences are too large.	Economic constraints limit uptake.

Codes	Dutch quote	English quote	Explanation of attribution
Economic trade-off	Dan worden dit soort middelen gewoon allemaal naar achter geschoven, omdat je je economie onder druk staat.	Then these kinds of measures are simply pushed back because your economy is under pressure.	Economic priorities outweigh climate investments.
Emissions accounting	De modellering die daar is zegt eigenlijk dat het aantoonbaar is, wetenschappelijk, dat CO2 wordt opgeslagen in de bodem en in gewassen.	The modelling there basically says that it is scientifically demonstrable that CO2 is stored in soil and crops.	Discusses quantification and accounting of carbon.
Financing	Zeg maar door de CSRD weer in te voeren	For example by reintroducing the CSRD.	References funding stimulus through policy.
Financing	Als we hier naar kijken dan is die CRSD, Hij heeft een enorm effect gehad, maar het is een goede impuls dan de overheid die opkoopt.	If we look at this, the CSRD has had a huge effect, but it is a better impulse than the government buying up.	Discusses financing mechanisms.
Financing	met mandjes werken, dan hoeven we dat dan zeggen ze, je koopt 90% in internationaal en 10% Nederlands. Maar dat is zo sporadisch nu. Dus Dat is een ook een hele belangrijke impuls,.	working with baskets, then they say you buy 90% internationally and 10% Dutch. But that is so sporadic now. So that is also a very important impulse.	Describes financial demand creation.
Financing	Dat commerciële bedrijf zoals ons de focus hebben op waar zit de handel want als daar geen handel is, gaan wij daar geen tijd in stoppen. En dan zou het nog interessante oplossingen zijn, maar dan moeten die veel meer vanuit de politiek komen.	Commercial companies like us focus on where the market is because if there is no market there, we are not going to spend time on it. And then there may still be interesting solutions, but those should come much more from politics.	Market activity determines investment.
Financing	Als je het commercieel doet, moet een verdien capaciteit voldoende zijn En er moet ook marge komen.	If you do it commercially, earning capacity must be sufficient and there also has to be a margin.	Financial feasibility is required.
Financing	Het gaat om rendement en een overheid heeft een heel ander vraagstuk over rendement. Want daar is klimaat en gezondheid en de economie en het welzijn. Dat zijn ook allemaal waardefactoren.	It is about returns and a government has a very different question regarding returns. Because climate, health, the economy and wellbeing are all value factors as well.	Contrasts public and private valuation.
Financing	De overheid die gaat daar een belangrijke rol in spelen en die moeten uiteindelijk vanuit de politiek transparant uit kunnen leggen en Laten zien Waarom ze iets doen en Waarom het geld daar aan besteed wordt.	The government will play an important role in that and must ultimately be able to transparently explain and show from a political perspective why they do something and why money is spent on it.	Government financing role.

Codes	Dutch quote	English quote	Explanation of attribution
Mandate	En er wordt besproken om CRCF onderdeel te laten worden en dan zullen daar spelregels aan worden gesteld,	And it is being discussed to make CRCF part of it and then rules will be established for it.	Refers to formal regulation.
Mandate	Waar ik ook een voorstander van ben is dat daar iets meer verplichting komt, dus los van de ETS op de vrijwillige markt.	What I am also in favour of is having somewhat more obligation there, separate from the ETS in the voluntary market.	Advocates mandatory measures.
Market conditions	Ik denk dat je hem zo kan stellen is dat de certificeren. In dit geval werken wij in Nederland met de SNK en ONCRA, dat die bepalen wat de spelregels zijn en van die gaan dan ook weer uit van de wetenschappelijke modellen.	I think you can put it this way, the certifiers. In this case we work in the Netherlands with SNK and ONCRA, they determine the rules of the game and they in turn rely on scientific models.	Describes market governance.
Market conditions	mijn instelling is, namelijk dat ik afhankelijk ben van wat er bij de certificeerde en wat er op Europese Unie niveau wordt besloten.	my position is that I am dependent on what is decided by the certifiers and what is decided at the European Union level.	Highlights dependence on market governance and regulatory decisions.
Market conditions	We hebben ons ook te houden aan die markt Omdat we behoefte hebben aan een betrouwbare markt waar betrouwbare partners met elkaar samenwerken.	We also have to comply with that market because we need a reliable market where reliable partners work together.	Emphasizes functioning market conditions and trust.
Market conditions	Ja ik merk steeds meer dat dat verdienmodel niet de bovenaan gaat voeren, dus mijn voorspelling is dat bij Carbon credits meer gezien moeten worden als icing on the cake.	Yes, I notice more and more that that revenue model will not take the lead, so my prediction is that carbon credits should be seen more as icing on the cake.	Discusses expected market value and incentives.
Market conditions	(ETS) Stel dat deze credits daar ook onderdeel van worden, dan worden ze verhandelbaar en dan worden ze onderdeel daarvan. Dan zal het hoogstwaarschijnlijk voor een beperkt gedeelte zijn.	(ETS) Suppose these credits also become part of that, then they become tradable and they become part of it. Then it will most likely only be for a limited portion.	Links market demand to ETS integration.
Market conditions	Deze markt anders zelfstandig denk ik dus, niet van de grond komt.	Otherwise, I think this market will not get off the ground on its own.	Addresses market viability.
Market conditions	Wij zijn echt wel fors opgeschoten in de afgelopen 5 jaar, Maar we hadden veel meer verwacht en veel meer snelheid en er wordt eigenlijk veel te weinig gekocht en veel te weinig geïnvesteerd	We have made substantial progress in the past 5 years, but we expected much more and much more speed, and actually far too little is being bought and far too little is being invested.	Reflects current market performance.

Codes	Dutch quote	English quote	Explanation of attribution
Market conditions	Omdat dit nog z'n jonge markt is, heeft het die impulsen nodig	Because this is still such a young market, it needs those impulses.	Describes immature market conditions.
Market conditions	grote corporates die eigenlijk veel uitstoten, waaronder ook de ETS bedrijven die zouden echt wel in Nederland willen inkopen onder een aantal voorwaarden dat ze de SNK en ONCRA kunnen toepassen en ook direct compliant zijn	large corporates that emit a lot, including ETS companies, would really like to purchase in the Netherlands under the condition that they can apply SNK and ONCRA and are directly compliant.	Explains requirements for market participation.
Market conditions	de offsetting daar wordt Alleen over naar gekeken naar projecten in het buitenland.	for offsetting, only projects abroad are being considered.	Contrasts domestic and international market preferences.
Market conditions	Dus insetting is eigenlijk Alleen nog maar interessant op dit moment in Nederland dus dan blijft het in die keten, dus ik voorzie wel dat dat de komende zeker de komende 5 jaar.	So insetting is really only interesting in the Netherlands at the moment, so it remains within that chain, and I do foresee that for at least the next 5 years.	Discusses expected market development.
Market conditions	een industriële partij in Nederland gaat zeggen uit economisch perspectief kocht ik altijd al in in in het buitenland. Ik heb geen enkele stimulans om dat anders te doen	an industrial party in the Netherlands will say: from an economic perspective I have always purchased abroad. I have no incentive whatsoever to do otherwise.	Economic incentives shape market behavior.
Moral hazard	Omdat Iedereen wel snapt van dat het heel lastig is om dan vast te stellen of dat zo'n pand nou 25, 50 of 75 jaar blijft staan,	Because everybody understands that it is very difficult to determine whether such a building will remain standing for 25, 50, or 75 years.	Questions certainty surrounding permanence claims.
Moral hazard	Maar het kan best zo zijn dat het op een gegeven moment de markt gaat imploderen, omdat er een te lange periode een stand stil is.	But it may well be that at some point the market implodes because there has been stagnation for too long a period.	Warns about systemic market risks.
Moral hazard	dan gaan Mensen leunen op het feit dat daar allemaal subsidiëring is, dus subsidies moeten kort en die moeten ook het doel hebben om te zeggen, dit is allemaal voor een impuls.	then people start relying on the fact that there is all kinds of subsidisation, so subsidies should be short and should have the purpose of saying: this is only meant as an impulse.	Highlights dependency risks created by subsidies.
Moral hazard	Omdat Iedereen wel snapt van dat het heel lastig is om dan vast te stellen of dat zo'n pand nou 25, 50 of 75 jaar blijft staan,	Because everybody understands that it is very difficult to determine whether such a building will remain standing for 25, 50 or 75 years.	Questions certainty of long-term outcomes.

Codes	Dutch quote	English quote	Explanation of attribution
Moral hazard	Maar het kan best zo zijn dat het op een gegeven moment de markt gaat imploderen, omdat er een te lange periode een stand stil is.	But it may well be that at some point the market implodes because there is stagnation for too long a period.	Highlights systemic risks.
Moral hazard	dan gaan Mensen leunen op het feit dat daar allemaal subsidiëring is, dus subsidies moeten kort en die moeten ook het doel hebben om te zeggen, dit is allemaal voor een impuls.	then people start relying on the fact that there are all kinds of subsidies, so subsidies should be short-term and aimed at giving an impulse.	Warns against dependency on support.
Policy regarding Pilots	het Nederlandse waterschap Vallei en Veluwe is het eerste waterschap in Nederland wat een Carbonfarming project heeft ingekocht. Bij ons en vorig jaar hebben ze daar een heel tenderproces van gemaakt en zij zijn echt wel voorloper in Nederland.	The Dutch water authority Vallei and Veluwe is the first water authority in the Netherlands that purchased a carbon farming project. From us, and last year they made a whole tender process out of it, and they truly are a frontrunner in the Netherlands.	Provides an example of a pilot procurement initiative.
Policy regarding Pilots	Ik heb ook aan die tender meegedaan Dat was voor hun ook een heel leerproces. Dan zie je gewoon hoe je je elkaar nodig hebt	I also participated in that tender. It was a major learning process for them as well. Then you simply see how much you need each other.	Emphasizes learning through pilot projects.
Policy regarding Pilots	Er moet een structuur zijn waarin die overheid gewoon kan inkopen en er moet een politieke wil zijn om te zeggen, dat er ingekocht moet worden of dat er ruimte is dat het mag gebeuren en volgens deze standaarden, dan heb je iets geïnstitutionaliseerd.	There must be a structure in which the government can simply procure, and there must be political willingness to say that procurement should take place or that there is room for it to happen according to these standards, then you have institutionalized something.	Discusses policy frameworks for scaling pilot initiatives.
Public support	Ik heb bijvoorbeeld zelf, een ketencontract gemaakt met Iedereen in die keten. Dat was niet een exacte verplichting, maar ik vond dat ook weer belangrijk om te laten zien hoe wij dit doen.	For example, I personally created a chain contract with everyone in that chain. It was not an exact obligation, but I considered it important to show how we do this.	Demonstrates efforts to build trust and support among stakeholders.
Reaction on framing of DAPP	Dus wellicht wellicht kan dit ook helpen, Omdat hier ook heel veel variabele zijn, waar door je eigenlijk nog de uitkomst, nog niet van weet.	So perhaps this could also help, because there are also many variables here, which means that you still do not know the outcome.	Highlights uncertainty in long-term scenario framing.
Reaction on framing of DAPP	Nee, heb ik niet. (on 5Gt)	No, I do not have that. (on 5Gt)	Expresses uncertainty regarding the scenario assumption.

Codes	Dutch quote	English quote	Explanation of attribution
Reaction on framing of DAPP	Het is een heel uitgebreid gebied met heel veel Invalshoeken en stakeholders.	It is a very extensive field with many perspectives and stakeholders.	Emphasizes complexity of the system.
Reaction on framing of DAPP	Maar dat vind ik heel moeilijk, hè? Ik vind dat die 2050 al al heel, heel moeilijk is laat staan 2100.	But I find that very difficult, you know? I already find 2050 very, very difficult, let alone 2100.	Questions the validity of long-term forecasting.
Reaction on framing of DAPP	Ik snap dat je dat soort voorspellingen moet doen en en modellen maar omdat de complexiteit zo groot is. Ja zou ik eerder kijken naar inderdaad 2040 en 2050	I understand that you have to make those kinds of predictions and models, but because the complexity is so large, I would rather look at 2040 and 2050.	Advocates shorter planning horizons.
Reaction on framing of DAPP	nou denk ik dat die 2040 vrij realistisch kan worden gezien, maar 2100 nou ja, dat dat ja, daar zou ik niet zoveel over kunnen zeggen.	Well, I think 2040 can be seen as fairly realistic, but 2100, well, I could not really say much about that.	Expresses confidence in near-term rather than long-term scenarios.
Scaling Issues	Boeren in transitie, die kunnen voor verschillende scenario's kiezen en één is carbon farming en dat zien we echt wel potentie en ik zie nog het meeste potentie dat die gewassen dan gebruikt wordt in de bouwsector.	Farmers in transition can choose between different scenarios and one is carbon farming, and we certainly see potential in that, and I see the greatest potential in those crops being used in the construction sector.	Discusses scaling opportunities through linking carbon farming to larger end-use markets.
Scaling Issues	Het zou iets meer sturing kunnen krijgen en dat begint al bij de overheid zelf die zegt wij gaan voor onze uitstoot kopen. Ja, en dat gebeurt niet, want de overheid kan dat ook gewoon besluiten	It could receive somewhat more direction, and that already starts with the government itself saying that we are going to buy compensation for our emissions. Yes, and that is not happening, because the government could simply decide that.	Identifies government demand as a mechanism for scaling the market.
Scaling Issues	je kan heel goed uitrekenen wat die ministeries allemaal uitstoten. En dan kun je heel makkelijk zeggen, We gaan dat compenseren voor hè al en dan kan je ook zeggen, goh, we doen dat voor voor 25% uit Nederlandse projecten. Is helemaal niet ingewikkeld en dan ben je klaar	You can very easily calculate what all those ministries emit. And then you can very easily say, we are going to compensate for all of that, and say, well, we will do 25% of that through Dutch projects. It is not complicated at all and then you are done.	Illustrates a practical pathway for increasing demand and scaling domestic projects.

Codes	Dutch quote	English quote	Explanation of attribution
Scalling Issues	in het bedrijfsleven, daar is nu een fonds voor opgezet, Ik vind dat goed, mits het kort is, want als dat te lang duurt dan komt die markt weer niet op gang.	In the business sector, a fund has now been established for that. I think that is good, provided it is temporary, because if it lasts too long then the market will not get going again.	Discusses temporary support measures to stimulate scaling.
Scalling Issues	Dus die drempel moet weg die moet er echt vanaf. (compliance) want nu kopen ze in met Vera een gold Standard, wat ook al jarenlang als compliant wordt gezien,	So that barrier has to disappear, it really has to be removed. (compliance) because now they purchase through Verra and Gold Standard, which have been considered compliant for years already.	Highlights regulatory barriers limiting market growth.
Scalling Issues	We moeten de drempels weghalen zodat corporate gewoon kunnen inkopen. De CSCF gaat daar absoluut bij. Bijdrage verwachtte ik,	We need to remove the barriers so that corporates can simply purchase. I expect the CRCF to absolutely contribute to that.	Suggests standardisation and compliance frameworks as scaling mechanisms.
Scalling Issues	daar zal de overheid wezenlijk voortouw moeten blijven geven. Om te zoeken ook naar onderdelen die het bedrijfsleven minder snel zou oppakken of zou kunnen oppakken.	The government will have to continue taking a substantial leading role there. Also in identifying components that the private sector would be less likely to take up or be able to take up.	Describes the government's role in enabling large-scale deployment.
Setting of goals	dat parijs akkoord en de aantallen die er staan en de miljpalen die getrokken worden is 2040 en 2050. Dus de reductie die dan plaats moet vinden op CO2 niveau en het feit dat we naar nul uitstoot moeten. Die zou je als benchmark kunnen nemen.	The Paris Agreement and the targets stated there and the milestones that have been set are 2040 and 2050. So the reduction that must take place at the CO ₂ level and the fact that we have to move towards zero emissions. You could use those as a benchmark.	References established climate targets as benchmarks for goal setting.
Setting of goals	Er zijn verschillende uitgangspunten, één uitgangspunt is Natuurlijk Parijs akkoord.	There are various starting points, and one starting point is of course the Paris Agreement.	Identifies the Paris Agreement as a key reference point for setting goals.
Setting of goals	Dus ze dwingen om te vernieuwen en dan zie je dat die vernieuwing gewoon cruciaal is om eerst te zorgen dat je überhaupt niet uitstoot. Om daarin ja, echt te versnellen daar geloof ik in.	So they force innovation, and then you see that this innovation is crucial to first ensure that you do not emit at all. I believe in really accelerating that process.	Links climate goals to technological innovation and emission reduction.

Codes		Dutch quote	English quote	Explanation of attribution
Shifting definitions	defini-	Als het in de bouw is, dan gaat het over permanentie. Hoe lang zit dat materiaal dan in die bouw? Ja, nou, daar zijn nog niet hele strikte regels over	If it is in construction, then it concerns permanence. How long does that material remain in that construction? Well, there are not yet very strict rules about that.	Shows that definitions of permanence are still evolving.
Shifting definitions	defini-	Dan gaat het ook om weer twee varianten en dan is er één variant die zegt, ja, Je moet ook nog aantonen dat het in welk pand het zit. Dat pad hebben ze een beetje verlaten, daar was ik heel blij mee, want dat had het heel complex gemaakt.	Then there are again two variants, and one variant says that you must also demonstrate in which building it is located. They have somewhat moved away from that approach, which I was very happy about, because it would have made things very complex.	Illustrates changing methodological requirements over time.
Shifting definitions	defini-	Je moet eigenlijk aantonen dat je het geproduceerd hebt. Want als het In de bij de groothandel ligt, dan dan wordt het ook toegepast.	You essentially have to demonstrate that you produced it. Because if it is at the wholesaler, then it will also be used.	Demonstrates a shift in how evidence and eligibility are defined.
Theory practice	versus	De andere kant is van dat is allemaal in de bodem of in het gewas. Wat gebeurt er dan met het gewas? Want het feit dat we het in het gewas zit zegt niet zoveel, want het wordt verwerkt.	The other side is that it is all in the soil or in the crop. What then happens to the crop? Because the fact that it is in the crop does not say very much, because it gets processed.	Questions whether theoretical carbon storage assumptions hold throughout practical value chains.
Theory practice	versus	wat je ziet in de bouwsector is, die gaan uit van die 35, of dat nou temporary of permanent is dat speelt daar ook veel minder.	What you see in the construction sector is that they work with those 35 years, and whether that is temporary or permanent matters much less there.	Highlights a difference between theoretical permanence debates and practical industry application.
Theory practice	versus	Dat het Een betrouwbare Markt wordt, Dat is veel belangrijker.(dan temporary or permanent)	That it becomes a reliable market is much more important. (than temporary or permanent)	Emphasizes practical market functionality over conceptual distinctions.
Theory practice	versus	Dus en er gebeuren ook dingen. De overheid investeert bijvoorbeeld met building balance in in 200 miljoen in biobased bouwen. Dan denk je, ja, nou, we stoppen er geld in, maar verstoren ze de hele markt. Dus dat heeft ook weer risico's	And things are happening as well. For example, through Building Balance the government invests 200 million in biobased construction. Then you think, well, we are putting money into it, but are they disrupting the entire market? So that also brings risks.	Illustrates how practical policy interventions can have unintended consequences.

Codes		Dutch quote	English quote	Explanation of attribution
Theory practice	versus	die kopen internationaal in en dat komt omdat we afgestemd hebben dat er een aantal voorwaarden aan moeten voldoen. En Dat is onder andere ook de sociale component, en die is er in Nederland niet. We zijn een te rijk land.	They purchase internationally, and that is because we have agreed that a number of conditions must be met. One of those is the social component, and that is not present in the Netherlands. We are too wealthy a country.	Shows how practical implementation differs from theoretical local sourcing ambitions.
Theory practice	versus	Dat is ook wel een beetje mijn kritiek op op deze hele sector, dat het overgecompliceerd wordt en dat er te weinig gesproken wordt over pragmatische oplossingen die tot geld en opbrengsten leiden	That is also somewhat my criticism of this entire sector, that it is becoming overcomplicated and that too little is being said about pragmatic solutions that lead to money and returns.	Contrasts theoretical complexity with practical outcomes and incentives.
Theory practice	versus	Dat zal dan een kwaliteitsstempel (CRCF) zijn maar die moet dan ook wel compliant worden, dus die moet eigenlijk op hetzelfde niveau komen als als Vera en gold Standard. En als dat gebeurt, dan hebben we wel weer een hele sprong gemaakt.	That will then be a quality label (CRCF), but it must also become compliant, so it should essentially reach the same level as Verra and Gold Standard. And if that happens, we will have made a major step forward.	Discusses the practical requirements for theoretical standards to become usable in the market.
Theory practice	versus	Mijn inschatting is wel is dat we dit niet in Nederland kunnen oplossen Met Alleen carbon farming en biobased achtige oplossingen	My assessment is that we cannot solve this in the Netherlands with only carbon farming and biobased-type solutions.	Highlights limitations of theoretically attractive solutions when applied in practice.
Undecided choice		of het wordt toegelaten tot de ETS twee of ETS 3 straks is is aan aan de politiek	Whether it will be allowed into ETS 2 or ETS 3 in the future is up to politics.	Indicates uncertainty because the decision depends on future political choices.
Undecided choice		we zitten nog heel erg in die explorerende fase. Waarin er nog teveel onzekerheden zijn	We are still very much in that exploratory phase, in which there are still too many uncertainties.	Reflects ongoing uncertainty and the absence of a clear strategic direction.
Unjustified method		Je moet snappen hoe het geld werkt, want anders er kan iets wel interessant zijn, maar hoe interessant het ook in het buitenland is, dan houdt het gewoon op.	You have to understand how the money works, because otherwise something may be interesting, but no matter how interesting it is abroad, at some point it simply stops.	Argues that approaches lacking economic feasibility are not justified in practice.

Appendix D: Pathway creation

In the following appendix the tables providing a justification for the creation of each pathway map gets presented. Next to a table providing an overview for the framing of who is responsible for the action. The tables should be read as in relation to one-another and to their respective pathway maps.

Table 12: Primary actor responsible for the implementation of actions considered in the pathway maps.

Action	Action framed as (taken by)
Permanent	
Create CCS-hubs	State-owned company
Subsidise DACCS deployment	Government subsidy
Subsidise CCS	Government subsidy
Subsidise use of BECCS	Government subsidy
Subsidise CCS R&D	Government subsidy
Subsidise Mineralisation R&D	Government subsidy
Subsidise Mineralisation deployment	Government subsidy
Allow storage Groningen	Government decision
Retrofit current BE Facilities	Government mandate
Require use CCS	Government mandate
Temporary	
Reforestation	Government procurement
Creation of new forests	Government procurement
Subsidise wood building	Government subsidy
Enhanced carbon farming	Government subsidy
Soil-carbon sequestration	Government subsidy
Policy/innovation	
Carbon bank	Government procurement
ETS-tax	EU — additional Dutch government
Invest in R&D	Government subsidy
New-technology	Government subsidy

The pathway table showing the justification for pathway one is present within the main body of the report, Table 4.

Table 13: Justification for inclusion or exclusion of actions in pathway map 2 Mandatory long-term storage, X=Yes, O=No.

Action	Included	Reason for (non)inclusion	Timeline framing
Permanent			
Create CCS-hubs	X	Indirect subsidy	Dependence for scaling in 2040 (Roadmap)
Subsidise DACCS deployment	X	Direct subsidy of permanent method	Likely no significant potential before 2050, limit storage CCS
Subsidise CCS	O	Subsidy of storage method, changed to mandate	O
Subsidise use of BECCS	X	Direct subsidy of permanent method	Potential when sink is available, limit storage sink
Subsidise CCS R&D	X	Developmental subsidy of permanent method	To account for increase storage using saline aquifers
Subsidise Mineralisation R&D	X	Developmental subsidy of permanent method	Dependence for scaling, mainly financial
Subsidise Mineralisation deployment	X	Direct subsidy of permanent method	Large potential if economics works out, highlighted in later stages due to current costs
Allow storage Groningen	X	Policy decision on permanent sink	Policy decision which would largely negate limitation of storage size CCS
Retrofit current BE Facilities	O	Included in BECCS, Excluded to differentiate from other map	O
Require use CCS	X	Mandate change to CCS if currently not using	A requirement to utilise CCS based removals could be effective till storage is full, likely to increase the speed at which capacity is reached
Temporary			
Reforestation	O	Temporary action excluded	O
Creation of new forests	O	Temporary action excluded	O
Subsidise wood building	O	Temporary action excluded	O
Enhanced carbon farming	O	Temporary action excluded	O
Soil-carbon sequestration	O	Temporary action excluded	O
Policy/innovation			
Carbon bank	X	Indirect subsidy	Used as impulse, could continue to contribute at high public cost, therefore post 2050 only in combination
ETS-tax	X	Mandate	As fewer credits are awarded, there is a high chance that revenue stagnates/decreases thus only in combination post 2045
Invest in R&D	X	Developmental subsidy of potential permanent method	Dependence for new technology, used in combination after 2040 because it will not allow for scale on its own
New-technology	X	Included to cover developing permanent methods	Possible large potential, if sufficient R&D has been done

Table 14: Justification for inclusion or exclusion of actions in pathway map 3: Voluntary market, X = Yes, O = No.

Action	Pathway map 3	Reason for (non-)inclusion	Timeline framing
Permanent	Included		
Create CCS-hubs	X	Indirect subsidy through enabling infrastructure.	Dependence for scaling in 2040 (Roadmap).
Subsidise DACCS deployment	X	Direct subsidy of a permanent removal method.	Likely no significant potential before 2050 due to limitations in CCS storage availability.
Subsidise CCS	O	Excluded for simplicity, as support is incorporated within CCS hubs and individual methods.	O
Subsidise use of BECCS	X	Direct subsidy of a permanent removal method.	Included to highlight the theoretical potential of BECCS.
Subsidise CCS R&D	O	Excluded for simplicity, as support is incorporated under general R&D measures.	O
Subsidise Mineralisation R&D	X	Developmental support for a permanent removal method.	Dependence for scaling, mainly through financial support.
Subsidise Mineralisation deployment	X	Direct subsidy of a permanent removal method.	Large potential if economic viability can be achieved.
Allow storage in Groningen	O	Policy decision regarding permanent CO ₂ storage.	Excluded for simplicity and space considerations.
Retrofit current BE facilities	X	Included to show the potential of retrofitting existing facilities.	Theoretically could provide sufficient removals to contribute significantly to demand by 2050.
Require use of CCS	O	Mandate excluded.	O
Temporary			
Reforestation	X	Separated from wood building to highlight additionality risks.	Limited potential in the Netherlands, but likely high political acceptability.
Creation of new forests	X	Included as a temporary removal method with limited potential.	Limited potential in the Netherlands due to land constraints.
Subsidise wood building	X	Separated from forest creation to highlight biomass sourcing issues.	Potential is insufficient to fully meet demand; full implementation is unlikely.
Enhanced carbon farming	X	Included as a temporary removal method with modest potential.	Limited potential in the Netherlands.
Soil-carbon sequestration	X	Included as a temporary removal method with uncertain potential.	Biomass sourcing and storage duration create uncertainty; likely to play a small role in the Netherlands.
Policy/innovation			
Carbon bank	O	Indirect subsidy mechanism.	O
ETS-tax	O	Mandate excluded.	O

Action	Pathway map 3	Reason for (non-)inclusion	Timeline framing
Invest in R&D	X	Developmental support for emerging CDR methods.	Included to account for the need to improve CDR methods; potential remains uncertain.
New technologies	X	Included to represent emerging CDR approaches.	Includes methods such as ocean alkalinity enhancement and DOCCS; future potential depends on technological development and deployment.

Table 15: Justification for inclusion or exclusion of actions in pathway map 4: Temporary storage under regulation, X = Yes, O = No.

Action	Included	Pathway map 4	Reason for (non-)inclusion	Timeline frame
Permanent	Included			
Create CCS-hubs	X	Indirect subsidy	Dependence for scaling in 2040 (Roadmap)	
Subsidise DACCS deployment	X	Direct subsidy of permanent method	Likely no significant potential before 2050, limited by CCS storage availability	
Subsidise CCS	O	Excluded for simplicity, incorporated in CCS-hubs	O	
Subsidise use of BECCS	X	Direct subsidy of permanent method	Highlight of theoretical potential, limited by storage and biomass sourcing	
Subsidise CCS R&D	O	Excluded for simplicity	O	
Subsidise Mineralisation R&D	X	Developmental subsidy of permanent method	Dependence for scaling, mainly financial	
Subsidise Mineralisation deployment	X	Direct subsidy of permanent method	Large potential if economic viability can be achieved	
Allow storage in Groningen	O	Policy decision on permanent sink	Excluded for simplicity and space considerations	
Retrofit current BE facilities	X	Mandate, included to differentiate from other pathway maps	Theoretically could reach the demand needed by 2050	
Require use of CCS	O	Mandate to switch to CCS if currently not using it	O	
Temporary				
Reforestation	X	High political feasibility	Limited potential in the Netherlands, likely high political acceptability	
Creation of new forests	X	Small-potential temporary method	Space constraints and limited potential	
Subsidise wood building	X	Combination with other temporary methods to differentiate risk evaluation	Medium potential, with difficulties in scaling up	
Enhanced carbon farming	X	Small-potential temporary method	Limited potential in the Netherlands	
Soil-carbon sequestration	X	Small-potential temporary method	Uncertain potential, with limited potential due to biomass sourcing	
Policy/uncertain				
Carbon bank	O	Excluded for simplicity	O	
ETS-tax	X	Included to display the financial aspect	Highlights that, in the short term, a general investment impulse may achieve a similar effect to supporting specific technologies	
Invest in R&D	X	Developmental subsidy of potential permanent methods	Long investment time needed	

Action	Included	Pathway map 4	Reason for (non-)inclusion	Timeline frame
New technologies	X	Included to cover developing permanent methods	There is large uncertainty regarding the speed and proliferation of new technologies; this pathway illustrates this uncertainty	