Carbon Capture and Storage in the Netherlands

Protecting the growth paradigm?

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A qualitative research into the impact of the policy choice for CCS in relation to decoupling and degrowth policy strategies

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Abstract

Current environmental policies often focus on decoupling economic growth from environmental degradation. An alternative environmental strategy is degrowth: *"the equitable downscaling of production and consumption that increases human wellbeing and enhances ecological conditions at the local and global level"* (Schneider et al., 2010:512). This decoupling vs. degrowth debate can be applied to the Dutch environmental policies, regarding the choice for Carbon Capture and Storage (CCS). This thesis has analysed the impact of the Dutch policy choice for CCS on the themes of climate, living environment, energy, economy and ethics, in regard to decoupling and degrowth policies. While CCS is found to be essential for the energy transition, several negative impacts are also found. The current emphasis on CCS in the Dutch policies is too large, which is partly since the feasibility of CCS at the proposed scale has not yet been proven. The public acceptance of CCS has been very low. However, the proposition of offshore CCS and the abolition to implement CCS at coal-fired powerplants, has reduced this opposition. Furthermore, CCS is a costly method for an interim solution to reduce emissions, especially since CCS could be seen as a method to delay the inevitable change toward renewable energy. It can therefore be agreed upon that CCS is not the ideal solution to combat climate change and reduce the environmental crisis. However, due to the time concerns it is imperative that emissions levels go down instantly to reduce the impacts of climate change. It is therefore imperative to ensure CCS is only used as an interim solution, while not hampering the renewable energy transition.

When linking the debate on CCS to the impact of decoupling and degrowth environmental policies, CCS seems to be a perfect example of decoupling policies. While decoupling does not offer a complete solution, neither does degrowth since our current economic system and political will are not adaptable to a sudden systemic change. A revolution seems inconceivable, perhaps an evolution can lead our society towards a sustainable degrowth-like state. However, since the current climatic and environmental issue are urgent, there is no time to wait for an evolution. Therefore, both decoupling and degrowth policy measures should be implemented to combat climate change and reduce our environmental impact.

Key concepts: *Carbon Capture and Storage, Impact, Decoupling, Degrowth, Environmental policies.*

Preface

When I first started this master programme – Sustainable Development – I enrolled in the track International Development. During my two years in this program I began to realise that my true interest laid more with Sustainability than with International Development.

During the first paper I wrote for this programme, I looked into Bhutan. A country that has dismissed GDP as a measure for well-being, and instead uses the Gross National Happiness index. This notion has remained in the back of my head for the last two years. How is it possible that we aim for everlasting economic growth, while it has been proved again and again that money (after a certain threshold) does not improve happiness? Additionally, why do we maintain this growth obsession while it is the origin of all the current environmental and climatic issues? I mean we live on a finite planet, how is everlasting growth possible on a finite world?

During the course Environmental Ethics, I looked into the ethics of the Dutch Coalition Agreement regarding their climate policies. Was the Netherlands doing enough to take their responsibility in the collective action problem of climate change and the environmental crisis?

In this thesis I try to combine these two topics, by doing a qualitative research into the impact of the policy choice for CCS in relation to decoupling and degrowth policy strategies.

I would like to thank all my respondents for the time they took for answering all my questions. Furthermore, I would like to thank Dr. Kei Otsuki and Dr. Mucahid Bayrak for their feedback, Guus Hermans for his read-throughs, and my fellow student, Lisette Goes, for her advice and moral support.

Jimmy Mulkens
13th of August 2018, Utrecht

Abbreviations

BECCS	Bio-Energy with Carbon Capture and Storage
CATO	CO2 Afvang, Transport en Opslag
	the Dutch national R&D programme for CCS
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CO2	Carbon dioxide
CPB	Bureau for Economic Policy Analysis
EOR	Enhanced Oil Recovery
EU	European Union
ETS	(European) Emission Trading Scheme
GDP	Gross domestic product
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
NIMBY	Not In My Backyard
NUMBY	Not Under My Backyard
OECD	Organisation for Economic Co-operation and Development
PBL	Netherlands Environmental Assessment Agency
ROAD	Rotterdam Storage and Capture Demonstration project
SDE+	Renewable Energy Grant Scheme
SDGs	Sustainable Development Goals
TNO	Netherlands Organisation for Applied Scientific Research
UNEP	The United Nations Environment Programme
WRR	The Scientific Council for Government Policy

Introduction

Introduction sustainability issue

The growth debate is not a new phenomenon. Malthus stated in 1798 that since population grows exponentially it would exceed the linear food production, leading to population expansion beyond subsistence levels (Malthus, 1807). In 1972, the 'Limits to Growth' report predicted an overshoot and collapse of the environment, economy and population (Meadows et al., 1972). According to Kallis et al. (2009), the 2008 crisis was caused by unsustainable growth. Schneider et al. (2010) argued that the crisis offered an opportunity to restructure the economy by taking the planetary boundaries and social equality into account. However, this opportunity has not been seized.

Decoupling vs. Degrowth

Current environmental policies often focus on *decoupling* economic growth from environmental degradation. Decoupling is the foundation of environmental strategies as Green Growth or Sustainable Development. The United Nations Environment Programme (UNEP) defines decoupling as *"using less resources per unit of economic output and reducing the environmental impact of any resources that are used or economic activities that are undertaken"* (UNEP, 2011:4). A lot of scepticism arose on the feasibility of decoupling. Enhancing the efficiency of economic output would result in a rebound effect of increased production and consumption, leading to limited or no environmental benefits (Schneider et al., 2010; Conrad & Cassar, 2014). The UNEP stated that *"resource and impact decoupling are already taking place, though at an insufficient rate to meet the needs of an equitable and sustainable society"* (UNEP, 2011:74). Additionally, despite environmental policies, global CO_2-emissions have only increased since 1990 (Olivier et al., 2017). This question whether we can solve the environmental crisis through the same growth focussed economic system that caused it?

Perhaps an alternative to the decoupling policy strategy is needed to ensure a sufficient reduction in environmental degradation. *Degrowth*, offers such an alternative. According to Schneider et al. (2010:512) degrowth is *"an equitable downscaling of production and consumption that increases human wellbeing and enhances ecological conditions at the local and global level, in short and long term"*. Latouche (2003:18) argues that a degrowth society is *"built on quality rather than on quantity, on cooperation rather than on competition [...] The motto of degrowth aims primarily at pointing the insane objective of growth for growth"* (Martínez-Alier et al., 2010:1742).

Carbon Capture and Storage

This decoupling vs. degrowth debate can be applied to the Dutch environmental policies. In 2017, the coalition agreement 'Confidence in the Future' of the Rutte-III cabinet was presented. Rutte-III, presented itself as 'the greenest cabinet ever', by proposing a 49% (56 Mton) reduction in greenhouse gas (GHG) emissions by 2030. More than 1/3rd of this reduction would take place through Carbon Capture and Storage (CCS). CCS is the process of capturing carbon from the emissions of powerplants or industrial processes, compressing and transporting it as liquid carbon, and then storing it in gas or oil reservoirs (Hazseldine, 2009). CCS thus facilitates the continued use of fossil fuels. It can therefore be seen as a decoupling policy strategy, since it promotes economic growth while reducing emissions and thus environmental degradation. This decoupling CCS is often seen as a short term interim solution to realize the emission reduction proposed in the Paris Agreement, while working long term on a transition from a fossil based to a renewable energy system. However, Rutte-III states that the funds for CCS will come from the SDE+ (Renewable Energy Grant Scheme) grant (Regeerakkoord, 2017). Indicating that funds that were previously available for renewable energy will also be used for decoupling CCS. This questions Rutte-III's environmental intentions as this measure protects the status quo of the growth focussed economy, while reducing the investment in truly green alternatives and addressing the cause of the problems.

At the other side of this technological based decoupling CCS, a different type of carbon storage strategies is found which is more related to degrowth. These strategies focus on soil carbon sequestration, which uses the soil's ecosystem service of soil carbon storage. This can be done through regenerative agriculture, which consists of techniques that restructure soil and sequester carbon. This type of degrowth CCS can therefore offer a more ecological and less impactful method of carbon storage. Furthermore, there are additional effects such as reduced soil erosion, remineralisation of soil, enhancement of water pureness, reduced need for pesticides and fertilizers, and a reduction in their runoff (Eisenstein, 2015). According to Lal (2004), carbon sequestration has the capability to offset GHG emissions by 0.4-1.2 Gton/yr. Research at the Rodale Institute (2014), argues that global implementation of regenerative agriculture on cultivated land could even offset 40% of global GHG emissions. This soil carbon sequestration strategy could therefore be called degrowth CCS, since it is not a techno-fix solution, it is less focussed on growth (it costs more time and money), and it is more in harmony with nature by not just focussing on carbon storage. Additionally, this degrowth CCS strategy is a bottom-up initiative, while decoupling CCS can be seen as top-down.

Knowledge gap and problem definition

Rutte-III's emphasis on decoupling CCS as a method of CO2-emissions reduction raises questions on the effectiveness of the technique. Scott et al. (2013) argue that we should focus on a decline in demand, renewable energy, and energy efficiency. However, since the scale of these measures is insufficient in short time, CCS provides an effective interim solution to prevent additional environmental degradation. This is confirmed by the IPCC (2014), who state that most modelling scenarios require decoupling CCS to reach the emissions targets. However, according to the Netherlands Environmental Assessment Agency, Rutte-III's intended reduction of 56 Mton is not feasible since the proposed measures will only generate a reduction of 11-26 Mton (Tielbeke, 2017; Giebels, 2017). Will CCS thus be able to provide an effective tool to reduce emissions, comply with the Paris agreement, and reduce environmental degradation?

Apart from its feasibility to combat climate change, it is also important to understand the wider impact of the projects to improve their feasibility and effectiveness. Therefore, this thesis tries to evaluate the decoupling and degrowth CCS projects through their impact on climate, living environment, energy, economy, and ethics, based on research done by CATO (2018a, see §1.3). All the research done on CCS in the Netherlands mainly focusses on public acceptation of CCS (Terwel et al., 2012; Terwel & Daamen, 2012; Krause et al., 2014). Furthermore, this research has been places within the Dutch context and government policies. Internationally, the impact of CCS has mainly been analysed according to their environmental and climatic impact, or social impact. No research has been found that has a more holistic approach to the impact of CCS by looking into more themes. By analysing the impact of CCS on these five themes, this thesis tries to close this gap.

Additionally, the debate on CCS has not been linked to the effectiveness of decoupling and degrowth policy strategies. Will decoupling strategies be sufficient for the needed reduction in environmental degradation? Or will alternative degrowth strategies be needed to sufficiently reduce environmental degradation? This thesis will thus try to fill this research gap by conducting a qualitative research with in-depth interviews with experts on CCS, and four case studies on Dutch CCS projects as an example of the effectiveness of decoupling and degrowth environmental policies.

Research objective and research questions

The research objective of the thesis is to evaluate the impact of CCS on the five aforementioned themes. The analysis of the impact of CCS will be based on the findings of the interviews, case studies, and the impact of environmental decoupling and degrowth policy strategies. The external aim of this research is to contribute to the effectiveness of Dutch environmental policies, by offering policy recommendations on decoupling and degrowth policy strategies and CCS. This will be done through the following research questions:

What are the implications of the Dutch government's choice for CCS as one of the main climate policies in relation to decoupling and degrowth strategies?

- What has been learned from previous CCS projects?
- What aspects of the political landscape influence CCS policies?
- What is the impact of decoupling and degrowth policies?
- What impact does the Dutch policy choice for CCS have on the climate, living environment, energy, economy, and ethics?

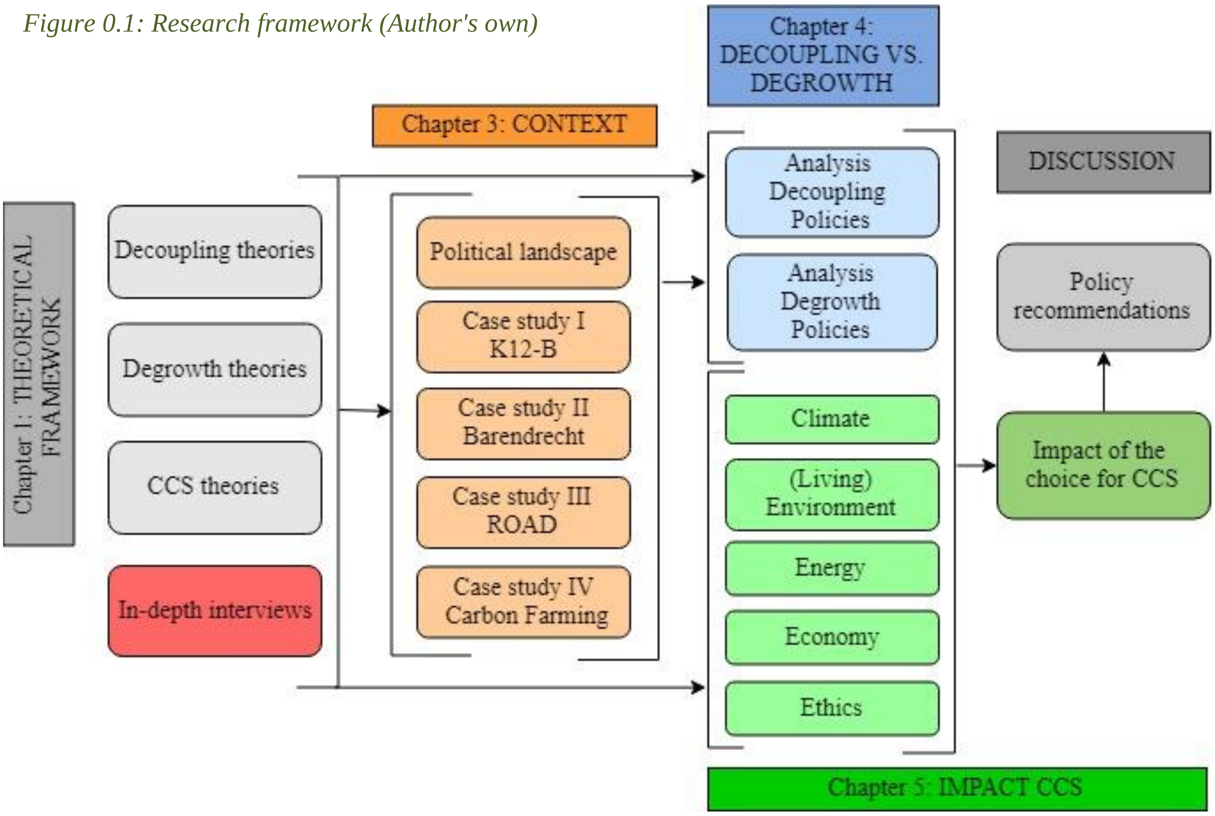
Scientific and societal relevance

The findings of this thesis will contribute to a better understanding of the role CCS can play in reducing climatic and environmental degradation and the other impacts CCS can have on energy, economy and ethics. Furthermore, the effectiveness of decoupling and degrowth policy strategies will also be discussed. It will thus strengthen the body of scientific literature on the topic. Moreover, the findings will contribute to practical solutions by forming policy recommendation. Since there is a lot of public opposition to CCS, the findings can contribute at a social level by reducing the insecurities of the effects of CCS. Additionally, the findings can contribute at global level. As stated in the 12th goal of the Sustainable Development Goals, it is important to ensure responsible production and consumption by reducing our ecological footprint. This thesis will contribute to whether this can be done in a decoupling or degrowth manner. Moreover, the 13th goal indicates the urgency for collective climate action (UNDP, 2018). The Netherlands, as a developed and industrialized country has contributed more to environmental degradation than developing countries, while the latter will sustain more damage from the environmental crisis due to geographical location and limited resources (Parks & Roberts, 2006). This climate injustice is another reason the Netherlands should take their responsibility and ensure that their environmental policies are effective enough.

Research framework

The nature of this research will be an intervention-oriented research. According to Verschuren & Doorewaard (2010:77), "Intervention-oriented research aims at analysing the implementation of the proposed design intended to solve the diagnosed problem", in which the implementation of the proposed design are the CCS policies, and the diagnosed problem climate change. The research framework offers a schematic visualisation in figure 0.1, to create a better understanding and overview of the needed activities.

Figure 0.1: Research framework (Author's own)



Outline thesis

In figure 0.1 the different components of the thesis are visible. Chapter 1 is the theoretical framework which will entail theories on decoupling, degrowth, and CCS. Chapter 2 is the methodology which regards the research design, the data collection and analysis. Chapter 3 is a contextual chapter on the case studies and political landscape. Chapter 4 focuses on the impact of decoupling and degrowth policies. Chapter 5 regards the impact of CCS on the five themes. Finally, the conclusion and discussion with policy recommendations will be presented.

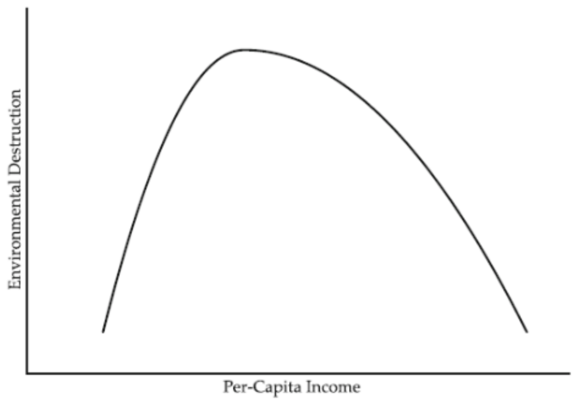
Chapter 1: Sustainable growth: an oxymoron?

This chapter looks into the theoretical framework, it therefore focuses on scientific theories on decoupling, degrowth, and CCS.

1.1: Decoupling

Attempting decoupling is not a new phenomenon. In 1991, the Environmental Kuznets Curve argues that there is a relationship between income per capita and environmental degradation, as seen in figure 1.1. After the initial period of growth, environmental degradation would decrease when higher levels of development were achieved (Stern et al., 1996). However, many criticisms contested this theory due to the lack of influence of globalisation, move of production, governance, and increase in the global in GHG emissions (Dasgupta, 2006; Dinda, 2004; Stern, 2004; UNEP, 2011).

Figure 1.1: Environnemental Kuznets Curve (Uchiyama, 2016).

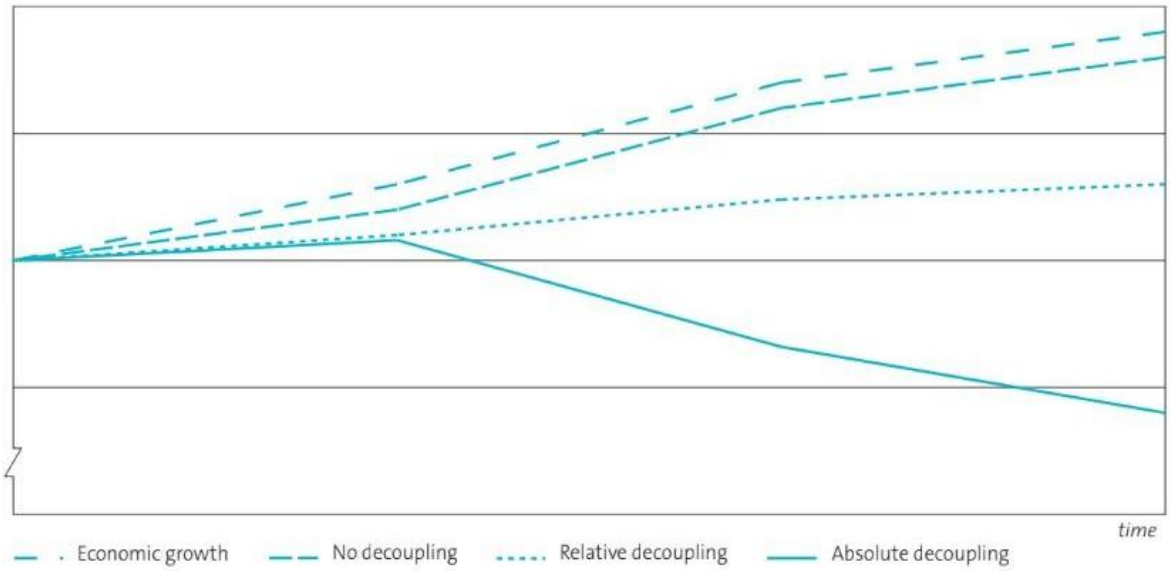


In 2001, the OECD was the first international institute that named decoupling as their main objective, by *"breaking the link between 'environmental bads' and 'economic goods"* (UNEP, 2011:4). According to the CBS (2011), the Dutch bureau for statistics, decoupling takes place when the growth rate of a certain environmental pressure, like CO2-emissions, is lower than the economic growth rate.

According to the UNEP (2011), two types of decoupling exist. Firstly, *resource decoupling*, which indicates the rate of resource use for each unit of economic activity. This is a form of dematerialisation since less land, water, energy and materials is used per economic output. This resource decoupling can be achieved by increasing the resource productivity, which can mitigate the resource scarcity problem. Secondly, *impact decoupling*, which entails a reduction in environmental impact while increasing the economic output. This can be achieved by increasing the eco-efficiency. Improving impact decoupling is not always related to the improvement of resource decoupling. In the case of CCS, impact decoupling takes place since CO2 is no longer emitted. However, resource decoupling does not take place since it requires a lot of energy to store the CO2 (UNEP, 2011).

Decoupling can also be defined as relative and absolute, which are both visually clarified in figure 1.2.

Figure 2.2: Decoupling (CBS, 2011)



Relative decoupling entails an increase in the growth rate of the environmental pressure, which is less than the economic growth rate. Relative decoupling can thus be seen as increasing the efficiency of economic output. Jackson (2017) states that this decline in ecological pressure per unit of economic output has been occurring in global economies. But even though the economic system will become more efficient if the GDP increases, the ecological intensity will increase as well, which will in turn led to an increase in environmental degradation. Additionally, Jevons paradox states that: *"the more technologically advanced and efficient an economy becomes the more resources it consumes because the resources get cheaper"* (D'Alisa, 2015: 7). This rebound effect thus leads to an increase in demand due to the decrease in cost, which could cancel out the positive effects of the increase in efficiency (Greening et al., 2000; Schneider et al, 2010).
Absolute decoupling entails a constant or decreasing growth rate of the environmental pressure, with an increase in economic growth rate (CBS, 2011). According to Jackson (2017), this absolute decline in environmental degradation with rising economic output, has not yet been found in the global economy. However, the OECD (2015) claims that the Netherlands has achieved absolute decoupling of GHG emissions from economic growth (not of CO2-emissions), due to a decrease in carbon intensity as a result of savings in energy, increase of electricity import, and the economic crisis. However, the OECD does state that *"the country's commitments under the Kyoto Protocol have been fulfilled through the acquisition of carbon credits under the Protocol's flexible mechanisms to complement domestic reductions"* (OECD, 2015:23). Additionally, trade embedded emissions are not included in this data. When taking the carbon and environmental destruction embedded in the imported products and services into account, much higher emissions would arise. Developed countries, thus, often do not take responsibility for their full climate impact since a large section of their carbon emissions are ascribed to developing countries (Isenhour, 2012; Jackson, 2017). These externalities of imported products and services contribute to climate injustice.

When linking decoupling to a greater ethical debate, it can be related to ecomodernism. Ecomodernists believe that climate mitigation should not have negative effects on the economy, since it can be solved through technical innovations. They believe this happens through decoupling by improving technical intensification and efficiency gains (Isenhour, 2016). Ecomodernism, and thus decoupling, can be linked to the environmental ethical theory of shallow ecology. Shallow ecology solutions are often based on the belief in technology, so-called 'techno-optimism'. These shallow ethics can be seen as anthropocentric, since nature is only valued by its instrumental value. Its focus lies on tackling the symptoms instead of the origin of the problem, it can therefore be seen as a short time solution for the problem (Curry, 2011; Van den Berg, 2013).

The main question is whether the rate of decoupling can exceed and continuously exceed the rate of growth. Since environmental degradation is urgent, governments should act now (Steffen et al., 2015). Which means that they can only rely on known technologies, since new technologies and innovations will come too late. If it is not possible to continuously decouple, then decoupling is not the right tool for reducing environmental degradation, indicating that alternatives are needed.

1.2: Degrowth

Degrowth offers such an alternative. As with decoupling, the debate on growth is not new. As early as 1848, John Stuart Mill talked about the benefits of a stationary state of capital and population, in which social, cultural and moral development could grow further (Mill, 1848). John Maynard Keynes argued that there would be a time when the 'economic problem' was resolved and we would dedicate our time to non-economic directions. *"We would once more value ends above means and prefer the good to the useful"* (Keynes, 1930:364).

D'Alisa et al. (2015) argue that degrowth has numerous interpretations and not a single definition, since it is a frame that links ideas and concepts. The main aspects of degrowth are criticisms of growth, criticisms of capitalism that perpetuates growth, criticisms of GDP as a measure of growth and wellbeing, and criticisms of commodification, while praising a reproductive economy of care (D'Alisa et al., 2015). Degrowth does, however, not necessarily aim at negative GDP growth. But negative GDP growth is a likely outcome, since: *"a caring, green and communal economy is likely to secure the good life, but unlikely to increase gross domestic activity two or three per cent per year"* (D'Alisa et al., 2015:4). From an ecological perspective, degrowth entails reducing the economic throughput measured by the energy and material flows (Martínez-Alier et al., 2010). According to Schneider et al. (2010:512) degrowth is *"an equitable downscaling of production and consumption that increases human wellbeing and enhances ecological conditions at the local and global level, in short and long term"*. Kerschner (2010) argues that degrowth will lead to a globally equitable steady-state-economy. This degrowth does not take place in all sectors, technological and knowledge progress is redirected from 'more to better'. Degrowth should therefore not be seen as turning back the clock to pre-industrial communal past, but as an alternative sustainable future (Schneider et al, 2010). Within degrowth, growth and innovations will take place within the planetary boundaries.

Van den Bergh (2011) is more critical on degrowth. The numerous interpretations of degrowth create ambiguity, and literature on radical degrowth is often more normative and idealistic, than analytical and realistic. Furthermore, the author disagrees with the strands within degrowth that aim for a reduction in GDP. Long term effects are unclear, and could work counterproductive due to reduction efficiency, and research and innovations in cleaner technologies. Environmental policies should aim to reduce environmental degradation, this could result in a decrease in GDP, but whether this happens should be irrelevant. Van den Bergh therefore proposes not to oppose GDP growth in general but be indifferent about it, which he calls 'a-growth' (Van den Bergh, 2011).

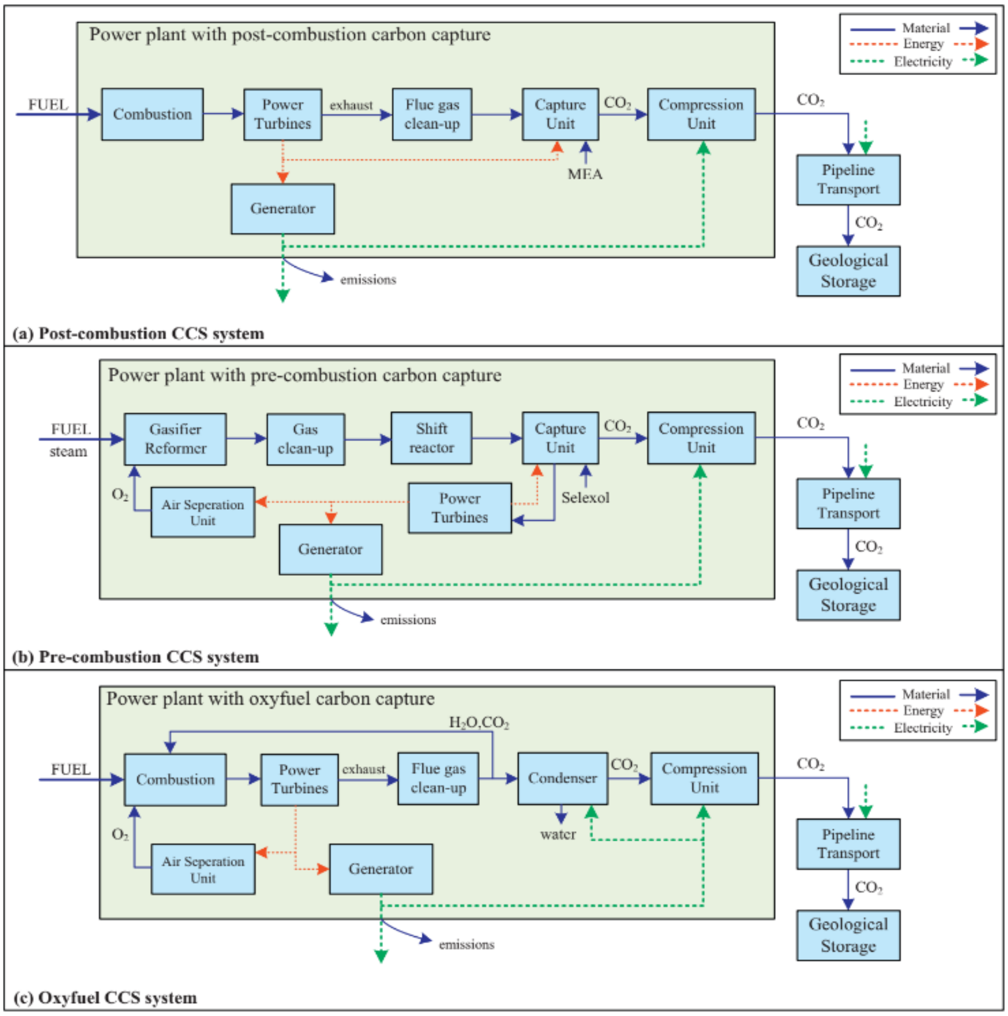
When linking degrowth to a greater ethical debate, it can be related to deep ecology. This ethical theory focuses on our moral responsibility to live sustainable and ethical. Instead of focussing on the symptoms of the problem, it tries to solve the origin of the environmental degradation, through long term solutions. It offers an intrinsic value to nature, and it pleads for a radical change society (Curry, 2011; Van den Berg, 2013).

1.3: CCS: types and framework

1.3.1: Types of Carbon Capture and Storage

CCS can be divided into three consecutive steps, namely capture, transport and storage. Within the capture phase of CCS, three different categories can be found which are visually represented in figure 3.1. *Post-combustion capture* entails the separation of CO2 from nitrogen within the flue gas of fuel combustion. *Pre-combustion capture* entails the gasification of the fuel following the separation of hydrogen and CO2. After the capture of the CO2 the remaining hydrogen can be combusted for power generation. *Oxy-fuel combustion* entails the separation of oxygen and nitrogen in an air separation unit. The remaining oxygen is used for the fuel combustion. The resulting flue gas consists of water and CO2, which are consecutively separated through condensation (Volkart et al., 2013).

Figure 3.1: CCS capture methods (Singh et al., 2011)



In the second phase the transport of the CO2 can take place by truck, ship or pipeline. Of which the last option is most economically feasible due to the limited capacity of the other options (Volkart et al., 2013). The Netherlands will use the existing gas infrastructure, and invest in new pipelines. Chemelot, a large chemical industry complex in the province of Limburg, is looking into transport of CO2 by boat to Rotterdam (R9; Chemelot, 2018).

For the last phase, the CO2 storage, several options are possible such as: ocean storage, enhanced oil recovery, storage in geological formations (such as depleted oil or gas reservoirs, or saline aquifers), or mineralisation (Volkart et al., 2013; Leung et al., 2014). The CO_2 can also be utilised as chemical feedstock, fuel, mineral carbonation or enhanced oil recovery (Cuéllar-Franca & Azapagic, 2015), which is addressed in §5.2.4.

1.3.2: CCS framework

The framework which has been used to analyse the impact of the choice for CCS in the Netherlands is based on research done by CATO. CATO which stands for CO_2 Capture, Transport and Storage, is the Dutch national R&D programme for CCS.

In 2018, CATO published a revised version of their 2011 debate map on CCS which focussed on the pro and con arguments for CCS in the Netherlands based on the themes of climate, environment, safety, economy, energy and ethics. The revised version (see appendix III) was been applied to the new governmental policies, by looking into the pro and con arguments for offshore CCS in the Netherlands, according to the themes climate, living environment, energy, economy and ethics (CATO, 2018a). As stated in the introduction, this debate map is unique compared to other literature since other research mainly focusses on either the social or the environmental impact.

Regarding Climate, CATO states CCS will decrease CO_2-emissions, while also providing the possibility of negative emissions through the burning of biomass. CATO also states argues that CCS is not a definitive solution, since it maintains the dependence of fossil fuels and its infrastructure. Regarding Living Environment, they mention that CCS has been safely implemented abroad, however long-term risks remain unsure. Concerning Energy, CCS offers the possibility to remain using cheap and effective fossil energy sources, which could hamper the development of the renewable energy transition. However, CCS also ensures that certain industries without a sustainable alternative can remain running. Regarding Economy, CATO mentions that CCS is a cost-effective method to reduce CO_2-emissions, which is also good to reduce the displacement of companies abroad. However, the money invested is still invested in a technique that serves as an interim solution. Concerning Ethics, CATO argues that the Netherlands has to reduce their CO_2-emissions and CCS offers a feasible method to do this. However, CCS is a form of symptom alleviation since it does not prevent the production of CO_2 emissions (CATO, 2018a).

1.4: Conclusion

To conclude, the relationship between decoupling and degrowth is that they form two contrapositive environmental policy strategies. Decoupling believes in economic growth without environmental degradation through techno-optimism, while degrowth believes this is not possible or not possible at a rate sufficient for reducing environmental degradation and therefore proposes to no longer focus on economic growth and to downscale the production and consumption in an equitable manner.

Furthermore, there are three types of CCS, which will be analysed according to the five themes (climate, environment, safety, economy, energy and ethics) of CATO.

Chapter 2: Methodology

This chapter looks into the research strategy, the research materials, the data collection, the data processing, the validity and reliability, ethical issues, and the justification for all the choices made within the research.

2.1: Research strategy and design

This research was conducted in a qualitative manner to collect in-depth knowledge on the impact the Dutch policy choice of CCS has on the five chosen themes of: *climate, (living) environment, economy, energy, and ethics*. These five themes are based on research by CATO, which provides an overview of stakeholder views on the before mentioned themes on offshore CCS in the Netherlands (CATO, 2018a), see Appendix III. CATO, the Dutch national R&D programme, was founded in 2004, along with the start of the first CCS project in the K12-B reservoir. CATO has been involved in all Dutch CCS projects and has collaborated in research project with more than 50 partners. Therefore, CATO, is knowledgeable about which main sectors will be affected by CCS (the five themes), and which general views exist on CCS in the Netherlands. This research will go more in-depth about the impact of the choice for CCS will have on these five themes, since the CATO research only states a few pro and con arguments of stakeholders per theme.
These research is linked to two main environmental policy theories of *Decoupling* and *Degrowth.* These theories are therefore used in a deductive manner, since the theories are applied to the findings of the research (Bryman, 2012). A qualitative approach allows the research to incorporate the different opinions of the respondents and their interpretation of the impact CCS has on the five themes.

In regard to the research design both a comparative and case study approach is chosen. Through the comparative approach the different opinions of the respondents regarding the impact of CCS on the five themes can be compared. The case study approach entails the detailed and intensive analysis of one case (Bryman, 2012). In this thesis three smaller case studies look into previous CCS projects, and one case study looks into the Carbon Farming project. The first three CCS case studies offer insights into the Dutch context for CCS. For example, it looks into: what happened with previous CCS projects; who were involved; what were the main barriers for successful implementation. Additionally, the three CCS case studies also offer a more practical insight into the effect of *decoupling* policy strategies, since CCS is a prime example of a decoupling policy. The last case study offers insights into alternatives for CCS, through a less technological approach to carbon storage, namely the carbon soil sequestration through alternative farming methods. This last case study also offers more practical insights into *degrowth* policies, since carbon farming is a less technological dependent method of carbon storage which also scales down production, while enhancing the ecological conditions of the soil and thus the environment.

In order to collect the data semi-structured interviews have been chosen as a research method. Through this interview technique, an interview guide has been made with a general structure and topic list. This interview guide offers scope to the interviews, while keeping enough flexibility to switch topics or follow stray topics that might originate from the interview.

2.2: Research materials

The respondents of the research were mainly experts in the field of CCS, Carbon Farming, decoupling or degrowth, all from different type of sectors. This research therefore uses purposive sampling, in which the sampling does not happen in a random manner but in a strategic manner, in order to ensure the respondents are relevant to the research questions (Bryman, 2012). In order to ensure a wider variety of answers, maximal variation sampling has been applied. For example, expert interviews on CCS are based on respondents employed in CCS projects, in CCS research, in government. Unfortunately, the NGO sector has not been interviewed. Five NGOs with a pronounced opinion on CCS were approached, but none were available for interviews. All the respondents that declined interviews are added in Appendix II.

Additionally, snowball sampling was used. Originally, an interview with the Ministry was denied, however though a CCS conference contact details with a Ministry employee were acquired.

The complete respondent list can be seen in table 2.1, from which two respondents were omitted due to no received feedback on their quotes because of holidays. Three additional respondents who were not interviewed but were asked a few questions can be seen in table 2.2.

Table 2.1: Interview respondent list

NO	Date	Respondent	Institute	Function
R1	09-05-2018	Maurice Hanegraaf	TNO	Business Director Geo Energy
R2	15-05-2018	Sjef Staps	Louis Bolk Instituut, + Carbon Farming	Project Manager + Project leader Koolstofboeren
R3	25-05-2018	x	CATO	Director CATO
R4	26-06-2018	Marc Londo	NVDE: The Dutch Association for Sustainable Energy	Senior Researcher in Energy & Resources
R5	29-06-2018	Piet Hermus	Carbon Farming	Farmer
R6	02-07-2018	Jan Juffermans	PlatformDSE: sustainable solidarity economy platform	Board Member + author: Utility and Necessity of the Global Footprint
R7	02-07-2018	Gerrit Stegehuis	PlatformDSE	Secretary PlatformDSE
R8	09-07-2018	Dick Biesta	E.ON + PlatformDSE	Former Director Engineering in Energy sector
R9	17-07-2017	x	Ministry of Economic Affairs and Climate Policy	Senior Policy Advisor Energy
R10	25-07-2018	Jaap Tielbeke	De Groene Amsterdammer: opinion journal	Journalist: written on ecomodernism and climate policies

Table 2.2: Additional respondents list

NO	Date	Name	Institute	Function	Location
PC1	06-06-2018	Peter Alderliesten	TKI Energy and Industry +	Director + *Participant Industry table of the Climate Agreement*	CATO CCS Conference
PC2	06-06-2018	Hans Warmenhoven	De Gemeynt	Partner + Involved in CCS Roadmap	CATO CCS Conference

PC3	19-06-2018	Kate Raworth	University of Oxford	Economist + Author Doughnut Economy	Reading at the Balie.

To analyse both decoupling and degrowth policy strategies, the case studies entail three 'normal' decoupling CCS projects, and one degrowth CCS project namely the Carbon Farming project. As indicated in the coalition agreement, the Dutch climate policies are heavily dependent on the 'normal' decoupling CCS projects. Therefore, the analyses of the decoupling CCS projects are more inclusive by focussing on three different smaller case studies. There is only one Carbon Farming project, mainly since there is no emphasis on this technique in the Dutch climate policies and it therefore only offers a small-scale alternative to CCS. However, this case study does offer insights into degrowth policies. The following case studies were chosen:

1. **Decoupling CCS case study I: K12-B**
   K12-B is a pre-combustion offshore CCS project, that has been operational since 2004. The project in the North Sea is the only operational CCS project in the Netherlands. This case is therefore interesting since it is the only CCS project in the Netherlands that has succeeded. Furthermore, since it is offshore, the project is comparable to the newly planned CCS projects that will all be offshore.

2. **Decoupling CCS case study II: Barendrecht project**
   The Barendrecht project, forms the second decoupling CCS project. This project was founded by Shell in 2007 and tried to store CO2 from the Pernis oil refinery in two depleted gas fields in Barendrecht. This case study is interesting since it's an onshore CCS project, public acceptance therefore plays a much larger role. During the start-up phase of the project the public opposition was very large, which led to the decision of the Dutch government to cancel the project in 2010. Henceforth all future CCS projects will be offshore instead of onshore.

3. **Decoupling CCS case study III: ROAD Project**
   ROAD is the Rotterdam Storage and Capture Demonstration project. This project arose through the original CCS policies of the Netherlands, in which newly build coal-fired powerplants would be build fitted with post-combustion CCS. The ROAD project was initiated by EON (later Uniper) and ENGIE, two energy companies, who withdrew from the project in 2017 due to uncertain government policies. This case study is interesting since government policies play a large role, and it is an offshore project just like all future CCS projects.

4. **Degrowth CCS case study I: 'Carbon Farming'**
   The fourth case study is a degrowth CCS project. Degrowth CCS is a more ecological approach to storing carbon, through the ecosystem services of the soil. This case study focuses on the 'Koolstofboeren' (carbon farmers) cooperative, a Dutch farmer collective that aims to improve farming methods to effectively sequestrate carbon in the soil (ZLTO, 2017).

The storage location of these projects can be seen in figure 2.1: the K12-B and ROAD projects are offshore, while the Barendrecht project was onshore. The fourth case study, Carbon Farming, has not been implemented in the map since the project is not based in one location.

Figure 2.1: Storage locations of the case study CCS projects (Author's own through Google Maps, 2018)

In addition to the interviews, more information and data was acquired through a literature review based on academic articles, policy documents, research findings by research institutes, news websites, and books. This information is used in the interviews and the result chapters.

2.3: Themes interview guide

By the means of an interview guide (appendix I), semi-structured interviews were conducted. The interview guide was structured along the lines of the five themes of *climate, (living) environment, economy, energy, and ethics*. All themes were treated in all the interviews. However, some respondents were more knowledgeable about certain topics, therefore more in-depth questions were asked from them. To gain more knowledge on the case studies and decoupling and degrowth policies, additional questions were developed for certain respondents. Furthermore, the interview guide is also iterative, new topics, corresponding to the five themes, that arose from the interviews were added to the guide for future interviews.

2.4: Data analysis and processing

All interviews have been audio-recorded using a mobile-phone application. All the audio files were around one hour, with one outlier of three hours. The transcription allowed for a more detailed analysis of the findings, while also offering the possibility to be more attentive towards the respondent during the interview.

To process and analyse the acquired data, all the interviews have been coded. This has been done through the qualitative data analysis software programme 'NVivo', in which open coding has labelled text fragments to their corresponding themes. During the axial coding, the open coding labels have been compared and aggregated into core themes. These mostly consisted of the five themes and their subthemes. By coding all the interviews the impact of the case studies, the decoupling and degrowth policies, and the impact of CCS regarding the five main themes could be determined, which formed the basis of the answer to the main research question.

2.5: Validity and reliability of methods

The validity can be divided in external and internal validity. The choice of case studies can influence the external validity, since the acquired results might differ if other case studies had been chosen. To increase the external validity, three case studies on different types of decoupling CCS are chosen. One successful offshore project, one failed onshore project, and one failed offshore project. Since there are less degrowth CCS projects and since they are not included in the current Dutch policies, only one case study will take place on degrowth CCS. While this reduces the external validity, a compromise has been made between validity and feasibility. The external validity also applies to the choice of respondents, since different respondents might have given different answers. To increase to external validity, a wide variety of respondents knowledgeable on CCS were chosen. As mentioned in §2.2, no NGOs were willing to participate in this research due to time constraints. This, unfortunately, reduced the external validity of the research.

The choice of case studies increases the internal validity of the research, since this is higher in case studies compared to surveys. This is mainly due to the increase in flexibility and depth (Verschuren & Doorewaard, 2010).

The reliability of the research can also be divided in internal and external. The internal reliability only applies to research with several researchers, which therefore is not relevant for this research. The external reliability is based on whether the results of the research are repeatable (Bryman, 2012). To improve the external reliability, the transparency of the research has been improved by providing the research methods, interview list, interview guide, and methods of analysis. Furthermore, to increase the reliability of the results, the same process in data acquisition has been used for all interviews and case studies. This will enhance the consistency of the methods and the results.

2.6: Ethical issues

For this research, no severe ethical issues have been experienced. To be considerate of ethical issues within the research, informed consent has been asked of all respondents in advance of the interviews. Furthermore, the anonymity and confidentiality has been respected of the respondents. This has been done by asking approval of recording the interview and by excluding the name of the respondent, if preferred by the respondent. All respondents approved of the recording, and allowed the use of names and quotes, if the quotes were emailed to them before publication to provide possible feedback. One respondent felt that part of her answers was only in line with her personal opinion and not in line with the views of her employer, therefore these answers have been excluded from the thesis. Additionally, all respondents had the right to withdraw themselves from the research at any time.

Chapter 3: CCS and its context in the Netherlands

This chapter focuses on the case studies, which are placed in the wider political context. Therefore, this chapter will focus on: the four case studies, the choice for CCS, the current barriers, and the political climate and policies at a national and European level.

3.1: Case studies

3.1.1: K12-B

The K12-B is an offshore pre-combustion CCS project in the North Sea. The project is currently the only operational CCS project in the Netherlands. From 1987 gas has been extracted at the K12-B site. Since the CO2-content of the gas is too high for the Dutch gas infrastructure, the CO2 is separated from the production stream onsite. Before 2004, this additional CO2 would be vented into the atmosphere. However, from 2004 and onwards, the K12-B site became the first CCS project to re-inject CO2 that originated from the same reservoir (Hanegraaf, R1).
Hanegraaf (R1), involved in the K12-B project through TNO, states that the project was founded by GDF Suez and TNO. The project was also part of the CATO programme, and was financed for 50% by the government and 50% by the industry. Apart from reducing CO2-emissions, this project also aimed to increase the gas extraction through the same effect as EOR (see §5.2.4). Additionally, the project also aimed to generate knowledge on CCS through research on the distribution of CO2 in the reservoirs with the use of tracers (R1 + R3).

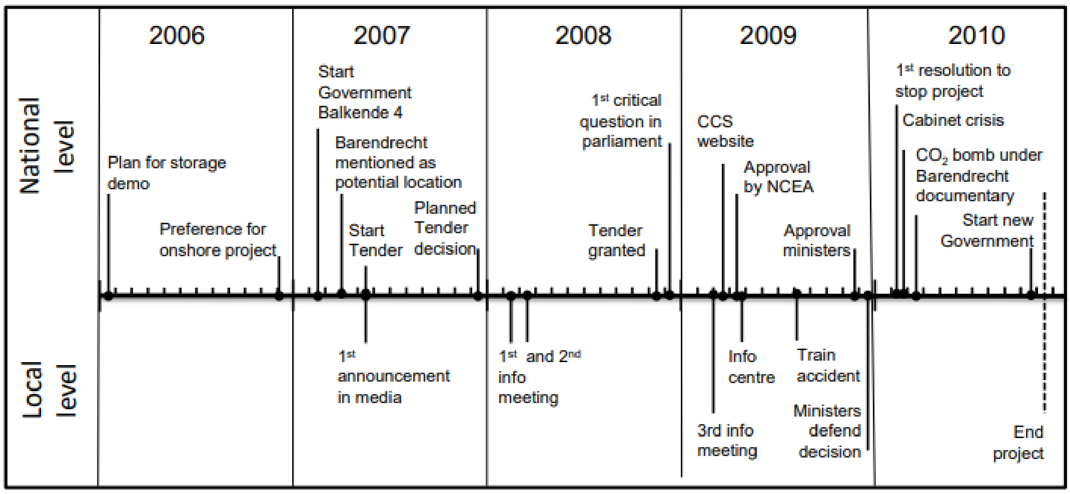
However, according to Hanegraaf, the K12-B project is not a good example of CCS projects. Firstly, since the capture of CO2 happens at the site. The capturing aspect is thus not comparable to other CCS projects, since these happen at coal-fired powerplants or at industry level. Secondly, the K12-B project is a small-scale CCS project since it stores 0.02 Mton CO2 each year. Since 2004, more than 0.1 Mton CO2 has been injected in the K12-B reservoir. This quantity is low compared to the plans to store 20 Mton a year by 2030. The K12-B project does therefore not offer any insights into the aspects of large-scale CCS.

3.1.2: Barendrecht

The Barendrecht project, also known as Pernis Refinery CCS, was an onshore post-combustion CCS project founded by Shell in 2007. The project aimed to store CO2 from the Pernis oil refinery in two depleted gas fields in Barendrecht, a small municipality near the Port of Rotterdam (Egmond, 2016).
Figure 3.4 gives an overview of the most influential events of the Barendrecht case.

During the first information meeting in 2008, the first signs of local public unrest were visible (Egmond, 2016). Terwel et al. (2012) analysed the opinion on the Barendrecht project of the local population (811 respondents) in Barendrecht. Their findings stated that the local population was worried about the safety of the project and a decrease in property value. Additionally, they perceived that the decision-making process was unfair, since the private parties had too much influence in the project. Furthermore, they mistrusted Shell and the national government, because they only served their own interests.

Figure 3.4: Timeline of Barendrecht project with crucial local and national event (Egmond, 2016)



According to Terwel et al. (2012), the respondents were convinced of the necessity to combat global warming (91.6% of respondents), and most of the respondents (60.4%) even thought CCS offered a valid solution to combat climate change. Still, 86.3% of the respondents thought the CCS project in Barendrecht was unacceptable. This indicates that Not-In-My-Backyard (NIMBY) sentiments might play a role in the public acceptance of CCS. NIMBY sentiments originate when local population objects a certain project or policy in their own neighbourhood, while not objecting to similar projects or policies elsewhere (Terwel & Daamen, 2012). The NIMBY sentiments are thus related to the local self-interest, which can be confirmed by the local population's worry about the safety and the loss in property value. However, the NIMBY sentiments do not fully explain the public opposition since the socio-political factors such as decision making, perceived procedural unfairness, and a lack of trust in the stakeholders also play a large role (Terwel et al., 2012). This can be confirmed by Londo (R4), who argues that research done by communication and behavioural research indicates that the approach in the Barendrecht case was seriously lacking basic public participation and engagement rules.

The public opposition to the Barendrecht project grew. In 2009, the local population started the foundation 'CO2isNEE', an activist group against the storage of CO2 underneath Barendrecht. According to Hanegraaf (R1), the fact that CCS was planned to be used at coal-fired powerplants also fuelled the public opposition. NGOs tried to boycott anything related to coal-fired powerplants, in their eyes CCS only led to the prolonged use of coal as an energy source. The voice of the NGOs led to even more public opposition.

In 2010, the Dutch government fell which led to a delay in decision making regarding controversial topics such as the Barendrecht case. After the new elections, there was no longer a majority in Parliament that supported the CCS project in Barendrecht (Egmond, 2016). Due to the public opposition even worsened by the documentary "CO2 bomb under Barendrecht" broadcasted on the Dutch national TV, the Dutch government decided to cancel the Barendrecht project on the 4th of November 2010 (Zembla, 2010; Egmond, 2016; Terwel et al., 2012). From the Barendrecht project onwards, the Dutch government decided that all future CCS projects should be based offshore instead of onshore to limit public opposition (R1, R3, R9).

3.1.3: ROAD

The ROAD project (Rotterdam Storage and Capture Demonstration Project), arose through the original CCS policies of 2007, in which the government decided to build four new coal-fired powerplants, with the premise of being fitted with CCS. During these times the WRR (2006), the Scientific Council for Government Policy, depicted CCS as a method to clean up fossil energy.

ROAD was initiated by EON (later Uniper) and ENGIE, two energy companies. The project entailed post-combustion CCS to capture CO2 from the flue gasses of the new MPP3 Maasvlakte coal-fired power plant in the Port of Rotterdam. The captured CO2 will be stored through a pipeline in the P18-A reservoir about 20 km off the coast. The main objective of the ROAD project was to demonstrate the technical and economic feasibility of large-scale CCS in power generation plants. The knowledge generated in the project would consist of technical, legal, economic, organisational and societal knowledge and experience which would serve CCS in both a larger and broader scale: apart from powerplants also implementation in the industry sector (European Commission, 2018).

According to the Noordzeeloket (n.d.), the ROAD project had already received their permits in 2013. However, the failing ETS (§3.4.4) led to delays in the ROAD project (R8). Due to the much lower carbon credit prices the ROAD project no longer had a viable business case. This is confirmed by R9, who states that the subsidy scheme was already in place in 2010, while the budget was not completed until 2015. However, the project still did not start at this time due to a new debate on the continued existence of the coal-fired powerplants.

The ROAD project was cancelled in 2017 when UNIPER and ENGIE withdrew from the project. The main reason the project was cancelled was due to the unsure future of the coal-fired powerplants. The companies were uncertain whether they could earn their investments back since the plants would have to run a certain amount of years to make profit (R9).

Biesta (R8), who was involved in this project through EON, argues that the building of CCS equipped coal-fired powerplants had a high degree of greenwashing. The government had promised new coal-fired powerplants with a reduced climatic effect through CCS. However, since all the CCS plans have been cancelled, all of the produced CO2 of the new plants has been emitted into the atmosphere. The failure to comply to the original plans has thus made the creation of the new coal-fired powerplants seem more environmentally friendly.

The original policies to implement CCS on coal-fired powerplants also led to many protests; the opposition thought CCS was used as an excuse to retain production of coal-based energy (Teffer, 2018). However, coal-fired powerplants are the most polluting method to produce energy since they emit nitrogen dioxide, sulphur dioxide and mercury. These substances have harmful effects on nature and health. Furthermore, the seven operational plants in the Netherlands are responsible for 26% of the national CO2-emissions (Natuur&Milieu, 2018). Since there are renewable alternatives to producing energy, such as wind and solar. CCS should therefore not be used as a method to create "green" energy through coal-fired powerplants, instead the dependency on coal should be reduced. According to Teffer (2018), CCS should be implemented in industrial processes, since feasible and cost-efficient methods to reduce CO2-emissions in the chemical industry and the production of steel and cement are not yet available because these industries cannot run on renewable energy

3.1.4: Carbon farming

The Carbon Farming project (Koolstofboeren) is a collaboration between the Louis Bolk Institute (a research and advice institute to advance sustainable agriculture), Bionext (an organisation that aims to connect the organic farming chain from farmer to consumer) and the ZLTO (the Southern Agriculture and Horticulture Organization). The main goal of the project is to research alternative farming techniques to effectively sequestrate carbon in the soil. The Louis Bolk Institute is mainly responsible for the collaboration with the participating farmers, and the analysis of the effectiveness of the farming techniques. Furthermore, the institute also creates a guide to good carbon practices, which will be freely distributed amongst farmers. Bionext is responsible for the valuation of the project. They investigate to opportunities to create financial added value for these low carbon crops, to create a variable business case for farmers. *"Bakeries could for example sell CO2-neutral bread, since the grain is bought at a carbon farm"* (Hermus, R5).

One of the methods to stimulate carbon sequestration is less and less deep ploughing. Conventional ploughing exposes the underlying soil which reduced the soil organic carbon levels. Additionally, it reduces the soil quality since the soil is more vulnerable to erosion. Another method is to constantly cover the soil. The residue of the harvest should be returned as surface mulch, or natural fertilizers such as compost and biosolids should be distributed on the soil. During off-season, non-cash crops should be implemented to increase nutrient uptake of the soil. Furthermore, no intensive mono-crops should be used only a highly diverse crop rotation system to increase diverse nutrient uptake (Hermus, R5).
The Carbon Farming thus provides a more holistic approach to carbon storage. *"Storing carbon in the soil is both beneficial for the climate and the soil. By adding more organic matter to the soil, the soil fertility increases which is beneficial for crop yield, biodiversity, and a reduction in the use of fertilizers"* (Staps, R2). At the same time, a soil with a more organic matter is more resistant to extreme weather conditions such as drought or heavy rainfall due to a reduction in runoff and leads to enhancement of water pureness.

However, compared to CCS, the climatological impact of Carbon Farming is much smaller. Staps (R2), chairman of the Louis Bolk Institute in the Carbon Farming project, states that the project could reduce 5-10% of the total CO2 emissions of the Dutch agriculture system if it were implemented at large-scale. According to the CBS the total CO2-emissions of the agricultural sector is 8.6 Mton of CO2, however it is important to note that other GHG-gasses like CH4 and N2O are emitted on a larger scale (CBS, 2018; RVO, 2016). This would indicate that 0.4 to 0.9 Mton of CO2 could be reduced each year through carbon farming. According to the PBL (2018) a reduction of 0.8 Mton CO2 is feasible. The net reduction of CO2 is thus not comparable to CCS since it aims to store 18 Mton per year by 2030.
However, when looking at the cost efficiency, the correlation between the two different measures increases. The total cost of carbon soil sequestration would be €40 million, making the cost efficiency of the measure €50 per ton of CO2. §4.1.1 gives an overview of the cost efficiency of CCS measures. CCS applied to coal-fired powerplants would for example cost €35/ton-CO2, while CCS applied to industrial processes ranges from €70-120/ton-CO2.

In normal CCS the energy penalty entails the additional energy requirement to store the CO2. In the Carbon Farming project other types of energy penalty also exist. Certain carbon techniques entail the sowing of crops that improve the soil quality that are not meant for retail purposes, this leads to a reduction in yield per hectare (Staps, R2). However, the reduction in tilling reduces the energy penalty of carbon farming. Still, the energy penalty of Carbon Farming is negligible compared to CCS.

3.2: The need for CCS in the Netherlands

As the case studies indicate, the alternative Carbon Farming project does not offer a viable alternative, and in the past CCS projects have not been very successful in the Netherlands. Why would the Netherlands still focus this much on this unproven technique in its new climate policies?

According to R9, the Netherlands has chosen for CCS since it's a cost-effective method to reduce CO2-emissions in the industry sector. Due to CCS, the industries can remain competitive to reduce relocation abroad. Biesta & Londo (R8, R4) argue that the Netherlands is perfect for CCS due to the existing gas infrastructure and abundance of storage possibilities. Londo (R4) states that the Netherlands has a large industrial and chemical sector, where at some places pure CO2 is produced which reduces the cost of CO2 capture.

The Dutch CO2 storage capacity in (former) gas reservoirs is ~2.700-3.200 Mton CO2 of which 1.200 Mton is in the North Sea. The Groningen gas field is an additional 9.000 Mton (Noordzeeloket, n.d.). According to Hanegraaf (R1) and R9, new research states that there is 1.700 Mton storage capacity in the North Sea. Since the government aims to store 20 Mton a year by 2030, storage possibilities in the North Sea would last around 80 years. According to R9, it is difficult to determine how long CCS will be necessary, she guesses the transition will take around 40 years. The Netherlands thus has ample storage capacity for the needed transition.

3.3: Current barriers for effective implementation of CCS

To ensure that the future CCS projects will be successfully implemented in the Netherlands, the following barriers must be overcome. According to Leung and Sathre (2014; 2012) CCS must be implemented large-scale globally to be an effective mitigation option. According to R9, the lead time of a CCS project is around seven to nine years. Considering this timescale, it is imperative that the construction of the new projects will start soon for the project to be effective.

Leung (2014) argues that there are additional barriers for CCS. There is a lack of incentive or market mechanism to reward companies to implement CCS. Additionally, there are no mechanisms in place to punish the heavy polluters. Furthermore, the legal framework for transport, storage, import and export of CO2 is currently inadequate. Finally, most of the current CCS projects are Enhanced Oil Recovery projects (see §5.2.4). While these are more financially viable, most projects have limited storage capacity. More research and demonstration projects are thus needed for large-scale CCS projects.

To ensure the successful implementation of CCS in the future the Ministry of Economic Affairs and Climate Policy has commissioned the Roadmap report. The objective of the Roadmap was to look within a broad stakeholder process at the technical barriers of CCS, to find a broadly supported vision of the role of CCS within the transition, and which steps to take to realize this role (De Gemeynt, 2018).

According to Warmenhoven (PC2), co-writer of the Roadmap, CCS should be implemented at three types of CO2 sources in the Netherlands. Group 1 are industrial sources with a long-term perspective, without possible alternatives before 2050, such as steel and certain chemical companies. Group 2 are activities that are less relevant for the transition but will still have considerable emissions and no alternatives for CCS. This category entails refineries, H2-production, NH3-production and waste incinerations. Group 3, will focus on future CO2 sources that are essential within the transition, such as blue hydrogen and BECCS (see §5.2.3). According to R9, Senior Policy advisor for the government, the new CCS policies follow these recommendations.

Furthermore, six main preconditions must be met by 2018 for a successful implementation of CCS in the Netherlands. Firstly, the launch of 2-4 start-up projects financed by the government and the European Commission, to increase knowledge and maximise the CO2-storage effect. Secondly, the government should ensure transport and storage infrastructure, partly financed by private parties. Thirdly, there should be a generic CO2 instrument for industry, to create a viable business case for CCS. Fourthly, the legal context should be improved. Fifthly, a public private research and development program should be strengthened. Finally, societal acceptance of CCS within the energy transition should be improved.

Other aspects that are essential for CCS are placed on the following timescale. From 2019-2021, the preparations for new CCS projects will take place. From 2021-2025, most of the CCS projects will be realised. From 2025 onwards, the CCS projects will be large-scale implemented. R9 states that while the advice of the Roadmap has been mostly followed up by the Ministry, the timescale is not the exact one they will follow. R9 does agree that to store CO2 large-scale in 2030, CCS projects will have to be prepared soon since the implementation time of a CCS project is around seven years. To this extent, CCS projects will have to be up and running by 2025 be able to store CO2 large-scale in 2030.

3.4: Political climate and policies

3.4.1: The Coalition Agreement

In October 2017, Rutte-III presented their coalition agreement named 'Confidence in the Future'. In the coalition agreement Rutte-III proposed to reduce 49% (56 Mton) GHG-emission reduction compared to 1990 by 2030 (Kabinetsformatie, 2017). Table 3.1 gives an overview of the allocation of the proposed reduction. The share of CCS totals a reduction of 18 Mton, with an additional 2 Mton at waste incinerations. More than 1/3rd of the proposed reduction will thus be realised through CCS. According to Londo and Tielbeke (R4, R10), there is an imbalance between CCS and other emission reduction strategies, with too much attention going towards CCS.

Table 3.1: Allocation of the proposed 49% emission reduction by 2030 (Kabinetsformatie, 2017)

Sector	Reduction by 2030 (Mton)	Measures
Industry	1	Recycling
	3	Process efficiency
	18	**Carbon Capture and Storage**
Transport	1.5	Electric vehicles, fuel-efficient tires, European Standards
	2	Biofuels, measures in cities
Build surroundings	3	Optimising office energy use
	2	Insulation houses, heat pumps and district heating
	2	New builds more energy-efficient
Electricity	1	Energy-efficient lighting
	12	Closing of coal-fired power plants
	2	**Carbon Capture Storage at waste incineration plants**
	4	More offshore wind power
	1	More solar power
Land use and agriculture	1.5	More efficient land use
	1	Lower methane emissions
	1	Energy-producing greenhouses
Total	56	-

The agreement noted that a large section of the proposed reduction is allocated to industry due to the potential to reduce cost-efficiency. Reduction at industry level can thus secure the competitiveness of the Dutch industry, while also creating opportunities for economic growth and employment (Kabinetsformatie, 2017).

3.4.2: The Climate Agreement

After the publication of the coalition agreement, Rutte-III started the negotiations for a national Climate Agreement (Klimaatakkoord) in February 2018. The aim of the Climate Agreement was to formulate plans on how to reduce the national GHG-emissions by 49% compared by 2030. For four months, negotiations have taken place in five roundtables: built environment, industry, agriculture, mobility, and electricity. Government, private companies and NGOs and civil society organisations participated in these roundtables.

Alderliesten (PC1) was involved in the negotiations of the industry table. He states that the industry must reduce 60% of their emissions by 2030. *"This would total to 19.4 Mton reduction in 12 years, which led to a lot of discussions at the tables. However, we can no longer wait, if we want to meet the targets we need to hurry up"*. According to Santen & Walle (2018), there have indeed been problems with the negotiations at the industry table, mainly since this is the only table at which individual companies take place. There is even a sub-table of the largest emitters, responsible for 75% of the CO2-emissions of the Dutch industry, like TATA-Steel and Shell. These companies are still reluctant to make all the changes necessary for the transition. This can related to Tielbeke (R10) who argues that the industrial lobby is very powerful.

In July, the main aims per table were presented. The main aims of the industry table, where electrification, process efficiency, heat utilization, and circular use of raw materials. The proposition also named CCS as an unavoidable interim solution. However, the table understands the criticism of the NGOs concerning the necessity and risks of CCS. Therefore, for all individual projects, a consideration will be made whether alternative options are also feasible. In September of 2018 the proposed plans will be further developed into concrete programs. From January 2019, the proposed plans in the Climate Agreement will be executed (Klimaatakkoord, 2018).

3.4.3: The Dutch Climate Act

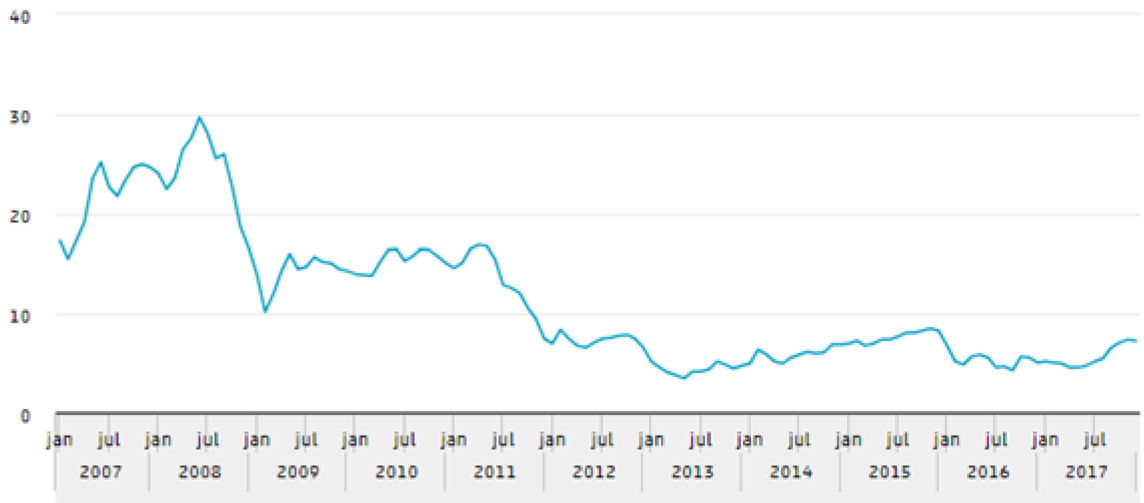
In June 2018, the Dutch government presented the Climate Act. This Climate law legally establishes climate objectives, along with mechanisms to uphold these objectives. Every 4th of October will henceforth be known as Climate Day, on which the cabinet presents the current GHG-emission reduction (Hofs, 2018).

The Climate Act will contain three objectives. Firstly, in 2050 the GHG-emissions will have to be reduced by 95% compared to 1990. This is more ambitious than the European ruling of an 80% reduction by 2050. Secondly, in 2030 the government aims (not mandatory) to reduce GHG-emissions by 49% compared to 1990. And finally, in 2050 the electricity production will have to be 100% GHG-neutral (Groenlinks, 2018). The original proposition for the Climate Act, presented in 2017, required 100% renewable energy by 2050 (PvdA, 2017). According to Hofs (2018), this objective was scaled down in a compromise with the VVD and CDA coalition parties, who wanted to retain the option to apply CCS to coal-fired powerplants to reduce CO2-emissions. This is striking, since the Coalition Agreement promised to close the coal-fired powerplants by 2050.

3.4.4: The European Emissions Trading System

At a European level the Emissions Trading System (ETS), founded in 2005, is the key instrument for tackling climate change by reducing GHG-emissions in a cost-effective manner by implementing the 'cap and trade' principle. A cap is set on the maximum GHG-emissions. Within this allowed emission level, companies can buy allowances or international credits from emission-reducing projects. The flexibility in trading these credits and allowances is meant to ensure investments in clean and low-carbon technologies (European Commission, n.d.b). Because of the decrease in available emission-rights each year, a higher demand and thus a higher price of emission-rights was expected, which in turn would force companies to invest in sustainable alternatives. However, in practice, the cost of emission rights has decreased as seen in figure 3.2 (Roffel et al, 2017; Zhang & Wei, 2010).

Figure 3.2: CO_2 price in euro per ton in ETS. (CBS, n.d.)



Londo (R4) states: *"The ETS is a polluter pays system, that has one specific drawback: the future price of CO2 is not very predictable. Public subsidies such as the SDE+ provide a more stable business case for investing in sustainable alternatives."* In sum, creating incentive at EU-level is tied to money and markets. Trust in the market and the capitalist system fits the neoliberal growth paradigm that has been dominant since the 1980s. In 15 years the ETS has not been sufficient enough to meet the targets of the Paris Agreement. Change and investment in sustainable alternatives is postponed because the price of emission-rights has been too low. In February 2018, the Council decided to reform the ETS from 2020 onwards, since the current ETS was not sufficient to meet the targets. According to Tielbeke (R10): *"The ETS does not function properly because there is not enough political will, The Netherlands has to take their own measures."* The question remains whether there will be enough political will on the European level at this time (The European Council, 2018).

3.6: Conclusion

In the past CCS has been met with a lot of negative publicity. The association of CCS with the prolonged use of coal-fired powerplants, along with the large-scale public opposition and NIMBY sentiments of the Barendrecht case, forced the Dutch government to change their CCS policies. In the new CCS policies, CCS no longer takes place onshore but offshore to reduce public opposition. Additionally, CCS will no longer be implemented at energy production level since these sectors can also run on renewable energy. The coalition agreement states that from now on CCS will only be implemented at industry level, since there are currently no viable green alternatives to CCS.

While the balance of the transition mix is questionable in the Dutch policies, with a lot of attention going to CCS, new features in the political climate such as the Dutch Climate Act and the Climate Agreement, show that the government is much more serious about climate policies than previous cabinets.

Chapter 4: Decoupling vs. Degrowth

This chapter analyses the impact of decoupling and degrowth strategies based on the CCS case studies and in-depth interviews.

4.1: Impact of decoupling policies

4.1.1: Decoupling policies

Regarding the feasibility of decoupling the opinions of the respondents differ. A few of the respondents think decoupling is a feasible method to reduce environmental and climate pressures. However, most respondents think decoupling might have negative impact. Juffermans (R6) agrees that only relative decoupling is possible. However, he warns for the rebound effect. The fact that growth would be possible without environmental degradation, could lead to more consumption which could offset the gains made through decoupling.

Tielbeke (R10) argues that relative decoupling would be possible, but not absolute decoupling. *"But I don't think we can solve these problems with decoupling. Not if we will maintain the ideal of everlasting economic growth"*. Additionally, decoupling is based on the premise of the Environmental Kuznets Curve (see §1.1). Tielbeke thinks it's unbelievable that this premise is still being used, since it has been proven wrong empirically again and again. Developed countries did indeed reduce their environmental impact, but only since all the polluting industries and production have moved abroad. The produce is now just imported by the developed countries, though the externalities of these imports are not registered in the national emission data. So, while decoupling might be possible relatively at a national scale, it is not possible at a global scale.

> *"I think it is dangerous that ecomodernists [the advocates of decoupling] still use the Environmental Kuznets Curve as evidence, since it promoted economic growth as the solution. However, if you look at the emission data. The only time that emissions reduced at a global scale was right after the financial crisis of 2008. Isn't that a very clear sign?"* (R10).

Londo (R4) argues that our economic system is trapped in the paradigm of economic growth. To what extent does economic growth contribute towards more welfare and happiness? However, he doesn't think any breakthroughs will happen anytime soon, since the growth paradigm is deeply rooted in our society. He therefore believes that we should work towards decoupling in the meantime. Mainly since decoupling is more marketable and easier to communicate. Biesta (R8) does not believe in decoupling. Decoupling will not lead to the sustainable society we need. He does believe in technological solutions, but these will not lead towards decoupling. True CO2 reduction only possible through growth.

Whether or not the respondents thought decoupling was possible, it is still the question whether decoupling can contribute enough, even if it would be possible. Some of the respondents mentioned that even if decoupling would take place, this would still not be enough to meet the Paris Agreement.

4.1.2: Decoupling in practice

CCS is a prime example of a decoupling policy strategy, a method to maintain economic growth while reducing its climatic impact. At first sight, CCS seems like a perfect solution to climate change. It is a simple enough fix that can be applied to our current industrial and economic system. No fundamental changes are needed, the pollution that is caused by our society can just be captured and stored in the ground. This believe in a technological solution is one of the main principles of decoupling. Through economic growth, innovation, human resourcefulness, and pragmatic policies, all our current climate and environmental problems can be solved.

As stated in the previous chapter, CCS is an essential climate mitigation option. However, as the case studies indicate the previous decoupling CCS project (case study 1-3) have not been effectively implemented. The K12-B case was too small-scale to be considered an effective decoupling strategy, since its climate impact does not contribute enough to the needed CO2-emission reduction. The Barendrecht case, indicated that a decoupling strategy in climatic policies, where a technological solution was implemented to reduce emissions, can lead to severe public opposition. Additionally, the ROAD project showed that the original policies of CCS prolonged the use of coal-fired powerplants through CCS while renewable alternative were possible. Therefore, CCS can in this case be a way to preserve the growth paradigm by relying on decoupling.

The main question is whether decoupling can achieve enough increase in efficiency to maintain the everlasting economic growth, while remaining within the boundaries of our finite planet. Seeing as absolute decoupling has not yet taken place, it seems that decoupling is not enough to combat climate change and the environmental crisis. Or perhaps the political will is not high enough to attain absolute decoupling. Several respondents mentioned that more central decision-making could be beneficial, while pointing towards China as an example. Freedom and market-based incentives do not seem to work in all cases, the failing ETS serves as a prime example. Perhaps political parties worry too much about elections than the long-term consequences of their policies. It seems the current systems causes a type of inertia that hampers true change.

However, even though decoupling does not seem feasible currently, that does not mean that decoupling is not useful. As indicated before, decoupling offers a marketable solution that fits within the current paradigm of economic growth. And that is still valuable in times that we need to reduce our impact fast and hard.

4.2: Questioning growth

Questioning growth as an indicator of economic development and welfare is not a new phenomenon. According to Kallis (2018:85) the growth paradigm is *"the hegemonic idea that growth is natural, necessary and desirable"*. But why do we still use such a crude number as GDP, that is based on the value of the goods and services produced in a country in a certain timespan, as a proxy for a country's well-being?

GDP was actually an invention of Kuznets, also the inventor of the Environmental Kuznets Curve. One of his students even proclaimed that Kuznets himself was the GDP's largest opponent. Kuznets argued that the GDP in itself had no value, and he strived for a measure that would indicate welfare instead of a crude summary of all activities. Kuznets therefore stated that only economic activity that was good for the people should be included in the national accounts. However, this has never happened. The worse the crime rate and the more expensive the healthcare system is, the better the economy seems to be (Pilling, 2018). This has a perverse effect, only growth is the goal not wellbeing.

The other main issue with the growth paradigm, is that GDP is based on hidden costs, externalities. *"The economic system is not build to include externalities, all the detrimental environmental and climate impact are therefore left out of the system"* (R9). According to Dasgupta: *"Contemporary models of economic growth and development regard nature to be a fixed, indestructible factor of production. The* *problem with the assumption is that it is wrong"* (Pilling, 2018:195). These externalities are the main problem with our growth fetish since they remove the incentive to move towards green alternatives, environmental destruction is currently counted as growth and thus well-being.

> *"We know that oil is under-priced because it is not dictated by the fact that there's a huge externality [carbon] every time you burn a gallon of petrol. And if it is under-priced, then there will be a tendency for technological change to be slow. In other words, technological innovations are biased against nature"...."If environmentalists are right, the pursuit of growth without end could even threaten the very existence of humanity. Ransacking our biodiversity, driving us to unsustainable levels of consumption and CO2-emissions that wreck the very planet on which our wealth depends" (Pilling, 2018: 201 and 13).*

Measuring well-being through GDP is still a remnant from the industrial revolution in which physical production was measured. However, GDP is much less applicable to measure well-being in a services-based or digital age (Pilling, 2018). Nearly all respondents agree that economic growth is not the right tool to measure welfare. Most of them do mention that this applies to developed countries, since in developing countries economic growth still contributes to lifting people out of poverty.

Another issue with growth, is that a growing economy does not offer any insights into the distribution of growth. Inequality has increased, 43 billionaires now own the same amount of capital as the poorest half of the world population (Tielbeke, R10). According to Kallis (2018), growth has always been based on the notion of exploitation. Most of the world population is not feeling any benefit of growth since increased productivity has been decoupled from employment and wages. Then why and for whom is all this growth needed? Hans Rosling, the well-known Swedish statistician, stated: *"I love money. I love GDP. However, GDP was never an outcome measure; it was always an input measure. This is what you have, and now you can make something out of it. Growth is not an end in itself"* (Pilling, 2018: 160).
According to Raworth (PC3), the concept of everlasting growth is the most existential economic question of our times. Growth is built into our institutions, our financial, political and social system depend on growth to function. *"Without growth it is much harder to keep our economy standing"* (Biesta, R8). It is an international collective action problem; no country wants to lose their growth since it would reduce their geopolitical power. *"Releasing our grip on growth is a non-issue in our society, while it is actually the root cause of all the problems"* (Biesta, R8). Raworth (PC3) argues that to move forwards, we need *"to create economies that enable us to thrive, that are distributive and regenerative, that meet the need of all within the means of the planet, whether or not they grow"*. The question is, is this truly equal and sustainable society a degrowth society?

4.3: Impact of degrowth policies

4.3.1: Degrowth policies

The core of the degrowth movement is the critique of the paradigm of economic growth, and the ecological impact of economic growth (Kallis, 2018). However, the name degrowth seems not fitting to what most degrowth followers believe. *"Degrowth is not negative growth, that is recession. Degrowth refers to a trajectory where the throughput [energy, material and waste flows] of an economy decreases while welfare, or well-being, improves"* (Kallis, 2018:9). The difference is that a decline in GDP is not the aim of degrowth, though it might be a consequence if the throughput declines. This being agnostic about growth, is what Van den Berg (2011) calls 'a-growth'.

Juffermans and Tielbeke (R6, R10) agree that the term 'Degrowth' has a very negative connotation. It seems to focus on things society can no longer do, no more growth. While according to most advocates of degrowth, societies should become agnostic about growth. Growth should no longer matter, only well-being. This premise is much more positive approach. *"From a PR viewpoint, the term degrowth is not very attractive. We should talk about an ecological sustainable future and talk about the positive aspects of this society. Like less inequality, public goods for all, free public transport. That is important to create public support and acceptance"* (Tielbeke, R10). Kate Raworth (2015), agrees with this. While degrowth addresses the most profound economic question of today, the debate should be reframed to attract more people.

The degrowth vision still seems a very abstract and vague concept that would not be applicable in the current economic and political system. Kallis (2018: 127-128) offers some concrete policy proposals for prospering without growth.

1. "Abolishment of GDP and substitution with other indicator based on human and ecological well-being
2. Work-sharing, with a reduction of working hours to create employment
3. Basic and maximum income, or a guaranteed bundle of public services ensuring that everyone has enough to get by without relying on money.
4. Green tax reform, which includes externalities and is distributive to reduce inequalities
5. Stop subsidies for polluting activities. Switch from private investments toward public investments that green the economy and reclaim the commons.
6. Implement environmental limits
7. Reduce and restrict advertising"

An important question of degrowth is whether it would fit within our capitalistic world. *"While the pursuit of growth is inevitable under capitalism, it is harder to claim that capitalism necessarily produces growth"* (Kallis, 2018:165). This has important policy implications. If capitalism could function without growth, then reforms regarding sustainability and justice might suffice without a total reconstruction of the current system. However, some argue that degrowth can only originate through a systematic change that would abolish capitalism. Current uneven class relations and political power make redistribution challenging. While economies might prosper without grow, this is mainly dependant on institutional reforms that go against the grain of the political economy of capitalism. However, even if a systemic change would be necessary, any transition must start from the current system of capitalism, therefore degrowth must be placed within the limits and possibilities of capitalism. Biesta (R8) is an advocate of degrowth. He thinks degrowth is the essence of the solution, since the production and consumption levels need to decrease. This correlates to the opinion of Juffermans and Stegehuis (R6, R7), who argue that it all comes down to reducing volume of production and consumption. Increasing efficiencies would only lead to a rebound-effect.
However, most respondents were hesitant towards degrowth. One respondent agreed that growth was not the answer, but she did not know whether degrowth could offer a solution. Tielbeke (R10) mentions that the degrowth discussion is difficult.

> *"This era is called the Anthropocene. Humanity's impact has grown towards a power of geological force. This should make the urgency for change clear. I don't think any further progress is possible [within the same growth paradigm]. However, I don't think degrowth is the solution. We should not aim for a pre-modern society. We have to find a positive but radically different society"* (Tielbeke, R10).

4.3.2: Degrowth in practice

Degrowth policies are not high on the current policy agenda. It is therefore harder to determine what the impact of degrowth policies are in practice. The Carbon Farming project has served as an example of a degrowth alternative to CCS.

However, interestingly enough, some of the respondents did not see the Carbon Farming case study as an example for degrowth policies. Staps (R2), chairman of the Carbon Farming project, argued that the sequestration of carbon in the soil also led to CO2 storage, which would also contribute to decoupling. Tielbeke (R10) agrees, in principle the danger is the same since both policies entail the storing of carbon, not the reduction of emissions. However, Carbon Farming does offer a more holistic approach, since the stored carbon has other positive effects on the living environment. Stegehuis (R7) disagrees and states that these positive effects fit within a more ecological approach of degrowth. *"Decoupling CCS is only storing CO2 for a high price, without any other use. This can therefore be seen as tackling the symptom"*. While both reasonings are understandable, it is true that Carbon Farming is also a method to store carbon. Therefore, the implementation of this type of carbon storage should also be handled with caution, to ensure this does not have a negative effect on the reduction of the cause of the emissions.

Whether or not Carbon farming is a degrowth or decoupling strategy, its impact at climatic and environmental level is low compared to CCS. Therefore, it seems that this example of a degrowth policy is not effective enough to offer a solution to the climatic problems.

However, this does not mean that all degrowth policies will not be effective enough. If the government would truly give degrowth-like policies a chance, a lot of impact could be made. Where there's a will, there's a way. However, currently the political will is not enough. Degrowth seems a very sensitive topic. While nearly all the respondents agreed that economic growth is root cause of many of our problems, they still seem hesitant to see degrowth as the solution. Economic growth is so deeply embedded in our society and economy that we cannot seem to envision a world without growth. Especially a degrowth society that, at first sight, seems fixated on reducing growth and returning to pre-modern times. However, the foundation of degrowth, the questioning of economic growth, is still most important issue of our time. It is still the planet that provides us all the resources to achieve growth and life, not the other way around.

Since degrowth is not currently on the agenda, decoupling policies still play an important role in the transition. Hopefully, this provides some time to evolve our society to resemble a degrowth society. A Netherlands that consumes less, pollutes less, while being more equal and happier.

4.5: Conclusion

While decoupling and degrowth are two opposing policies in theory, in practice both can be implemented at the same time. Although decoupling does not offer a complete solution, neither does degrowth since our current economic system and political will are not adaptable to a sudden systemic change. A revolution seems inconceivable, perhaps an evolution can lead our society towards a sustainable degrowth-like state. However, since the current climatic and environmental issue are urgent, there is no time to wait for an evolution. Therefore, both decoupling and degrowth policy measures should be implemented to combat climate change and reduce our environmental impact.

Chapter 5: Impact of CCS in the Netherlands

This chapter focuses on the impact CCS has on the climate, (living) environment, energy, economy, and ethics, as presented in the conceptual model. Furthermore, alternative options to CCS are analysed.

5.1: Impact of the choice for CCS on the climate

5.1.1: Need for speed & CCS

During a reading, Kate Raworth, author of Doughnut Economy, tried to convey the necessity of a swift transition to a low-impact society.

> *"We can't just take the time we want to take. Because the earth has been incredibly tolerant with us. Her resilience is tested to its limits. We don't know where those resilient points break down and we go over tipping points. So, we don't have all the time in the world to sort this one out. Because we don't know when we will reach those tipping points. And we don't know how things interconnect. Which is two reasons why we should be extremely precautionary and take far more urgent action than our governments currently take."* (Raworth, PC3).

According to the IPCC, CCS is needed to meet the targets of the Paris Agreement (IPCC, 2014). While all respondents agree with the research of the IPCC, some are a bit more sceptical of the possible negative consequences of the choice for CCS.

Londo (R4) states that there are still scenarios possible without CCS. However, these scenarios entail serious consequences for the Dutch society. Without CCS we would need to change our energy management, resource management, and our economy much faster and rigorously. According to Londo, NGOs dislike CCS because they see it as buying time to change. However, when looking at the impact the required transition will have, we should be happy to buy some time for the transition with CCS. Juffermans and Stegehuis (R6, R7) are more critical of CCS. They see CCS as symptom relief, instead of tackling the origin of the problem. CCS is a method to delay true change, while we should focus more on gaining efficiency and reducing our need.
According to some of the respondents, CCS offers the opportunity to aid the Dutch transition to low-carbon alternatives, while meeting our climate goals in the meantime. *"There is no longer time for a gradual transition, we need a revolution not an evolution"* (Hanegraaf, R1). However, it is important to note that all respondents see CCS as an interim solution to meet the needed emissions reductions. According to Biesta (R8), it is clear that CCS is a transition method, you cannot use CCS for ever. However, through CCS you can use cheap fossil energy and this cheap energy is needed for the transition to renewable energy.

While nearly all respondents agree with the need for CCS, the feasibility on this scale has not yet been proven. Tielbeke (R10) states that CCS is still in its infancy. Of the 13 planned CCS projects in the Netherlands, only one research CCS project, K12-B, is currently operational (SCCS, n.d.). However, the K12-B project has stored 0.1 Mton CO2 in 10 years, while the proposed plan of the coalition agreement was 18 Mton per year in 2030. Greenpeace (2018) states that there is not enough experience with large-scale storage. There are currently only four dedicated CCS project in geological storage in the world. However, CATO (2018) states that there are 13 large-scale Enhanced Oil Recovery CCS projects (see more in §5.2.4), which have contributed to knowledge development on CO2 storage.

Londo and Tielbeke (R4, R10) argue that the main issue with the Dutch policies regarding CCS is balance. There is too much emphasis on CCS. The transition towards a sustainable society should be realised through a mix of policies. This mix needs to be constructive in short and long term, with completely energy neutral and renewable as an end goal. The current policies cause a disbalance due to the emphasis on CCS.

5.1.2: The Coalition Agreement: 18 + 2 Mton?

According to the coalition agreement, CCS is supposed to reduce 18 Mton CO2 in the industry sector and an additional 2 Mton CO2 at the waste incinerations. Together CCS will contribute to one third of the proposed CO2 reductions of 49% in 2030 (Kabinetsformatie, 2017).

Most respondents stated that the total proposed reduction of 20 Mton is quite overambitious. Hanegraaf (R1) stated that while a reduction of 20 Mton might be technically feasible, practically and realistically it is not. There needs to be a larger incentive for companies to invest in CCS. The government is known to be capricious, which increases the insecurity to invest in these technologies. Furthermore, CCS is a technique that has not yet been applied large-scale in the Netherlands. This means that all the CCS infrastructure still needs to be build. Reaching a level of 20 Mton in 12 years seems too much in such a short time span (Londo, R4). This can be confirmed by new research by the PBL, who state that a reduction of 7.2 Mton would be more feasible R9.

According to Londo (R4) and Tielbeke (R10) the CCS specialists did not have a large input in the Coalition Agreement. Research of the PBL was used initially. However, after allocating the amount of CO2 emission reduction in transport, build environment, electricity, land use and agriculture sections, the residual CO2 emission reduction required for a reduction of 49% in 2030, were just allocated to CCS.

However, according to R3, director of CATO, it does not really matter whether we really meet the proposed target. When taking the climate issue fully into account, and when looking at the Paris Agreement, we know the enormous problem facing us. Therefore, it is time for big measures and statements. There has not been a serious scenario created without CCS. As a result, CCS is one of the building blocks to tackle the climate issue. It is important that the incentive for CCS is there. By proposing a 20 Mton reduction, feasible or not, it sends a message to companies to invest in CCS.

5.1.3: The impact on the ETS

Implementing CCS will also influence the Emissions Trading System (ETS). By implementing CCS, Dutch companies will emit less GHG emissions. This will lead to a reduction in the need for ETS credits. Due to this reduction more, credits will be available on the market, which will lead to a drop in the price of the credits. Therefore, CCS can reduce the incentive to invest in clean technologies at European level (R3, 4, 5-7). Some of the respondents noted that the government or the companies that invest in CCS, should buy an equivalent of the expected CO2 reduction in credits to combat this issue.

5.2: Impact of the choice for CCS on the (living) environment

5.2.1: Public acceptance of CCS

Public acceptance of CCS in the Netherlands has been very low, as the Barendrecht case showcased. Due to the issues of low public acceptance, protests, and NIMBY sentiments, all future CCS projects have been moved offshore in the North Sea. According to several respondents CCS also had a bad reputation due to the original policies to build new coal-fired powerplants in the Netherlands equipped with CCS.

Currently CCS is more broadly accepted in the Netherlands. Offshore CCS has eliminated the NIMBY sentiments since the storage will no longer take place onshore near neighbourhoods. This can be related to the situation of the K12-B project before the "Barendrecht sentiments". As stated by R1, during the offshore K12-B project there was no public resistance whatsoever. *"The storage took place far away in the North Sea, no one was bothered by it"* (Hanegraaf, R1).

R3 thinks that due to the Paris Agreement people start to realise that we need to solve this problem. And solving this problem requires certain sacrifices. People start to see that CCS is one of the building blocks of the solution. *"CCS is seen as the necessary evil"* (Hanegraaf, R1).
According to R9, the public acceptance has increased among the population, while it is still a difficult issue for political parties. Political parties are hesitant to express support for CCS since it can cost them votes, while before Barendrecht there was much more support from the political parties and the European commission.
Londo (R4) states that onshore CCS might be possible in the future when offshore has proven to be safe and reliable. However, this will need to be handled with extreme caution. *"When you mess up like with Barendrecht, it will take a generation for the acceptance to increase again. Certainly, at local level, but also at national level"* (Londo, R4). R9 states that for the foreseeable future the Dutch government will only focus on offshore CCS, but onshore CCS might be possible again in the future.

5.2.2: Environmental impact

The main issue regarding the environmental impact of CCS is leakage. The potential leakage of CO2 could have both global and local environmental risks.
At global level, the leakage of CO2 could reverse the impact of CCS by contributing to higher atmospheric CO2-levels and thus climate change. The impact at global level thus depends on the amount of leakage. According to the IPCC (2005) a leakage rate of 0.1% per year is considered perfect storage, however a leakage rate of 0.5% makes CCS unattractive as mitigation option. Moreover, the percentage of CO2 contained in the storage reservoir is very likely (probability of 90-99%) to exceed 99% over 100 years. This is confirmed by research of Greenpeace (2018) who state that the chance of leakage is fairly small to very small, in which the most probable leakage will happen once every 100 years. Additionally, globally no leakage has yet been observed in any of the operational or demonstration CCS projects.

At local level, leakage might affect humans, animals, ecosystems and groundwater (IPCC, 2005). Concerning local risks, two types of leakages are possible. Firstly, acute leakage could originate because of well failure or leakage through an abandoned well. A CO2 concentration of more than 7-10% could lead to dangers for human health and life. These types of leakages are easily detected and can be contained within hours or days. Additionally, since CCS will take place offshore in the Netherlands no local population can be harmed through acute leakage.
Secondly, gradual leakage could arise due to undetected faults, fractures or wells, which leads to a diffuse release of CO2. This type of leakage mainly affects water aquifers and ecosystems. Due to the release of CO2, acidification and oxygen displacement could take place in the soil.

One of the positive effects of CCS is the increase of pressure in the gas reservoirs (R3). Due to the large-scale gas recovery in the Slochteren gas field in Groningen, the internal pressure of the reservoir has decreased leading to earthquakes which have caused 18 billion euros worth of damage. The chance of earthquakes in Groningen could be reduced by increasing the internal pressure of the reservoir with CO2. However, even though there is currently no onshore CCS planned, the storage capacity of the Slochteren reservoir is estimated at 9.000 Mton (Noordzeeloket, n.d.). The capacity of the Slochteren reservoirs is thus much larger than the amount of CO2 the Dutch government wants to store.

The attention CCS receives also impacts the environment negatively. While climate change is an important issue, the climate crisis is much broader than GHG-emissions. According to Steffen et al. (2015), several elements have surpassed the planetary boundaries which is the safe operating space for human development. These are climate change (CO2 concentration and radiative forcing), biosphere integrity (global extinction rate), land-system change, and biochemical flows (levels of nitrogen and phosphorus, mainly caused by fertilizer use). Other stressed elements that have not yet surpassed their boundary are: fresh water use, ocean acidification, atmospheric aerosols, and ozone depletion. The Coalition Agreement focusses a lot on the Paris Agreement by reducing CO2-emissions, however the impact on the environment seems to be less important than CO2-emissions. According to Tielbeke (R10) this course of the Dutch environmental policies is dangerous. *"The current policies have an accountancy-style solution, just add up all the CO2 reducing measures in a large table, et voilà. There is the solution"*. The danger to this approach is that the root cause of the problem stays out of reach. Deforestation, pollution of the ocean, plastic pollution, the extinction of insects, pesticide use. These are all other symptoms like climate change, that are caused by the same economic and societal problem. *"As long as they keep talking exclusively about CO2, then it seems like an issue you can solve within the same paradigm. And that is the true danger of looking through these CO2-glasses, and therefore also seeing CCS as the main solution for our current problems"* (Tielbeke, R10).

5.2.3: Bio-Energy with Carbon Capture and Storage

Some of the respondents state that the investment in CCS is also done to be able to apply Bio-Energy with Carbon Capture and Storage (BECCS) in the future to obtain negative emissions. BECCS applies CCS to the carbon stored in the biomass. As biomass grows it incorporates CO2 in its fibres from the atmosphere through photosynthesis. When the biomass is broken down due to natural decomposition or combustion, the carbon is released back into the atmosphere. A process which is also known as the short carbon cycle. Through BECCS the CO2 that is released from the combustion of biomass is captured and stored. Therefore, CO2 from the atmosphere is captured and stored, creating negative emissions (Global CCS Institute, n.d.).

At small scale BECCS will be applied in the current plans. The Coalition Agreement plans to reduce 2 Mton of CO2 at the waste incinerators. Half of the waste that is incinerated is actually biomass, which means there will be defacto negative emissions (Londo, R4). However, large-scale implementation of BECCS should not be a priority at the current times. *"I am not convinced that we should steer our policies toward BECCS. We should apply CCS in sectors that have long-term economic perspective"* (Londo, R4). This can be confirmed by the "Klimaatakkoord", in which BECCS is seen as a possible innovation trajectory for after 2050 (Klimaatberaad, 2018).

Environmentally, there are large implications of the production of energy through biomass. Stegehuis (R7) is sceptical of the use of biomass. Locally it could have a positive effect. But globally it could affect the land use, biodiversity and food security. Biesta (R8) agrees with this, and states that if implemented at large-scale bio-energy and BECCS could have detrimental effects on deforestation and food security. However, using fast growing energy crops could slightly reduce the effect on land use, deforestation, loss of biodiversity and food security. Additionally, the possibility of using BECCS in the future could lead to a current loss of urgency. Since, if the currently emitted CO2 can be captured in a later phase of development, pressure to reduce emissions at this time will decrease.

5.2.4: Carbon Capture and Utilisation

Another possible use of CCS is CCU, Carbon Capture and Utilisation. The utilisation aspect of CO2 can provide renewable energy sources to produce valuable products. However, at this time less than 1 percent of the CO_2 that is emitted is being utilized (Al-Mamoori, 2017). This is confirmed by several respondents (R1, R3, R4), who state that the utilisation aspect will only play a small role in the Netherlands. *"It forms a drop in the ocean. However, all the CO_2 you can use, you should use. And the other 95% of the captured CO_2 you should store"* (R3).

According to R3, the one sector where utilisation is taking place at a commercial scale is Enhanced Oil Recovery (EOR) in America. EOR entails the injection of CO_2, which mixes with the oil which then expands making it lighter and thus easier to recover. EOR with CO_2 is the most common and effective EOR method used (Al-Mamoori, 2017). While it is a method to store CO_2, the method is paradoxical. "*You have to wonder whether this is a good thing to do. Recovering oil with EOR is better for the climate than recovering oil without EOR. However, it would be even better not to recover the oil at all"* (R3).
The second type of utilisation that is already occurring in the Netherlands is the use of CO_2 in the greenhouses. The additional CO_2 provides an optimal growth curve for the crops in the greenhouses. Currently Shell and Alco are already providing CO_2 to 600 greenhouses. However, even though the CO_2 is utilised, it still enters the atmosphere. Nevertheless, this technique does mean that less gas is being used in the greenhouses (R1, 3, 5).

A third type of CCU is chemical conversion (Hanegraaf & Londo, R1, R4). Through chemical conversion the CO_2 can be utilised to produce fuels, such as methane, methanol, syngas. This type of CCU can also produce a large array of fine chemical, such as urea, the most widely used fertilizers (Al-Mamoori, 2017).
Another option is the desalination of the captured CO_2. The CO_2 can be used to remove total dissolved solids, and thus changing brine into water. Current desalination plants do not use CO_2 due to the relatively high costs. However, the development of new technologies will lead to more cost-efficient utilisation of CO_2 in this process (Al-Mamoori, 2017).
Even though the utilisation of CO_2 does offer perspective, certainly when more research and development has taken place, R3 is worried that money invested in CCU can no longer be invested in CCS. The Dutch government should primarily focus on reducing the climate crisis, in which CCS plays a much larger role than CCU.

5.3: Impact of the choice for CCS on energy

5.3.1: Implementing CCS in the industry sector

> *"People have no idea what the energy transition actually entails. People think a few windmills at sea and some solar panel, an electric car, and we are done. But when we look at our energy demand, it is so big, and [household] electricity is not the problem. We have to transform our industry"* (Hanegraaf, R1).

The application of CCS used to be planned for electricity generation in the new coal-fired powerplants in 2006. However, the Coalition Agreement states that CCS will now be applied to the industry to reduce 18 Mton of CO_2 in 2030. According to Londo (R4), this switch in CCS application has been a good choice for two reasons. Firstly, while there are many low-carbon alternatives to produce electricity, this is not the case in the industry, because it is difficult to electrify this sector. *"In the future we will still need steel for windmills. To produce steel high temperatures of 1000 degrees Celsius are needed, for which fossil fuels are required. So, we will need CCS for a certain period till alternative processes are available"* (Hanegraaf, R1).

Secondly, in the industry sector pure CO_2 is a direct by-product of several processes, while in the electricity sector flue gas is produced from which it is costlier to subtract CO_2 (Hanegraaf & Londo, R1, R4).

5.3.2: Energy penalty

The implementation and use of CCS leads to a so-called energy penalty. Due to the additional energy requirement to capture, compress, transport and store the CO_2, an energy penalty exists which reduces the net conversion efficiency (Koornneef et al., 2012). According to Sathre et al. (2012), the additional energy use due to CCS ranges from 16-65%. Koornneef indicates average percentages of energy penalties that are much lower, ranging from 2-19%, as seen in table 5.1. The capture efficiency entails the net reduction of CO_2 from energy production with and without CCS. According to Sathre et al. this percentage lies around 90%, Koornneef offers a slightly lower average as seen in table 5.1.

Table 5.1: Energy conversion and CO2 capture efficiencies of power plants with CCS (after Koornneef, 2012)

Capture process	Conversion technology	Energy penalty of CO2 capture (% pts)	Capture Efficiency (%)
Post-combustion	Pulverized coal	8-13	85-90
	Natural gas combined cycle	5-12	85-90
Oxyfuel	Pulverized coal	9-12	90-100
	Gas cycle + Natural gas	2-19	50-100
Pre-combustion	Integrated gasification	5-9	85-90
	Gas cycle	5-13	85~100

The range of energy penalty is thus dependant on the source, type of capture and type of storage (R1). As stated in §5.3.1, pure CO_2 is often produced in the energy sector. This means that the energy penalty in the industry is lower than with CCS in coal-fired powerplants. However, the energy penalty will increase in the Netherlands since all CCS will take place offshore instead of onshore. Offshore will require additional transport, and thus energy. However, the energy requirement for transport is only a fraction of the total energy requirement. The offshore energy penalty is thus negligible when looking at the total energy penalty (Londo, R4 & R9).

Londo (R4) states that the energy penalty is a large disadvantage of CCS. It seems paradoxical to use more fossil fuels and generate more CO_2 to store CO_2. However, the net gains of the CO_2 storage through CCS is much larger than without the use of CCS.

5.3.3: Impact of the closing of the Dutch coal-fired powerplants

In the Coalition Agreement the government states that they want to reduce 12 Mton of CO_2 by 2030 by closing the coal-fired powerplants. These coals plants will be phased out at the latest by the end of 2030 (Kabinetsformatie, 2017).

When transitioning our electricity grid towards local production of renewables such as wind and sun, there will always be high production levels during summer, daytime, and periods with wind. However, large-scale storage of electricity is still very costly and inefficient. This means that during low production times there is not enough electricity available. During these times coal-fired powerplants need to produce the residual electricity demand (R3). This means that even if the Netherlands will close the coal-fired powerplants, they will still be reliant on them. This results in an increase in the dependence

on import. According to R3, closing the powerplants short term is seen as a bad idea. *"We have very new, cheap, efficient, and clean coal-fired powerplants. By closing our plants, we will be reliant on the German brown coal-fired powerplants, which are much less efficient and emit much more CO2"* (R3). Therefore, while closing the coal-fired powerplants in the Netherlands might reduce our national CO2-emissions, it will only increase our total CO2-emissions embedded in our import.
Tielbeke (R10) is opposed to this argument, which is often used as an excuse to delay change. Coal is still the most polluting form of energy and applying CCS to coal plants prolongs the reliance on coal. Furthermore, the Netherlands is lagging in renewable energy. It is therefore necessary to get rid of coal as soon as possible.

According to R3, we should close the coal-fired powerplants in the long term. However, during the transition period we should still use the Dutch coal-fired powerplants and apply CCS to them. That way the Netherlands can use its existing CCS infrastructure, and still profit from cheap and clean energy to fuel our transition, while not being reliant on polluting import and externalizing our climate impact (R3 & Biesta, R8). According to PBL (2018) research, it is even unlikely that the Netherlands will meet the proposed reduction of 20 Mton in 2030 when closing the coal-fired powerplants. Mainly, since it is relatively easy to apply CCS to coal-fired powerplants, and they offer the largest technical potential for CCS, while also being the most cost-effective.
Biesta (R8) states that he thinks there is a chance that the Dutch plans to close the coal-fired powerplants might change. By the time we reach 2030 and the coal-fired powerplants need to close, the new government might decide to use the at large-scale operational CCS infrastructure and apply it to the remaining coal-fired powerplants. This hunch can be party confirmed by the changes made to the Climate Act (§3.4.3). Additionally, coal-fired powerplants can be refitted to co-fire biomass. So, a positive effect of the coal-fired powerplants could be to implement BECCS and acquire negative emissions in the future (Londo, R4).

5.3.4: Carbon Lock-in

Carbon Lock-in is a phenomenon of self-perpetuating inertia due to market and policy failures caused by the fossil-based energy system that inhibits the introduction low-carbon technologies (Unruh, 2000). According to Biesta (R8), the lock-in phenomenon affects the Dutch energy system, mainly due to our reliance on gas, coal, and our steel production. As stated in the previous two paragraphs, CCS allows the prolonged use of coal and gas and some respondents thinks this is a good option to supply the energy needed for the transition.
However, Tielbeke, Juffermans and Stegehuis (R6, R7. R10) agree with the negative effects of lock-in. By introducing CCS, the Netherlands can prolong the use of coal and gas instead of investing in renewable alternatives. *"Through CCS we only attempt to handle the symptoms by stuffing the CO2 below the ground, not the actual problem of producing CO2"* (Stegehuis, R7).
Londo (R4) does not believe in lock-in or path dependencies. *"While CCS does have investment costs, there are also variable costs. And at a certain time, you must decide to reinvest in CCS or choose one of the new alternatives. There will always be a moment in time where you can choose the new alternative option"* (Londo, R4).

5.4: Impact of the choice for CCS on the Dutch economy

5.4.1: The cost of CCS

According to the PBL (2018) (Netherlands Environmental Assessment Agency) the costs for CCS are uncertain since there is not yet a CCS project aimed at CO2-emissions reduction operational at commercial scale in the Netherlands. Additionally, the costs are dependent on the type of capture, transport, storage, and the current fuel prices. The costs of table 5.2 are based on foreign research applied to the Dutch context, including the saved purchase of ETS credits.

Table 5.2: Potential and costs of CCS in the Netherlands. (After PBL, 2018)

CCS Options	Technical potential (Mton)	Costs (M€)	Cost-effectiveness (€/ton)
CCS - Industrial process emissions low (NH3 and H2 production)	1.5	55	10 - 50
CCS - Industrial emissions steel industry	5.5	290	40 - 60
CCS - Refinery	6.0	520	60 - 100
CCS - Industrial emissions general	10.5	1085	70 - 120
CCS - Waste incineration	3.0	335	85 - 135
CCS - coal-fired power plants	13.0	455	35
CCS - Gas plants	4.1	255	62

However, Greenpeace (2018) is more critical of these costs. The costs of monitoring the reservoirs has not been considered. When either implementing monitoring and its costs or not implementing monitoring and thus potentially releasing CO2 from the reservoirs, in both cases CCS is a cost-ineffective measure compared to other emission reduction options. CATO (2018b) is critical on the calculations done by Greenpeace (2018). The monitoring plans Greenpeace suggests are 10.000 years. According to CATO this is not realistic, after 5 to 10 years of monitoring it is possible to determine whether the subsurface is stable, after that, monitoring is no longer necessary since research has indicated that the chance of leakage reduces in time.
According to Londo (R4), CCS will always cost money. When you look at renewables such as wind or solar, at a certain point in time they will generate income. However, CCS will always cost money since it only stores CO2 and does not produce any useable products. However, if the ETS prices would increase drastically, and the CCS investments costs would go down. Then it would be possible to make a viable business case for CCS, since it would be cheaper to invest in CCS than to buy ETS credits. Nevertheless, this is not likely to happen any time soon (R4). Biesta (R8) agrees with this and states that the impact of CCS on the Dutch economy all depends on EU policies and the price development of the ETS system which is currently much too low for CCS.

5.4.2: Financing CCS from the SDE+ fund

The Coalition Agreement (Kabinetsformatie, 2017) stated that CCS would be financed from the SDE+ operating grant. SDE+ is a grant meant to stimulate renewable energy production. The Coalition Agreements wants to broaden the grant to also include CCS. According to Londo (R4), this could pose a risk for renewable options. The government should ensure that the mix of renewable options is balanced. All options in the mix should receive adequate stimulation. However, Londo (R4) does state that there will be further negotiations on the way the SDE+ budget will be broadened in the Climate Accord.
Hanegraaf (R1) states that while it is true that each euro invested in CCS cannot be invested in renewable energy, it might be necessary: *“If you look at the numbers, then you can see it is really necessary to reduce our emissions quickly. We need CCS to be able to meet the 2 degrees Celsius target”* (Hanegraaf, R1).

5.4.3: Polluter pays vs. public subsidies

There is a larger debate on the financing of CCS. Opponents of CCS state that the large emitters should be responsible for most of the costs of CCS (Juffermans & Stegehuis, R6, R7). However, the polluter pays principle would mean that companies like Shell or EON would have to invest heavily in CCS. By doing so their products would become more expensive. The polluter pays principle thus leads to financing CCS through consuming. A consumer who uses more of the product, electricity for example, would contribute more to the financing of CCS (R3). This seems like a fair system since the consumer who pollutes more, pays more, creating an incentive to use and pollute less. However, measures like this would hit the poorest of the population harder. By implementing a polluter pays system poorer people would no longer be able to enjoy the same benefits as richer Dutch people. Nonetheless, if CCS would be financed from public subsidies, through the Dutch tax system, it would be financed more equally. Since the richer part of the population pays more taxes, they also invest more in CCS. Notwithstanding, this does remove the incentive to reduce pollution. Tielbeke (R10), disagrees with this argument since the possible inequality created by the polluter pays system could be compensated through other tax measures.

Nevertheless, the polluter pays vs. public funding debate are not two measures at either side of the coin. Both can, and should, be implemented at the same time according to nearly all the respondents. This is currently happening, the ETS is a European wide polluter pays system, while national subsidies are also needed to ensure CO2-emission reduction (Londo, R4). Most of the respondents agree that public funding is necessary for initial investments in the CCS infrastructure.

According to R3, you will need to start the finance of CCS through public subsidies, to get things going. But at a certain time when the CCS infrastructure has been built, you must switch to a polluter pays system. Londo (R4), disagrees with R3, he thinks you should always start with a polluter pays principle. However, Londo (R4) thinks the financing of CCS through public subsidies is not odd in the first development phase, however eventually it will be a mix. Later when the CCS infrastructure is operational, the financial balance should shift more towards a polluter pays system.

5.4.4: CO2 trade: importing CO2?

As stated in §4.1, the Netherlands has an enormous storage capacity for CO2. 1.700 Mton in the North Sea, and 1.200 onshore (Hanegraaf, R1). A capacity much higher than any of our neighbouring countries. Since our current aim is to store 20 Mton/year by 2030, there is a lot of residual storage capacity. Our neighbouring countries Germany, Belgium and Denmark would all be interested in exporting their CO2 (R1, 4, 8). According to Biesta (R8) Germany would be most interested since they are closing their nuclear powerplants and will become even more reliable on coal-fired powerplants.

While Juffermans (R6) is slightly pessimistic: *"Typically Dutch, making profits through sustainability"*.

Biesta (R8) states that the import of CO2 could help finance the CCS infrastructure in the Netherlands. A viable business case for CO2 import could yield the Dutch economy dozens of millions (R4).

5.4.5: CCS: maintaining economic growth?

According to Biesta (R8) our neoliberal system only functions with economic growth. Without growth it would be hard to keep the Dutch economy standing. However, it is this economic growth that is the root of all our problems. The transition towards sustainability offers an opportunity to steer our economy from economic growth. "*We don't realise how much impact the free market has. Energy price plays such a large role. Our current economy drives us to consume, while we should focus on saving and economizing. We won't make it without degrowth"* (Biesta, R8).

Londo (R4) disagrees with the fact that CCS is being used to protect the Dutch economic growth. Since CCS is more expensive than other options, it will also decrease economic growth. However, CCS does

enable the preservation of the current economic system. *"If you need CCS to buy time to change the economic system in a responsible manner, then I agree. But if you choose CCS to prolong the preservation of an economic system that won't last in future, then you are entering a dead end. So, the treatment of symptoms is not bad if it leads to a structural solution in the end"* (Londo, 26 June 2018).
R3 states that it might be possible to meet the Paris Agreement without CCS. However, there are few IPCC models that indicate it would be possible. If the Netherlands would try to meet the targets without CCS it would have a detrimental impact on our economy and society. *"It will cost a lot of money, and we will have to destroy our capital and some of our industries such as steel and the chemical industry. And if we are being realistic, we cannot build windmills and solar panels that quickly"* (R3).

5.5: The ethical impact of the choice for CCS

5.5.1: Ethical impact of CCS

When asked what ethical impact the choice for CCS has, a variety of answers are given by the respondents. One of the main arguments given was intergenerational justice. Large-scale implementation of CCS would lead to yet another to pass down to future generations. *"We are the first generation to actually experience the impact of climate change, and also the last generation who can prevent its worst impacts"* (Londo, R4). However, not implementing CCS could also decrease intergenerational justice, since this would lead to higher emission levels and thus climate change.

Another aspect mentioned is the precautionary principle. According to Kriebel et al. (2001), the precautionary principle comprises of four components: taking preventive action when dealing with uncertainty, applying the burden of prove to the activity, analysing alternative possibilities and improving public participation in decision making. Since the consequences of long term CO2 storage are not yet known, the precautionary principle should be considered.
According to Tielbeke (R10), another important ethical aspect is who will pay for CCS. CCS is a relatively expensive method to pay for CO2 reduction. As stated earlier, if the industry is responsible for the costs, the costs of the product will increase and will penalise the consumer. The energy transition is thus also related to the socio-economic distribution issue. Implementing certain measures, like CCS, could lead to a green upper class. Only the rich population can implement sustainable measures and make use of subsidies. While the poorer part of the population cannot make use of the subsidy schemes, and will take less sustainable measures, leading them to be punished financially for being less green since they emit more CO2. Resulting in an even larger inequality. This can be related to the polluter pays vs. public funding debate in §5.4.3.

5.5.2: CCS: delaying the inevitable change?

According to Kate Raworth (PC3), the investments in CCS could delay the inevitable change needed in the energy transition:

> *"I worry that CCS justifies continued investment in fossil fuels, as opposed to shifting deep investment in the technologies that are needed in renewable energies. Because that is what will bring the price down. So, while the fossil fuel industry continues to say: 'no it's ok, we can keep going, we'll dig deeper, and we'll frack further'. It's all stalling the shift in investments needed to bring the cost curve right down. So, at that level, I think it's holding on to the old system, rather than shifting to the new."*

This is related to another ethical aspect mentioned by Tielbeke (R10) about the fact that CCS is the preferred choice of the industrial sector. CCS is promoted by the industry since it's a climate policy choice that does not affect their business model. There is a large industrial lobby in the Netherlands, and the industry sees CCS as a magic silver bullet. The choice of CCS is therefore an indication of a business-as-usual path.

CCS is by definition an end-of-the-pipe solution. By capturing and storing CO2 no systemic change must take place. There's no need to reduce economic growth or change the economic or industrial model, when it's possible to 'solve' the problem by just storing the CO2 underground (R10). Additionally, the Dutch government will place their trust in a technological solution. A technological solution that has not been implemented at this scale world-wide. According to Tielbeke, believing in a techno-fix is risky behaviour, since no actions are taken presently to create actual change.
However, even though CCS is a method to combat the symptom instead of the actual problem, it's also known that CCS will still be necessary to reduce CO2 emissions quickly to meet the targets. This is confirmed by Londo (R4), who argues that CCS is an essential part of the policy mix to reduce emissions. However, he does state that we have to take in to account that CCS is just an interim solution to meet the current target, and that inevitable change towards renewable energy sources will still be necessary. He therefore argues that the current policy mix is not balanced. Too much attention is going towards CCS which could undermine renewable alternatives. The climate policy mix should therefore be more constructive towards the end goal of the transition: a completely carbon neutral and renewable economic system. This debate can be related to carbon lock-in (§5.3.5) since CCS protects the business-as-usual scenario in which we are reliant on fossil fuels.
According to Juffermans and Stegehuis (R6+7), large-scale CCS implementation could also lead to a form of the Jevons Paradox. By implementing CCS, a rebound effect could take place: because the CO2 can be stored, there is less incentive to reduce the use of fossil fuels or invest in increasing efficiency or reducing our consumption. CCS can therefore reduce the urgency for alternative solutions to the climate issue (R6, 7, 10).

5.6: Conclusion

In conclusion, the policy choice for CCS is a controversial topic. While all sources indicate that CCS is essential for the energy transition, several negative impacts are also found. Regarding the impact on the climate, the feasibility of CCS at the proposed scale has not yet been proven. Furthermore, the current emphasis on CCS in the Dutch policies is too large, the policy mix should be more balanced. With respect to the impact on the living environment, the public acceptance has been very low. However, the proposition of offshore CCS and the abolition to implement CCS at coal-fired powerplants, has reduced the opposition. CO2 leakage could lead to both global and local problems. Nonetheless, that chance of leakage is considered to be small. CCS can lead to the assumption that storing carbon can solve all current environmental issues, while the true problems are much more diverse.
Concerning the impact on energy, the energy penalty of CCS has a negative impact since more use of fossil fuels is needed to capture and store the CO2. The application of CCS in the industry sector seems a good policy choice since this sector is more difficult to run on renewable energy. Therefore, the choice to abolish CCS on coal-fired powerplants is justified.
Regarding the impact of CCS on the economy, it's true that CCS is a costly method for an interim solution to reduce emissions. Additionally, the plans to finance CCS from the SDE+ grants could lead to less investments in renewable energy.
Ethically, CCS can affect intergenerational justice because, yet another waste product is passed down to other generations. The main ethical question is whether CCS is just a method to delay inevitable change. CCS is an end-of-the-pipe solution, that combats the symptoms but not the root cause of the problem. It is therefore imperative to ensure CCS is only used as an interim solution, while not

hampering the renewable energy transition through carbon lock-in. Additionally, the industrial sector lobbies for the implementation of CCS since it does not affect their business model.

It can therefore be agreed upon that CCS is not the ideal solution to combat climate change and reduce the environmental crisis. However, it is just too late for other alternatives. The emissions levels need to go down instantly to reduce the impact of climate change. CCS is therefore a flawed but necessary policy to aid the transition.

Conclusion

This thesis investigated the impact of the choice for CCS through in-depth interviews and case studies, while linking the findings to decoupling and degrowth environmental policies, by means of the following question:

> *What are the implications of the Dutch government's choice for CCS as main climate policy in relation to decoupling and degrowth strategies?*

The policy choice for CCS is a controversial topic. While CCS is essential for the energy transition, several negative impacts are also found. Regarding the impact on the climate, the feasibility of CCS at the proposed scale has not yet been proven. Furthermore, the current emphasis on CCS in the Dutch policies is too large, the policy mix should be more balanced.
With respect to the impact on the living environment, the public acceptance has been very low. However, the proposition to offshore CCS and the abolition to implement CCS at coal-fired powerplants, has reduced said opposition. CO2 leakage should not be a problem, since the chance of leakage is small.
Concerning the impact on energy, capturing and storing CO2 requires the use of more fossil fuels which leads to an energy penalty. The application of CCS in the industry sector seems to be a good policy choice since this sector is more difficult to run on renewable energy. Therefore, the choice to abolish CCS on coal-fired powerplants is justified.
Economically, CCS is a costly method for an interim solution to reduce emissions. Additionally, the plans to finance CCS from the SDE+ grants could lead to less investments in renewable energy.
Ethically, CCS can be seen as a method to delay the inevitable change. CCS is an end-of-the-pipe solution, that combats the symptoms but not the root cause of the problem. It is therefore imperative to ensure CCS is only used as an interim solution, while not hampering the renewable energy transition through carbon lock-in.

Altogether, CCS is not the ideal solution to combat climate change and reduce the environmental crisis. CCS is a perfect example of a decoupling policy. The Dutch policy choice for CCS seems to be grounded in pragmatism and influenced by the industrial lobby. Just add up all CO2 reducing measures in a large table and this will solve the environmental and climatic issues, a quick techno-fix will lead to business as usual. In reality, this will not solve the root economic and societal problems. Nevertheless, it is too late for alternatives. The emissions levels need to be reduced instantly to combat climate change. CCS can therefore be seen aa a flawed but necessary policy to aid the energy transition but should not be the end solution. Since the clock is ticking and there is no time to waste, decoupling and degrowth policies should be implemented at the same time to combat climate change and reduce environmental impact.

Discussion

Theoretical implications

Regarding the context of CCS, the sub-questions on the previous CCS project and the context of CCS within the political landscape have been answered. In the past CCS has been met with a lot of negative publicity. The association of CCS with the prolonged use of coal-fired powerplants, along with the large-scale public opposition and NIMBY sentiments of the Barendrecht case, forced the Dutch government to change their CCS policies. While the balance of the transition mix is questionable in the Dutch policies, with a lot of attention going to CCS, new features in the political climate such as the Dutch Climate Act and the Climate Agreement, show that the government is much more serious about climate policies than previous cabinets. These findings have contributed to the understanding of the Dutch environmental and climatic policies.

Concerning the debate on Decoupling vs. Degrowth, the original premise was that decoupling and degrowth are two contrapositive environmental policy strategies. However, while decoupling and degrowth are two opposing policies in theory, in practice both can be implemented at the same time. Although decoupling does not offer a complete solution, neither does degrowth since our current economic system and political will are not adaptable to a sudden systemic change. A revolution seems inconceivable, perhaps an evolution can lead our society towards a sustainable degrowth-like state. Nevertheless, since the current climatic and environmental issue are urgent, there is no time to wait for an evolution. Therefore, both decoupling and degrowth policy measures should be implemented to combat climate change and reduce our environmental impact.

The analysis of the impact of CCS according to the five themes, has led to new insights regarding the implications of the Dutch government's choice for CCS as its main climate policy. It has been determined that CCS is not the ideal solution to combat climate change and reduce the environmental crisis. However, it is too late for other alternative options. The emissions levels need to go down instantly to reduce the impact of climate change. CCS can therefore be seen as a flawed but necessary policy to aid the energy transition. It is the question whether an energy transition without CCS would be possible without degrowth measures, because without CCS the economic system would have to be changed much faster. Previous research has only focussed on either environmental or social impact. This thesis thus builds upon the framework of CATO which investigated the pro and con arguments for CCS in the Netherlands.

Policy recommendations

Based on the suggestions of the respondents and the findings of this research, a set of policy recommendations have been made.

1. It is the government's responsibility to ensure the transition towards sustainability in the Netherlands. The government should steer the direction and make it easier for the polluting companies and consumers to follow.

2. CCS should be implemented in a cautious way, to not hinder alternative developments. Therefore, the use of the SDE+ funds for CCS is not advisable. Furthermore, the transition policy mix should be more diverse, with less emphasis on CCS. Moreover, the policies should also be more inclusive towards other issues within the environmental crisis.

3. CCS should be implemented at industrial level. It is imperative that the forthcoming CCS infrastructure will not be used as an excuse to continue energy production through coal-fired powerplants. This path dependency needs to be broken.

4. The climate and environmental policies should be beneficial for all Dutch people, by stimulating a redistribution of wealth. For example, instead of providing subsidies for Tesla cars, that still only the rich could benefit from. It would be better to create free public transportation. What better way is there to reduce emissions, reduce the pressure on the infrastructure, and be distributive in spirit?

5. A tax reform is needed to tax polluting activities, while also reducing tax on green alternatives. This would lead to an incentive, a nudge, for consumers to make a choice that has a reduced climatic and environmental impact.

6. All policies should be redirected towards long-term goals, not short-term gains. Within these long-term goals a degrowth resembling society needs to be leading example.

Limitations, validity and reliability of the research

The choice of case studies could have influenced the external validity, since the acquired results might differ if other case studies had been chosen. Additionally, since only one degrowth CCS case study was selected less results were produced on the impact of degrowth policies in practice. While this reduces the external validity, a compromise has been made between validity and feasibility. Since degrowth is still a very misunderstood topic, research into the practical impact of degrowth is still needed in the future.

Additionally, the use of decoupling and degrowth CCS projects as an example for decoupling and degrowth environmental policy strategies influences the external validity. Therefore, no general conclusions on the effectiveness of decoupling and degrowth environmental policy strategies can be given.

The choice of respondents also had an impact on the validity of the research. While a diverse respondent list was attempted, the NGO sector was not interviewed. This was mainly due to their time restrictions. To counterbalance this setback, a journalist that was familiar with the point of view of NGOs was interviewed instead. However, the balance between believers in decoupling vs. degrowth, was equally distributed over the respondents to reduce bias in the results.

To conclude, the thesis results have thus contributed to a better understanding of the impact of CCS on the climate, living environment, energy, economy and ethics. Furthermore, more knowledge is gained on the impact environmental decoupling and degrowth policy strategies have in practice. These results can be applied in practice by the policy recommendations and can contribute to a change in public perception by reducing the insecurities of the effects of CCS. Altogether, these results have contributed to the larger growth debate and the effectiveness of environmental policies, to reduce environmental degradation.

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Appendix I: Interview guide

Not all questions were asked to all respondents. The type of questions asked depended on the knowledge base of the respondent. For the questions regarding the five themes, only the first question was asked in all instances. The words in open bullet points, where determined by literature review or through new insights due to previous interviews.

Introduction

- What does your company do?
- What is your function?
- What is your role in the project?

Case studies

- How did the project arise?
- Which stakeholders were involved?
- What was their roll and interest?
- What happened during the project?
- What was the impact of the project?
- What was learned from the project?

General CCS

- How do you envision a sustainable Netherlands?
- What is your opinion of the current climate and environmental policies?
- What were the original CCS policies?
- What do you think about the Dutch policy choice for CCS?
- Why did the Netherlands chose for CCS?
- In which sector will CCS be implemented?

Climate

- What impact does the choice for CCS have on the climate?
    - Is 18 + 2 Mton feasible?
    - What storage potential is possible in the Netherlands?
    - Risks?
    - Difference on- and offshore?
    - Alternative for CCS possible?

Living environment

- What impact does the choice for CCS have on the living environment?
    - What is the public acceptation like currently?
    - Utilisation?
    - BECCS?
    - Risks?
    - Onshore possible in the future?

Energy

- What impact does the choice for CCS have on the energy?

    - Energy penalty?
    - How long will the energy transition take?
    - Is the energy transition mix in balance?
    - Will the transition focus on molecules or electrons?
    - Impact closing coal-fired powerplants + Import needed?
    - Impact end of gas extraction?
    - For which sectors is there no alternative for CCS?
    - Lock-in effect?

Economy

- What impact does the choice for CCS have on the economy?
    - Costs of CCS? + Difference on- and offshore?
    - SDE+ funds?
    - Polluter pays vs Public subsidies?
    - CO2 import trade ?
    - CCS to maintain economic growth ?

Ethics

- What impact does the choice for CCS have on an ethical level?
    - Intergenerational justice?
    - Precautionary principle?
    - Delaying change?
    - SDGs, does NL take its responsibility?

Decoupling vs Degrowth

- Is decoupling possible? (trade embedded emissions?)
- Economic growth is seen as a measure for wellbeing? What is your opinion on this?
- Alternative for decoupling is degrowth. What is your opinion on this?
- Is a degrowth society possible?
- What will be the impact of degrowth on the Dutch economy?
    - Are these theories their opposites?

Conclusion

- Who is responsible for change? Government, polluting industries, multinational companies, the individual?
- What steps should the Dutch government take to ensure effective climatic and environmental policies?
- How will the Netherlands look in 2100?

Appendix II: List approached respondents

The following list entails the respondents that have been approached for interviews, but did not respond or declined the invitation.

Carbon Farming (Koolstofboeren) project

- Wico Dieleman (ZLTO)
- Roel Clement (ZLTO)
- Heleen Klinkert (Bionext)

Decoupling

- Hidde Boersma (Groene Amsterdammer: ecomodernism)

Companies

- Ron Arts (ENGIE)

Government

- Ministry of Economic Affairs and Climate Policy

NGO's

- Sander van Egmond (Urgenda)
- Natuur en Milieu
- Greenpeace
- 350.org

Appendix III: CCS Framework

CCS framework is based on the five themes of climate, living environment, energy, economy and ethics, which originate from the CATO (2018a) Debate Map.