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Of washing machines, plumbing work and thermostats

An analysis of articles on climate engineering in German newspapers

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Abstract

This thesis aimed to identify what arguments are made and who is dominating the discourse about climate engineering in German newspapers. Climate engineering refers to methods that deliberately change the environment as a means to combat climate change. To answer these questions, the author conducted a Critical Discourse Analysis of articles about climate engineering published in German newspapers between January 2015 and March 2019. This analysis shows that the main argument in the articles is that climate engineering is necessary to limit global warming to a maximum of 1.5°C, compared to pre-industrial levels, and thereby advert catastrophic consequences of climate change. At the same time, climate engineering is described as being ignored by politicians and questions related to justice and costs of the implementations are barely mentioned. The discourse is dominated by a small group of predominantly male researchers from Germany and the US, some of which have financial interests in large-scale climate engineering deployment. These findings point to a need for more actors, especially with a clear focus on justice, in the German public discourse about climate engineering to make sure the technologies contribute to achieving climate justice and are not used as an excuse to maintain business as usual.

Keywords: climate engineering, geoengineering, critical discourse analysis, newspaper analysis, climate change, technofix, human ecology

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List of Abbreviations

AF	Afforestation and Reforestation
BECCS	Bioenergy with Carbon Capture and Storage
CDR	Carbon Dioxide Removal
CE	Climate Engineering
CCU	Carbon Capture and Use
CCUS	Carbon Capture Use and Storage
CCS	Carbon Capture and Storage
CO_2	Carbon dioxide
DAC	Direct Air Capture
DACCS	Direct Air Carbon dioxide Capture and Storage
IAM	Integrated Assessment Model
IASS	Institute for Advanced Sustainability Science (Research Institute in Potsdam, Germany)
IPCC	International Panel on Climate Change
NET	Negative Emission Technologies
NGO	Non-governmental organisation
OA	Ocean Alkalinisation
OF	Ocean Fertilization
SCS	Soil Carbon Sequestration
SR 1.5°C	Special Report on Global Warming of 1.5°C published by the IPCC
SRM	Solar Radiation Management
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

> If we could come up with a geoengineering answer to this problem, then [the Climate Conference in] Copenhagen wouldn't be necessary. We could carry on flying our planes and driving our cars.
>
> Richard Branson in Revkin (2009)

Entrepreneur and former airline owner Richard Branson illustrates the promise that technological responses to climate change seem to offer: carry on living like you do, technology can fix this. Being one such technofix, climate engineering proposals, deliberate large scale alterations of the environment as a means to combat climate change (The Royal Society 2009, 1), "have lost the ring of the impossible and have started to receive serious consideration by scientists and policymakers" (Burns and Nicholson 2016, 346).

The terms 'climate engineering' and 'geoengineering' are often used synonymously in the literature. However, in the following I will use the more accurate term 'climate engineering', henceforth abbreviated as CE, when referring to the phenomenon. The term geoengineering also entails large-scale measures that do not aim to alter the climate, such as geo-technical measures to extract resources or large-scaled dams (Gawel 2011, 451; Deutscher Bundestag 2018, 1).

A wider scientific and public debate around CE was initiated by Nobel laureate Paul Crutzen when he published an article advocating more research on using sunlight deflection to moderate climate change (Crutzen 2006). Since then, CE methods and their possible implications are being lively discussed, largely influenced by a report published by The Royal Society in 2009 (Gupta and Möller 2019, 484–91). The Royal Society broadly classified CE technologies into two categories: Carbon dioxide removal (CDR) and solar radiation management (SRM) (The Royal Society 2009, ix-xi). Carbon dioxide (CO_2) is not the only greenhouse gas discussed in the context of 'negative emissions', as CDR is sometimes referred to; other proposals include methane or nitrous oxide (de Richter et al. 2017). However, these technologies are not yet assessed regarding their effectiveness, cost, and sustainability impacts and therefore still play a minor role (Rogelj et al. 2018, 121).

CDR technologies create 'negative emissions' by removing CO_2 from the atmosphere and include land use management, Bioenergy with Carbon Capture and Storage (BECCS), Enhanced Weathering, Direct Air Capture and Ocean Fertilization. SRM aims at increasing the planetary albedo which means making the planet reflect more sunlight using technologies such as Marine Cloud Brightening or Stratospheric Aerosol Injection (The Royal Society 2009, ix-xi).

So far, only a limited number of countries conduct CE research. Therefore, Harnisch et al. (2015, 60) assert a key role in future debates about CE to the US, the UK, and Germany, which they identify as leading the research as well as having powerful political positions internationally. While CE research in the US is mostly privately funded (Oomen Forthcoming, 201-02), both the UK and Germany engage in state funded research projects (Uther 2014, 23).

Being German and having lived in Germany for most of my life, I am particularly interested in the German case. Although previous discourse about CE in Germany exists, the topic got a lot of attention through the field experiment 'LOHAFEX' (ibid, 19).The experiment was an Indo-German research project lead by the German Alfred Wegener Institute. 'Loha' is Hindi for 'iron' and 'FEX' derives from 'Fertilisation EXperiment' (Strong et al. 2009, 237; Oomen Forthcoming, 133).

The experiment was strongly criticised internationally, but also by the German Federal Ministry for the Environment, which opposed the experiment and has not been consulted by the Federal Ministry for Research and Education. Ultimately this scandal led to the 'Priority Program' *Climate Engineering: Risks, Challenges, Opportunities?*, which currently is "the most significant publicly-funded climate engineering research consortium" (Oomen Forthcoming, 25, 134).

Against this background, it is interesting that the majority of Germans do *not* support the implementation of CE technologies (Braun et al. 2018, 476). Braun et al. conducted an online survey with more than 3500 participants, allocating them to three methods, (1) such increasing the reflectivity of the earth, (2) such technically removing carbon dioxide from the atmosphere and (3) afforestation. Their results show that methods to increase the reflectivity of the earth and to technically remove CO_2 are widely rejected, while afforestation was accepted. Furthermore, for all three methods, support was lower among those participants that received more information on the technologies and their respective implications compared to those with basic information (ibid., 475-76).

Nevertheless, although CE is widely rejected, Germans do generally consider technological innovation necessary to lessen negative impacts on the environment. Technological innovation is identified as the most important factor to protect the environment, with 69% considering it 'very important' and 26% 'rather important'. The second biggest challenge is the shift from fossil fuels to renewable energy, with 58% considering it 'very important' and 32% 'rather important' (BMU and UBA 2017, 32–34).

Analyses of countries' pledges to reduce their emissions until 2030 predict a global warming of 3°C by 2100. However, as these numbers assume that emissions peak in 2030, which the authors do not expect to hold true, the actual number is likely to be higher (UNEP 2018, xiv–xv). Therefore, the numbers reflect a considerable gap between actual emissions and the goal to limit global warming "well below 2°C above pre-industrial levels and [to pursue] efforts to limit the temperature increase to 1.5°C above pre-industrial levels" determined in the Paris Agreement (UN 2015, 2). In light of this emissions gap, technologies to remove CO_2 play a "substantial" role in most of the pathways explored in the Special Report on *Global Warming of 1.5°C* (henceforth referred to as 'SR 1.5°C') published by the Intergovernmental Panel on Climate Change (IPCC) (Rogelj et al. 2018, 121, 159). However, the inclusion of CDR in IPCC reports and emission pathways is not new. They have already been included in the fifth Assessment Report on Climate Change, the last regular report evaluating climate change and predicting future scenarios (Clarke et al. 2014).

The Royal Society report explains that CDR addresses “the root cause of climate change” while SRM techniques “offset effects” of increases in greenhouse gas emissions (The Royal Society 2009, ix) which makes CDR technologies preferable to SRM technologies. However, SRM techniques are likely to become relevant when “there is a need to rapidly limit or reduce global average temperatures” (ibid., xi). Such a quick reduction could be used during ‘overshoot’, when temperatures are expected to temporarily exceed 1.5°C of global warming (de Coninck et al. 2018, 349) or to avoid reaching a ‘tipping point’ (The Royal Society 2009, xi).

Generally, the IPCC is considered an authority regarding scientific knowledge on climate change (Corbera et al. 2015, 94). Gupta and Möller (2019) demonstrate that the report published by the Royal Society in 2009, as well as the report by the US National Academy Sciences from 2015 are ‘authoritative assessments’ regarding CE. The Royal Society report determined CE as a relevant topic in climate change research and it has been widely cited in CE publications (ibid., 486). Additionally, the classification in CDR and SRM and the accompanying assessment of CDR being safer than SRM, was only one of the possible classifications discussed at the time (ibid., 487). Other classifications that were discussed when the Royal Society report was published, for example into methods that can be deployed within national borders versus others that have to be deployed in the global commons, could have been beneficial within social science discussions. Nevertheless, CDR and SRM are the prevailing categories (ibid., 490).

The report of the National Academy of Sciences has, among other factors, influenced the way in which CE is framed (ibid., 495). Already in the title, the academy refers to CE as ‘climate intervention’ and it decided to use the term ‘albedo modification’ instead of SRM (NAS 2015a, 2015b, viii). This makes CE technologies appear less outstanding and more normal. Furthermore, this impression is enforced when the climate is compared to a “heating system with two knobs” making it seem like the global temperature can easily be controlled: ”The first knob is the concentration of greenhouse gases such as CO_2 in the atmosphere (...) The other knob is the reflectance of the planet, which controls the amount of sunlight that the Earth absorbs“ (NAS 2015b, 33).

Cox et al. criticise the assessment by the Royal Society (2009, ix), which states that CDR addresses “the root cause of climate change”, because it neglects that CDR treats the consequences of emissions resulting from fossil fuel use (Cox et al. 2018, 3). Furthermore, Gupta and Möller (2019, 495) argue that both reports, by the Royal Society and the National Academy of Sciences, shifted the focus from philosophical and ethical questions around CE to technical and practical questions. However, critical discussions regarding social justice and governance started after CDR methods like BECCS had been included in the fifth Assessment Report by the IPCC in 2014 (Gupta and Möller 2019, 487).

Technological solutions that do not require structural changes seem to be the solution of choice for the elite, explaining why billionaires like Richard Bronson, Bill Gates, tar sands magnate Bill Murray, and Niklas Zennström, co-founder of Skype, finance CE research (Vidal 2012). The opening quotation by Richard Branson illustrates a general concern related to CE methods: that of some hoping that CE can prevent structural changes leading to significant reductions in greenhouse gas emissions, thus presumably allowing for continuous fossil fuel use.

A recently published report by the Center for International Environmental Law supports this claim and does not only demonstrate how CE research is funded by fossil fuel industries but also how technologies like Direct Air Capture rely on the further use of fossil fuels (Muffett and Feit 2019). Even though SR 1.5°C demonstrates that the large scale implementation of CE will not be able to mitigate climate change without drastic reductions of emissions (Caldeira et al. 2013, 250; IPCC 2018, 14–19) discussions around the technologies have the potential to distract or disguise the necessity of other climate action and thereby possibly delay it (e.g., Nicholson 2015, 333; Muffett and Feit 2019, 5, 10, 40–41).

CE methods are therefore accompanied by a large set of risks and uncertainties. Generally, SRM is considered to be riskier than CDR which is mainly due to unforeseeable side effects to the implementation of these methods (Preston 2017). Additionally, models show that temperatures are expected to rise quickly and dramatically, to match the actual concentration of greenhouse gases in the atmosphere, if the employment of SRM techniques would be stopped (Caldeira et al. 2013, 236). This phenomenon, referred to as 'termination shock', raises serious concerns regarding intergenerational justice because future generations would be locked in the use of SRM (Svoboda et al. 2019, 9–10). Although CDR is considered to be safer than SRM, this does not mean that it does not carry negative implications. BECCS, for example, requires large amounts of arable land, water and energy supply, positioning the technique in direct competition with food production, while at the same time leading to soil degradation and land grabbing, for example from indigenous communities (Burns and Flegal 2015, 261). A related question is where to store separated or captured CO_2, as it is so far unclear whether sufficient underground storage is available (Tavoni and Socolow 2013, 5).

The implications of CE technologies I briefly outlined in this introduction and the difference in support for CE technologies according to the amount of information available, caught my attention and motivated me to look into what information is available to the broader public.

1.1. Aim and research questions

This thesis is intended as a contribution to the debate around technological responses ('technofixes') to global problems like climate change and underlying assumptions about the relation between humans and technology. To be more specific, the purpose of this research is to analyse recently published articles on climate engineering in major German newspapers and magazines in order to assess which information is available to the broader public. In doing so, this project seeks to add to previous research on the discourse around climate engineering in German mass media and contribute to an understanding of the discourse in the context of global climate change mitigation.

To achieve the presented aim, I seek to answer the following research questions:

1. *Who, if any, is dominating the discourse in German newspaper and magazine articles?*

2. *Which other actors or institutions are involved in the discourse?*
3. *What kind of arguments and argumentation patterns for and against climate engineering are presented?*

1.2. Structure of the thesis

In the next chapter, I provide further information on CE. I start by briefly introducing the major technologies, before showing what role they play in IPCC reports. After that I give some insights in actors into CE research and briefly summarise previous studies on public discourse around CE.

Once the background is set, I move on to introduce the theoretical framework with the two pillars 'technology' and 'knowledge creation' which my analysis is based on. Thereafter, I describe my method of analysis and the articles selected.

Subsequently, I present my findings, which I then discuss in relation to the background and the theoretical framework, before concluding by returning to my research questions.

2. Background on climate engineering

This chapter intends to lay the basis to understand CE in the context of climate change. I start by describing major CE methods, before I illustrate what role CE plays in IPCC reports. Subsequently, I engage with actors in CE research to establish who is creating knowledge about CE, before I end the chapter with an overview of previous research about public CE discourses.

2.1. Climate engineering technologies

In this section, I describe those CE methods that the IPCC introduced and discussed in SR 1.5°C and present their limitations and risks . I start out with methods removing CO_2 from the atmosphere, which play a more prominent role in IPCC pathways, before moving on to Solar Radiation Management.

2.1.1. Carbon Dioxide Removal

'Carbon Dioxide Removal' (CDR), sometimes referred to as 'Negative Emissions Technologies' (NET), aims to reduce the amount of CO_2 in the atmosphere through a large variety of methods with Afforestation and Biomass Energy with Carbon Capture and Storage (BECCS) being the most well-known (Clarke et al. 2014, 484; IPCC 2018; Fuss et al. 2014, 850). Only methods that permanently store CO_2 underground are considered CDR. Other methods, that use the captured carbon (Carbon Capture and Use), for example as fertilizer when growing plants or temporarily store it in products (Carbon Capture Use and Storage), for example in fuel are not CDR methods as they do not remove CO_2 from the atmosphere.

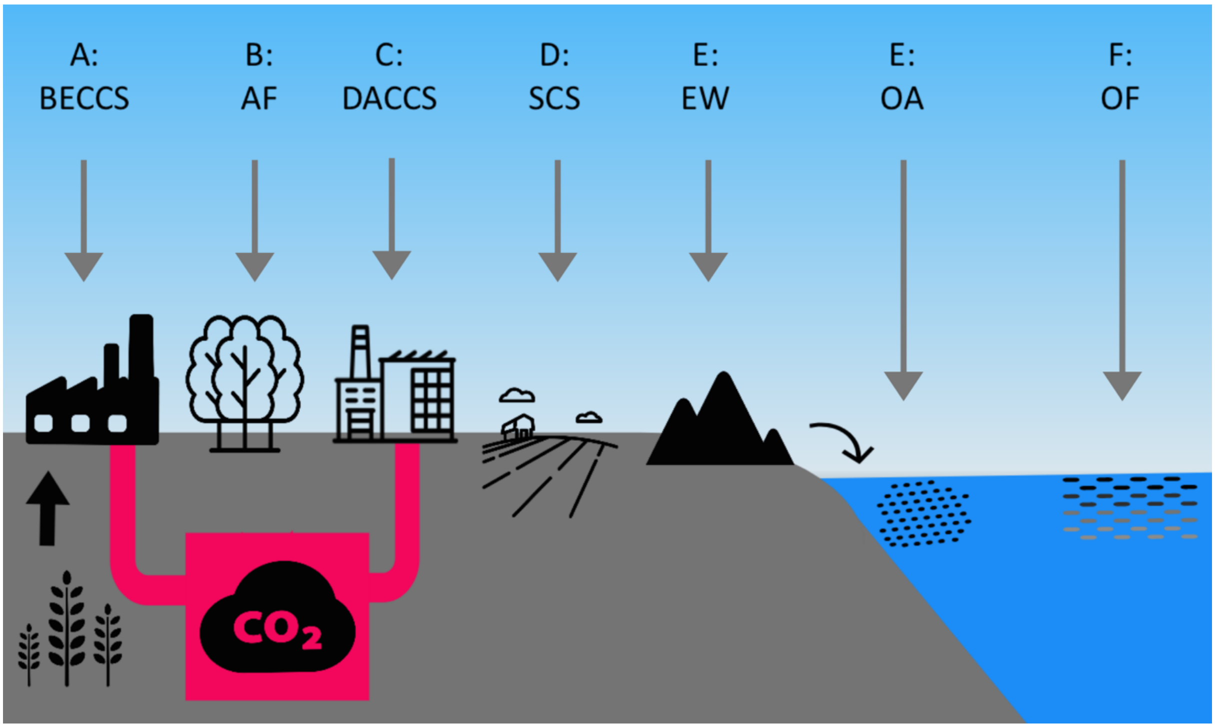

Figure 1 Carbon Dioxide Removal (CDR) approaches
A: Biomass Energy with Carbon Capture and Storage (BECCS); B: Afforestation and Reforestation (AF); C: Direct Air Carbon dioxide Capture and Storage (DACCS); D: Soil Carbon Sequestration (SCS); E: Enhanced Weathering (EW) and Ocean Alkalinisation (OA); F: Ocean Fertilization (OF). (adapted by the author from Caldeira et al. 2013, 242)

A: Biomass energy with carbon capture and storage (BECCS)

BECCS is based on the fact that plants take up CO_2 from the ambient air and grow and sustain themselves through this process. Plants can be grown and harvested, so that the captured carbon can be separated and stored. Although plants can repeatedly be grown on the same land, large land areas are needed in order to capture significant amounts of CO_2 (Caldeira et al. 2013, 246). Adding to concerns about the availability of land, BECCS is expected to negatively impact biodiversity, food security (through competition over land and nutrients) and increase air pollution and emissions of greenhouse gases other than CO_2 (de Coninck et al. 2018, 342–44). Vaughan and Gough (2016, 4–6) question the societal support of large scale bioenergy deployment and call for robust governance structures. Regulations of BECCS have to include “[p]roductivity, food production and competition with other ecosystem services and land use by local communities”, factors that are globally not equally distributed (de Coninck et al. 2018, 343).

B: Afforestation and Reforestation (AR)

Afforestation is the planting of trees on land that has not been forested, while Reforestation refers to the growth of forest on land that has previously but not recently been forested. As they grow, the trees capture carbon and store it for a couple of decades. Counteracting the beneficial effect of capturing CO_2, forests are likely to decrease the albedo of the land, which causes more sunlight to be absorbed resulting in increased warming (Caldeira et al. 2013, 245).

Although Afforestation and Reforestation are expected to have a positive impact on the soil quality, large scale planting of trees will negatively affect biodiversity, for example due to monoculture, and impact food security (de Coninck et al. 2018, 343–44; Smith et al. 2014, 855). Additionally, the carbon will be re-emitted into the atmosphere in case of forest fires, which are likely to increase due to global warming (Caldeira et al. 2013, 246).

C: Direct Air Carbon dioxide Capture and Storage (DACCS)

The direct capture of CO_2 from the air through chemical processes is possible at large point sources, like fossil fuel plants and other industrial plants, or from the ambient air. Although capturing CO_2 from the air is theoretically independent from the origin of the emission, capture from the ambient air is substantially less efficient because of the low concentration of CO_2 in the air compared to point sources (Metz et al. 2005, 108). The main limitation of direct air capture and storage is safe and accessible storage (de Coninck et al. 2018, 346).

D: Soil Carbon Sequestration (SCS) and Biochar

Degraded soil or land in agricultural use store between 50% and 66% of the carbon historically stored. Soil Carbon Sequestration aims to increase the amount of CO_2 stored in the soil and thereby increase its function as carbon sink (Lal 2004, 1623). This can for example be achieved through agroforestry, restoration of degraded land or conservation agriculture management practices. Biochar is very stable carbon that is obtained from pyrolysis, an incomplete combustion, of soil. When applied to soil, biochar enhances Soil Carbon Sequestration which ultimately leads to better soil fertility (de Coninck et al. 2018, 345).

Soil carbon sequestration is likely to be socially accepted because it does not require land use change, positively influences nutrients and food security while having negligible water and energy requirements (Smith 2016, 1317–19). Per contra, depending on the soil type and the climate zone, soil sinks are saturated after ten to 100 years (ibid., 1323).

E: Enhanced Weathering (EW) and Ocean Alkalinisation (OA)

Weathering is the natural process of rock decomposition by physical or chemical processes in which CO_2 is consumed (Metz et al. 2005, 39–40). Normally, this process occurs very slowly and is mainly influenced by water, but also by temperatures, reactive surface area, and interactions with flora and fauna (biota). However, it can be enhanced when grounded rock is distributed over land or in the ocean (de Coninck et al. 2018, 345). For the method of Ocean Alkalinisation, processed alkaline minerals are released in the upper layers of the ocean, near the atmosphere, increasing the ability of the water to store CO_2 (Ferrer González and Illyina 2016, 6493).

Terrestrial Enhanced Weathering can positively impact soil properties, but cause air pollution through small particles that can be breathed in. Furthermore, both terrestrial and ocean based Enhanced Weathering as well as Ocean Alkalinisation have negative implications related to mining and extraction activities as well as water pollution, for example with heavy metals (de Coninck et al. 2018, 344–46).

F: Ocean fertilisation (OF)

Just like soil, the ocean can be fertilized by adding nutrients such as iron, nitrogen or phosphorous, stimulating the biologic production for example of plancton which increases the consumption of CO_2 (Caldeira et al. 2013, 247). Subsequently, the plankton sinks to the ground where the carbon is stored (de Coninck et al. 2018, 346). The London Protocol of the International Maritime Organisation claims authority to regulate Ocean Fertilisation. In 1996, the protocol was added to the London Convention from 1972, that regulates pollution in the ocean via illegal waste disposal, to include the "Precautionary Principle" (Strong et al. 2009, 250–51). This claim is widely considered to end commercial fertilisation activities (de Coninck et al. 2018, 346).

2.1.2. Solar Radiation Management

After introducing the main methods removing CO_2 from the atmosphere, this section gives an overview over methods changing the reflectivity of the earth and thereby cooling it.

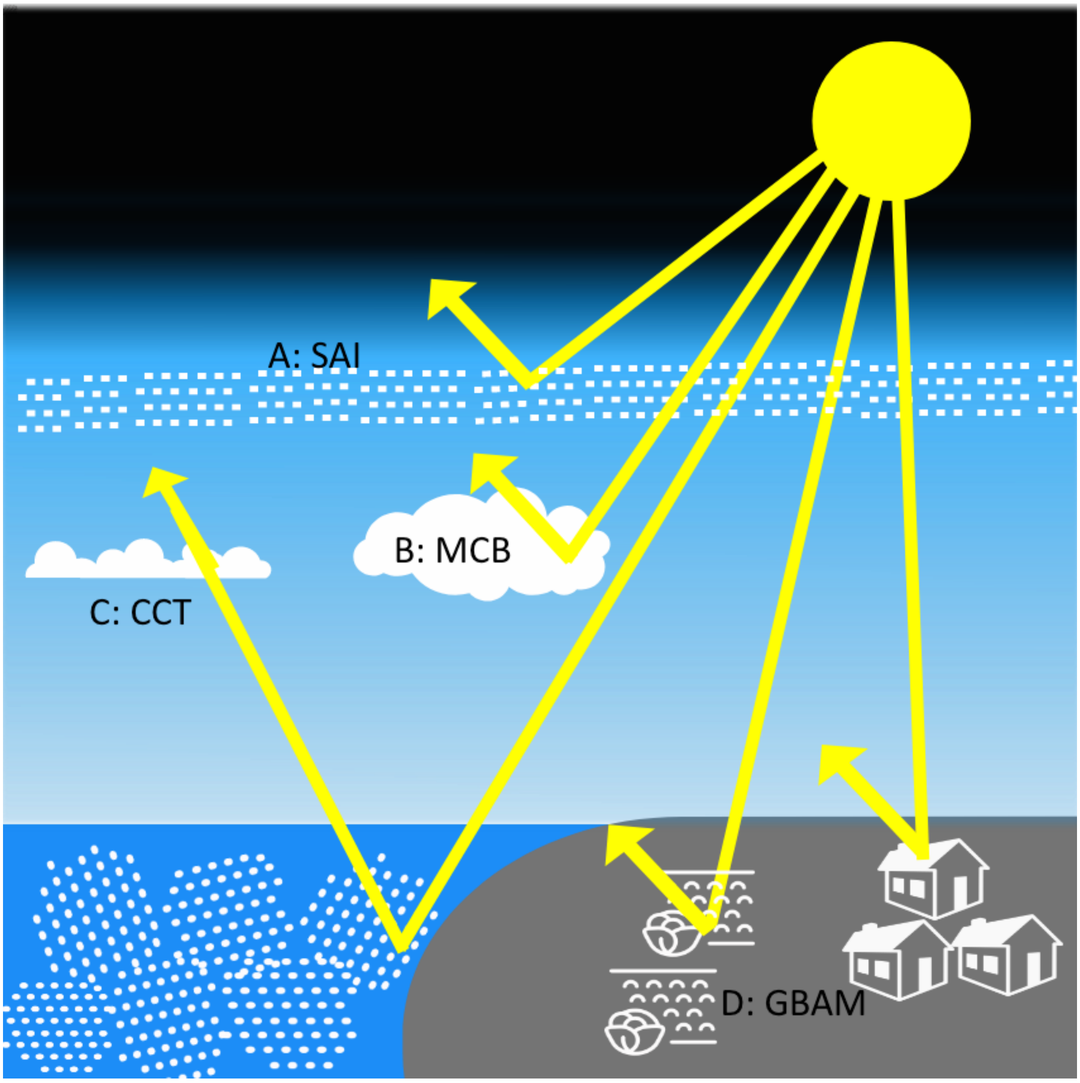

Figure 2 Solar Radiation Management (SRM) approaches
A: Stratospheric Aerosol Injection (SAI)); B: Marine Cloud Brightening (MCB); C:Cirrus Cloud Thinning (CCT)); D: Ground-Based Albedo Modification (GBAM). (adapted by the author from Caldeira et al. 2013, 235)

A: Stratospheric Aerosol Injection (SAI)

Stratospheric Aerosol Injection refers to the injection of gas into the stratosphere – a layer of the atmosphere – which then converts into aerosols. Most models assume sulphur injections (as Sulphur Dioxide, SO_2), although other particles have also been examined. Stratospheric Aerosol Injection is expected to influence precipitation patterns, the stratospheric chemistry and cloud microphysics, as well as to cause ozone loss and an increase of the surface UV due to the injection of sulphur (ibid., 348).

B: Marine Cloud Brightening (MCB)

In order to make marine clouds more reflective, they can be sprayed with sea salt or other particles. This is expected to have regional impacts on precipitation, reduce the intensity of hurricanes and the number of mild crop failures (ibid., 348).

C: Cirrus Cloud Thinning (CCT)

Cirrus Cloud Thinning aims to increase the number of droplets in clouds (nucleation), which let them appear thinner and reduces their lifetime. This process enables more longwave radiation, that has been reflected from the surface, to escape into space. Side effects of Cirrus Cloud Thinning include the drying of the troposphere – the lowest level of the atmosphere, right below the stratosphere – and the intensification of the hydrological cycle (ibid., 348).

D: Ground-Based Albedo Modification (GBAM)

Ground-based SRM includes the whitening of surfaces such as roofs, changes in the land management or methods functioning at a larger scale, such as covering glaciers or deserts with reflective sheeting. Reductions in temperature are expected to mainly be felt at regional scales which makes the approach suitable to target hot extremes. Furthermore, Ground-Based Albedo Modification influences precipitation in monsoon areas (ibid., 348).

2.2. Climate engineering and the IPCC

In the last decade, CE technologies have increasingly been included in IPCC reports. While the IPCC (2007, 15) considered CE “largely speculative and unproven, and with the risk of unknown side-effects” in the fourth Assessment Report on climate change, the fifth Assessment Report published in 2013 included BECCS and Afforestation in 101 out of 116 scenarios limiting warming below 2°C (Fuss et al. 2014, 850; Clarke et al. 2014, 486).

Furthermore, the fifth Assessment Report was the first to include ‘Responsible Concentration Pathways’. Previous reports included ‘Emissions Scenarios’ which represented possible social trends but no ‘climate policy’ (Beck and Mohany 2018, 3). ‘Responsible Concentration Pathways’ on the other hand changed the focus from social change to physical varibles. They are socio-economic scenarios based on ‘integrated assessment models” that “provide a set of end points against which climate policy options could be assessed” (ibid., 3).

While the work of the IPCC is considered to be “policy-relevant and yet policy-neutral, never policy-prescriptive” (UNFCCC n.d.), Beck and Mahony (2018) argue that the role of the IPCC is in fact political. Furthermore, the German Government "requested" a clear separation of CE from mitigation in the SR 1.5°C (Deutscher Bundestag 2018, 4). The report should differentially assess CE methods according to their "potential, feasibility, risks as well as interactions with other sustainability goals and involved gaps in knowledge and uncertainties" (ibid., 4, my translation). Such a request illustrates the entanglement between the IPCC and political bodies.

Especially 'Responsible Concentration Pathway' 2.6 from the fifth assessment report is argued to hold "huge political significance" by creating new "political facts" implying that ambitious mitigation targets can only be reached with CDR (Beck and Mahony 2018, 4). On the grounds that Responsible Concentration Pathway 2.6 massively relies on BECCS, Beck and Mahony (2018, 4) argue that the IPCC normalized "previously unthinkable notions" like overshoot and negative emissions and legitimised BECCS. They furthermore argue that this put CDR in a favourable position compared to other strategies such as radical mitigation (ibid., 4).

In SR 1.5°C, the IPCC ascribes CDR methods a "substantial" role in mitigation pathways limiting global warming to a maximum of 1.5°C, however they are always combined with mitigation, reducing greenhouse gas emissions (Rogelj et al. 2018, 121–22). BECCS and Afforestation can play a significant role in these pathways, but there are also pathways that do not include them. Overall the role of BECCS in deep mitigation pathways has been reduced (ibid., 122). Nevertheless, it is remarkable what a big role negative emissions play, considering that they are "largely unproven to date" (ibid., 121) and there is "substantial uncertainty about the adverse side effects of large-scale CDR deployment on the environment and societal sustainable development goals" (ibid., 158). Pathways with relatively minor emphasis on negative emissions and no or limited overshoot require significant reduction in energy consumption and/or dietary changes (ibid., 122).

Taking into account that BECCS is not a "mature" technology yet, Afforestation is expected to play a major role approximately until carbon neutrality is reached in mid-century, while BECCS would dominate later in the century (ibid., 123). Regarding other technologies, SR 1.5°C on the one hand observes that none of them is thoroughly assessed in 'Integrated Assessment Models' (IAM), which lay the basis for the emission pathways, and is ready to be upscaled (ibid., 158). On the other hand, it states that "a few potentially disruptive technologies that are typically not yet well covered in IAMs and that have the potential to alter the shape of mitigation pathways beyond the ranges in the IAM-based literature" (ibid., 111). SRM methods are not part of the 1.5°C pathways, still their potential role as "supplementary measure" to CDR, especially during temporary 'overshoot' is discussed (de Coninck et al. 2018, 349).

2.3. Actors in climate engineering research

Following a background on CE technologies discussed in scientific literature and included in emission pathways by the IPCC, I will here provide the context of CE research in order to offer a better understanding of how the information, upon which policymakers and others base their decision, is obtained. First, I demonstrate that the majority of knowledge on CE in created in Europe and North America and then I move on to funding of CE research and pilot projects.

In a recently published article, Biermann and Möller (2019) demonstrate that the scientific discourse on CE is, similar to the composition of IPCC authors, largely dominated by researchers located in North America and Europe. Arguing that the institutions researchers work at influence their scientific socialisation, Biermann and Möller focus on their location rather than nationalities of the researchers when analysing attendance and speaking lists at CE events (ibid., 151-56). They found that most organisations attending the analysed events where based in the US, the UK and Germany with 47, 42 and 22 organisations respectively. Among the organisations with the biggest groups of attendees are the Institute of Advanced Sustainability Studies (IASS) in Germany, Oxford University in the UK and Harvard University in the US (ibid., 156).

It is necessary to point out, on top of being concentrated in the Global North, CE research within recognized universities and research facilities such as Harvard, as well as within private entities, is funded by wealthy individuals and the fossil fuel industry. Richard Branson, who was quoted at the beginning of this thesis, started a competition in 2007 awarding US$ 25 million to those developing a "scalable and sustainable" CDR method (Virgin Earth 2019b).

Bill Gates set up a "Fund for Innovative Climate and Energy Research" with the purpose of funding CE research, for example the work of David Keith at Harvard University and Ken Caldeira at the Carnegie Institution for Science (The Keith Group 2019). Additionally, he is also funding Harvard's Solar Geoengineering Research Program (Harvard 2019). Besides financing research projects, Bill Gates, together with others like tar-sand tycoon Bill Murray, invested in 'Carbon Engineering', a company founded by David Keith. 'Carbon Engineering' is self-described as a "Canadian-based clean energy company leading the commercialization of groundbreaking technology that captures CO_2 directly from the atmosphere, and a second technology that synthesizes it into clean, affordable transportation fuels" (Carbon Engineering 2019). It is among the finalists to win Branson's Virgin Earth Challenge (Virgin Earth 2019a).

The large scale deployment of CE technologies is considered to allow continued fossil fuel use until the mid-century (IPCC 2018, 16). Bearing this in mind, it comes as no surprise that the fossil fuel industry is among the earliest and most active researchers and proponents of CE (Muffett and Feit 2019). The main focus lays on CDR technologies and Carbon Capture Use and Storage (CCUS). These are disproportionately controlled by fossil fuel companies (Muffett and Feit 2019, 10–14). For example, Chevron invested more than US$ 75 million in research and development of Carbon Capture and Storage (CCS) technologies (Chevron 2019). Additionally to direct investments in commercial use of CDR technologies, fossil fuel companies play a vital role in the "funding, communication, and advocacy of CCS research and CCS policies through a wide array of corporate consortia and industry groups, joint industry-government working groups, and funding partnerships" (Muffett and Feit 2019, 19).

These partnerships can be found on an institutional level as well as for individual researchers. Centers and initiatives like the Gulf Coast Carbon Center at the University of Texas are among others funded by BP, Chevron, ExxonMobil and Shell (Gulf Coast Carbon Center n.d.) and the Carbon Mitigation Initiative at Princeton University by BP (CMI 2018, 6). On the individual level, Shell is financing a postdoctoral position at the Center for Negative Carbon Emissions at Arizona State University (CNCE n.d.). As Bill Gates' "Fund for Innovative Climate and Energy Research" aims to create "peer-reviewed scholarly articles" (The Keith Group 2019), it is safe to assume that investments in research at established institutes aim to produce knowledge that, at first glance, is not connected to the industry and that might appear neutral to policy makers and other target groups. However, having "peer-reviewed scholarly" research does not seem to be necessary to reach this aim and advocate for CE, considering that Chevron proudly declares to contribute to the work of the IPCC and political bodies working on Carbon Capture and Storage:

> "Chevron participated in the development of the *Intergovernmental Panel on Climate Change Special Report on CCS*, the European Union's CCS Directive, Australian policy frameworks, Canadian CCS standards and the U.S. EPA's CCS guidance. The IPCC recognized Chevron experts for work on the CCS report and other IPCC assessments, which contributed to the IPCC being the recipient of the Nobel Peace Prize in 2007" (Chevron 2019, italics in originial).

In the German context most research is government funded (Oomen Forthcoming, 145). Within the past decade, the Federal Ministry for Education and Research and the Environment Protection agency commissioned and published several studies on CE (Deutscher Bundestag 2018, 2–3). With federal funds, the German Research Foundation is currently financing a nationwide research cooperation on CE operating at several institutes in Germany as well as Austria, Switzerland and France (Deutscher Bundestag 2018, 3; DFG n.d.). The Institute for Advanced Sustainability Studies (IASS), which has been identified as one of the most active institutions working on CE by Biermann and Möller (2019, 156), is funded by the Federal Ministry for Education and Research and the Ministry of Science, Research and Culture of the state of Brandenburg, where the institute is located (IASS n.d.).

The involvement of private entities and fossil fuel companies into CE research appears to be less prominent in Germany, however RWE initiated a series of CDR projects (RWE AG 2019a). RWE is one of the leading electricity providers in Germany and Europe (RWE AG 2019b, 43) and operates three of the top five European CO_2 emitters (European Commission 2019). In their so called "Coal Innovation Centre" the company is working on three Carbon Capture and Use projects, which are among others funded by the European Union and the German government (RWE AG 2019c). Interestingly, these projects are not listed among the research projects funded by the government (Deutscher Bundestag 2018, 3–4, 2019, 3).

Before ending this section about actors in CE research, I want to shed light on the gender component. An analysis of 100 journal articles sorted by relevance in 'EBSCO Academic Search Premier' —a multidisciplinary database – showed that only 17% of those articles have been written by women (Buck et al. 2013, 654). Furthermore the analysis reflects a comparably low level of representation of women when analysing the attendance list of the IPCC expert meeting in Lima, Peru in June 2011 (IPCC 2012, 97). Out of 51 attendees, eight (15%) where women (Buck et al. 2013, 654).

These examples illustrate what Oldham et al. (2014) documented in detail when demonstrating how CE is promoted by a relative small but well-resourced group of predominantly male scientists and industries. The geographical location of researchers as well as the funding of loud voices within the CE community, such as David Keith, clearly impact the direction the research takes as well as underlying assumptions. When assessing CE technologies and pathways projected by the IPCC, it is important to be aware of the background against which knowledge on CE has been created and whose voices are shaping it.

2.4. Framing of climate engineering

To end the background section, I introduce frames that have earlier been used in CE discourses. After a general overview, I highlight how the discourse is dominated by a few dominant voices and present the main findings of a previous analysis of the German discourse.

2.4.1. Overview

Table 1 Application of key climate discourses to CE
adapted from McLaren (2016, 141, 147)

	Prometheanism	Eco-modernization	Green Radicalism
Ideology	Free-market neo-liberalism. Actively advocating disruptive technological innovation	Social democracy, with managed capitalism and markets. Positive but selective and managerial view of technology	Green and socialist politics, collectivist economics. Critical and precautionary towards technology
Attitude towards CE	Supportive of research and development	Supportive of research and selective development	Largely opposed to research and development
Application to SRM	Supportive, even in some cases as an alternative to mitigation	Seen as last resort, requires research and careful risk assessment	Opposed: even to extend of preferring adaptation in some cases
Application to CDR	May be supportive if low cost. Likely to oppose subsidies	'Negative emissions' are important in managerial approach. Fits with carbon price/markets	Opposed to large-scale technologies such as OIF or industrial-scale BECCS and Afforestation

In a meta-analysis of CE discourse, McLaren (2016, 143) applies Dryzeks (2013) key discourses in climate change, 'Prometheanism', 'Eco-modernization' and 'Green Radicalism' to the CE discourse. For the CE discourse, he identifies three explicit master framings – 'technological optimism', 'political realism' and 'catastrophe avoidance' – as well as the 'clean sheet' as an implicit master frame. Before moving on to description of the identified master frames, Table 1 gives an overview of the three discourses and their respective attitudes towards CE, to foster the understanding of the background against which CE is discussed.

Within a 'technologically optimistic' framing, CE is a "controllable, feasible and practical" response to climate change in which the planet is often depicted as being a reparable machine or body (McLaren 2016, 143). The frame entails 'Promethean innovation' as well as 'eco-modern technical managerialism' (ibid., 143).

'Political realism' refers to claims that conventional responses to climate change, like mitigation and adaptation, have failed and that CE therefore is the pragmatic Plan B. Within this frame, difficulties of coordinated political actions are met with suggestions of unilateral employment of CE by a small 'climate engineering club' (McLaren 2016, 143–46). This ties in with descriptions of CE actors as 'Geoclique' (Kintisch 2010, 8), a point I will come back to in section 2.4.2.

By framing CE as a way to 'avoid catastrophe', possible negative implications of the technologies are downplayed by contrasting them to consequences of unabated climate change. In contrast to the 'technologically optimistic' framing, CE itself is not necessarily portrayed as safe. This frame is found both in Promethean and eco-modern discourses and has in earlier sources been referred as 'emergency' framing, often in the context of climate 'tipping points' (McLaren 2016, 144). Such a framing allows for"a 'techno-fix' to protect industrial modernity", clearly opposing an openly political discourse by green radicals arguing "for socially disruptive ways of responding to climate change" (ibid., 146-47).

The implicit master frame of the 'clean sheet' masks historical impacts on and responsibilities for climate change by discussing CE without reference to existing inequalities, leading to justice rarely being considered (McLaren 2016, 144–46; Buck 2013, 176). McLaren (2016, 146) argues that the 'clean sheet' is the most distinct characteristic of the CE discourse, setting it apart from the general discourse around climate change. Discussing CE without references to historical obligations takes attention from power dynamics, vested interests, the needs of future generations and disguises that "the power of the (corporate and national) fossil fuel lobbies [is] built on a history of colonialism and resource extraction" (ibid., 150).

2.4.2. 'Geoclique'

In an analysis of 178 newspaper articles published between 1990 and 2010, Buck (2013, 173–74) finds that 70% of statements about CE have been made by natural scientists and engineers, followed by government officials and political scientists, whereas voices of citizens, social scientists and philosophers have been missing. Furthermore, she demonstrates that 36% of these assertations have been made by nine scientists, with David Keith most frequently cited.

Whereas some individuals are regularly given a platform, Bucks (2013, 174) analysis reflects that women only made 3% (15 out of 500) of the statements about CE, leading to women having a "minority voice" when it comes to explaining CE and representing the topic in the media (Buck et al. 2013, 654).

Alongside Ken Caldeira, Keith is the "most visible climate engineer in the world" (Oomen Forthcoming, 24–25) and informally leads the 'Geoclique', a term Kinitsch (2010, 8) coined for a small but vocal group of North American scientists dominating the CE discourse (cf. Hamilton 2011; Anshelm and Hansson 2014, 139). Moreover, the group and its supporters are criticized because several of the most vocal CE proponents hold patent rights in the development of CE technologies and therefore have personal economic interests in pushing the CE agenda. Adding to examples of vested interests presented in Chapter 2.3, vested interests can be found among members of the UK Royal Society working group on CE which published the influential report "Geoengineering the climate" (Anshelm and Hansson 2014, 139–40; The Royal Society 2009).

Considering vested interests of actors in CE research and their geographical location (see Chapter 2.3) and the absence of justice from the public discourse around CE (see Chapter 2.4.1) it is important to point out that power to set the narrative is in itself i considered an issue of justice. The 'Geoclique', those in dominant and powerful positions, are able to construct the narrative and set the frame in which CE is discussed. One result of this is the 'avoiding catastrophe' frame in which possible negative consequences of CE are contrasted with unabated climate change instead of ambitious and transformative mitigation efforts (McLaren 2016, 154).

2.4.3. German discourse

In her analysis of 69 newspaper articles published between 2006 and 2011, Uther (2014, 83–84, 150) finds that the discourse in Germany is generally sceptical, risk-oriented and critical towards technology. In line with Buck's (2013) analysis of articles published in English, Uther finds that the discourse is very much dominated by scientists, German as well as from the US, the UK and Canada, which make up some 90% of citations, while voices from NGOs remain underrepresented (Uther 2014, 157). This focus on scientists is reflected in the topics of the articles, which are closely connected to the scientific discourse like newly published journal articles or conferences on CE (ibid., 150).

Uther describes the discourse as being balanced and differentiated, ranging from being very positive to being very negative towards CE. The articles mostly focus on SRM technologies and ocean fertilization, especially in relation to the LOHAFEX experiment (see Introduction), while other CDR technologies get little attention (ibid., 150-52).

Most arguments identified in the articles are concerned with 'side effects of the implementation' and are 'ethics or value based' or related to 'efficiency and technical feasibility' (ibid., 152-57). As Uther compared the discourses in the UK and Germany, she points out that the relevance of ethics and value-based arguments is particularly high in

Germany (ibid., 154–55). This is in line with an assessment by Oomen (Forthcoming, 24), referring to the public and scientific CE discourse in Germany as being "much more apprehensive and adversarial" compared to North America.

Metaphors used in German media, for the most parts, blend in with those used in English-speaking media. Most widely used are medical or war metaphors and such that depict the earth as a machine. Generally, the metaphors appear to be used to raise scepticism about CE. Medical or doctor metaphors almost completely have negative connotations, war metaphors are often used ironically to highlight how CE is no magic weapon and craftspeople metaphors such as those relating to plumbing work that depict the earth as a machine are used to point to the complexity of the earth (Uther 2014, 161–65).

Although the beginning of the German CE discourse (2006-2008) was rather sceptical, arguments pushing for further research of the respective technologies dominated later. In 2009, the discourse became more critical towards CE and the range of arguments significantly increased (Uther 2014, 184; Anshelm and Hansson 2014, 137). However, as NGOs are underrepresented in the German discourse, arguments often made by NGOs such as critically questioning economic interests of those involved in the discourse are missing (Uther 2014, 156–58).

3. Theoretical Framework

My thesis developed around two theoretical pillars: 'technology' and 'knowledge creation'. As climate engineering represents a technological response to climate change, the analysis has to include the context which allowed for such a response to be valid. The relevance of the second part, knowledge creation, stems from the dominance of specific actors that I described in Chapters 2.3 and 2.4.2.

3.1. Technology and technological optimism

I begin this section by demonstrating how the emergence of technology changed peoples attitude towards nature, an understanding that is based on *The Death of Nature* by Carolyn Merchant (1989). After this general introduction, I describe the concepts of 'machine fetishism' and 'technological utopianism' developed by Alf Hornborg (1992, 2013, 2016)

3.1.1. Mechanistic worldview

According to Environmental Historian Carolyn Merchant, the ways in which people perceive nature and ascribe meaning to their lives depends on the time they live in, the place they live at, and the their position in society "as elites or ordinary people, men or women, Westerners or Easterners" (Merchant 1989, xvi). During the course of the scientific revolution in the sixteenth and seventeenth century, the "root metaphor" for nature changed from that of on "organism" to one of a "machine". Whereas the organic theory prioritised interdependence and the subordination of individual to communal purposes, the latter is characterised by mechanisms and "the domination and mastery of nature" (ibid., 1-2).

This process was severely influenced by Francis Bacon (1561-1626), a so called "father of modern science," that picked up pre-existing tendencies in society and advocated "the control of nature for human benefit" (ibid., 164). His approach was "natural magic" and ultimately, he succeeded to reframe "the magus from (…) nature's servant to its exploiter, and nature from a teacher to a slave" (ibid., 164-69).

The mechanistic worldview, a result of the combination of the scientific method with mechanical technology, rearranged "reality around two fundamental constituents of human experience – order and power" (ibid., 216). In their representations of technology, machines became symbols of order, thereby laying the basis for the concept of power (ibid., 220-30). To summarise, Bacon and his followers established "mechanism as a world view" and "a conceptual power structure" (ibid., 216).

The mechanistic worldview helps to understand the context in which technology in general and CE technologies in particular are developed and discussed. I especially use it in the analysis of linguistic characteristics.

3.1.2. Machine fetishism and technological utopianism

The central argument regarding 'machine fetishism' is, according to Human Ecologist Alf Hornborg, that technology "*as a whole* is 'socially constructed'" (Hornborg 1992, 13 original italics). It is thereby impossible to separate 'physical/material' aspects of technology from 'social' aspects, although these social aspects are usually conceptualised separately (ibid., 15) and remain largely invisible to the users of technology (Hornborg 2013, 10). Hence, light is shed on the technical feasibility at a specific time and place, but not on broader global implications of the increase in technological capacity (ibid., 9).

'Technological utopianism' refers to an understanding of technology rooted in the "historical experience of core nations of the capitalist world-system"[1] (Hornborg 2016, 125). Because access to technology is limited by purchasing power, which is unevenly distributed, technology reflects an unequal exchange of resources (Hornborg 2016, 114, 2013, 9). Consequently, Hornborg (2016, 126) questions if technology can exist outside of asymmetric exchange relations.

I use Hornborg's concepts of 'machine fetishism' and 'technological utopianism' to illustrate societal implications of CE and to explain that the implementation of CE is, in fact, a political choice.

3.2. Science and knowledge creation

Both, Merchant and Hornborg repeatedly point towards science and the role of scientific knowledge in how technologies are perceived. Therefore, I first want to highlight the role of

[1] Hornborg (2016, 14) applies Immanuel Wallerstein's world-systems approach, which he describes to be based on a 'core', a 'periphery' and 'semi-periphery' buffering between them. The wealth of the 'core', where the majority of capital is accumulated is based on the extraction of raw materials from the 'periphery' (cf. Wallerstein 2004).

the researcher and how knowledge has to be understood in context by drawing on Haraway, before briefly engaging with how neoliberalism and resulting industry ties influence the kind of knowledge produced.

3.2.1. Situated Knowledges

The concept of 'situated knowledges' was introduced by Biologist and feminist writer Donna Haraway (1988). It is relevant beyond gender analysis because it provides valuable insight in how knowledge can never be complete. Haraway calls for an end of the "god trick of seeing everything from nowhere" and to acknowledge a limited, partial perspective instead (ibid., 581). In order to achieve 'objectivity' it is important to be aware of the "limited location" and "specific embodiment" that shape one's perspective as a viewer, rather than trying to reach "transcendence" and to be separated from the studied object (ibid., 582–83).

Haraway is aware that the partial perspective does not automatically lead to a better, more holistic understanding of reality (ibid., 584–85). Since "[t]he knowing self is partial in all its guises, never finished, whole, simply there and original" it is "*therefore* able to join with another, to see together without claiming to be another" and to include different perspectives (ibid., 586, original italics). Through conscious positioning, where one is aware of and takes responsibility for their partial perspective one is able to create knowledge that is situated in the context where it is created and does not claim to be universal (ibid., 587–89).

Against the background that CE research is dominated by mostly male researchers from Europe and North America (Biermann and Möller 2019, 5–6; Buck et al. 2013, 654) and Biermann and Möller's assessment, that the institution a researcher works at influences their work, I use the concept of 'situated knowledges' in the analysis of dominant actors.

3.2.2. Neoliberalism and science

Building on existing work on the 'knowledge economy', Moore et al (2011) argue that neoliberalism increased the influence of industry interests on science, compared with the previous relationship between research, government and industry interests. 'Knowledge economy' refers to an economy where "the most significant and financially valuable activities are knowledge based or 'symbolic'" rather than based on physical resources or human and material input (Temple 2012, 1). 'Neoliberalism' describes a set of ideologies and practices that favour market solutions and free trade over governmental intervention, and approach poverty from the viewpoint of self-responsibility (Moore et al. 2011, 508)

The neoliberal globalisation laid the basis for general economic changes which facilitated shifts of government and industry funding towards technological innovation. In the industrial setting, research increasingly focused on potentially profitable technologies. Additionally, research at universities is more and more oriented towards customs associated with neoliberalism such as entrepreneurialism (ibid., 510–14). As a result, a 'culture of commerce' spread in academia, which helped create both new programs in academia as well as new partnerships with industries. Taking the form of varied funding options, the potential for economic benefits such as licenses or start-up businesses, these partnerships lead to the emergence of ‘scientists-entrepreneurs’. However, his culture is not beneficial to all disciplines but benefits scientific fields with close ties to industries. At the same time, these find themselves polarized with some researchers that focus on “independence and traditional scholarship” on the one side while others encourage “new collaborations and industrial applications” (ibid., 512-13).

In face of the entanglement of actors in CE research and corporate interests addressed in Chapter 2.3, CE research is one of the disciplines with close industry ties. ‘Neoliberalism of Science’ and especially the ‘scientist-entrepreneur’ therefore offer valuable perspectives to analyse the role of certain actors in the CE discourse and to understand CE advocacy.

4. Material and methods

In this chapter I present the methods I applied and the material I analysed in this study. To facilitate the analysis, I used the software Nvivo to code the material. The analysis was split in two parts: the first step was informed by Content Analysis and focused on what is said in the text, the second part drew on Critical Discourse Analysis to analyse how the arguments were presented. After the sections on two methods, I introduce my material, before closing the chapter with a reflection on my positionality and limitations of the research.

4.1. Content Analysis

‘Content analysis’ generally aims to quantify content in “predetermined categories and in a systematic and replicable manner” (Bryman 2012, 290). However, my analysis consists of both quantitative as well as qualitative elements, with the quantitative element being the analysis of the actors and the analysis of the arguments being qualitative.

The analysis of actors can be of high relevance especially in the context of mass-media analysis (ibid., 295). In a first step I coded the names and affiliations of individuals and institutions cited or referred to in Nvivo. However, most of the detailed analysis of the 68 identified actors was done on a spreadsheet. To extract what actor is dominating, I focused on what actor appears in which article to identify the total number of articles that cite or refer to a certain actor. Only in a later step I then analysed the amount of total mentions of the individuals using Nvivo wordcount. To analyse what kind of actors dominate the discourse, I grouped them in ‘People related to CE companies’, ‘Researchers’, ‘Policymakers’, ‘People working for NGOs’ and ‘Others’.

After completing the first step of the analysis of actors, I identified which of the individuals are women and retraced my steps to get gender segregated data. Regarding the institutions, I first counted the institutions analogous to the individual. Later I added the sum of the individuals working at the institution but mentioned separately in other articles to get a more holistic understanding of the relevance of an institution.

In order to identify the main arguments presented in the articles I based my analysis on Kvale's (2007, 104–9) coding focused on meaning, having both predefined categories based on the literature as well as ad hoc codes arising from the articles.

4.2. Critical Discourse Analysis

The analysis of the articles as text, focussing on linguistic and discursive elements is inspired by Critical Discourse Analysis as described by Fairclough (2001b) in *Language and Power*. Critical Discourse Analysis examines the relationship between language, visual meaning or body language and other social practices to understand a text or an interaction in its broader societal context (Fairclough 2001a, 122–24). When analysing, one should be aware of 'power in discourse', which deals with power relations that are exercised and enacted in discourse and 'power behind discourse' that analyses how societal structures shaped discourse (Fairclough 2001, 36).

In discourse, power is exerted when powerful participants are "*controlling and constraining the contributions of non-powerful participants*" (ibid., 38-39, original italics) via the content of what is said or done ('content'), social relations in play during the discourse situation ('relations') or the position people occupy ('subject') (ibid., 39). On a more structural level, 'content' is related to knowledge and beliefs of producers or consumers of text, 'relations' with social relationships and subjects with social identities (ibid., 62).

'Hidden power', an element of 'power in discourse', is particularly relevant for written language and when "participants (…) are separated in place and time" for example via mass media. Mass-media situations such as in newspapers create special power relations, because they are often not transparent and there is a clear divide between 'producers' and 'interpreters' which become 'consumers' of text. Additionally, mass-media discourse does not allow producers of text to adapt it to a specific interpreter. Rather they have to produce the text with "*some* interpreter in mind, (…) an *ideal subject*", which the actual interpreters have to position themselves to (ibid., 41, original italics).

Fairclough separates three major steps of the analysis: description, interpretation and explanation (ibid., Chapter 5 and 6). However, he emphasises that "the procedure should not be treated as a holy whit - it is a guide and not a blueprint" (ibid., 92). I therefore did not meticulously follow the points he suggests for the respective steps but adapted the method to fit my material and the scope of this project.

In my analysis, I paid special attention to metaphors, because CE still is a relatively new topic many people have not engaged with. Charteris-Black (2004, 8) argues that metaphors play an important role in introducing a conceptual framework in which new ideas are presented and discussed. Metaphors are often used in persuasion, however, as their persuasive function is often not transparent at first glance they play an important role in the development of ideology (ibid., 8-9).

As I will specify in the next section, I analysed articles published in German newspapers, that were therefore written in German. I did the analysis in German, all translations included in the presentation of findings as well as the discussion and conclusion have been done by myself.

4.3. Data selection

In this thesis, I analysed articles from major German newspapers that were published between 1 January 2015 and 1 March 2019. I chose this starting date to cover the discourse leading up to the 21st Conference of the Parties (COP 21) to the UNFCCC, that led to the adoption of the Paris Agreement.

My choice of newspapers was inspired by Uther (2014, 83-84), who conducted a similar analysis between 2006 and 2011. In my sample, I include six major newspaper and one magazine, which is also updated on a daily basis online. *Süddeutsche Zeitung*, *die tageszeitung*, *Die Welt Frankfurter Allgemeine Zeitung, Die Zeit* and *Der Tagespiegel* are among the most circulated daily newspapers (Statista 2018), and *Der Spiegel* is the most circulated magazine excluding union magazines and TV programs (IVW 2019). Uther (2014, 83-84), also included *Frankfurter Rundschau*, however, as it was not included among the top newspapers, I excluded the paper from the sample.

All newspapers were accessed via Nexis Academics, a database available at Lund University, except for *Süddeutsche Zeitung* and *Frankfurter Allgemeine Zeitung*, which were accessed via their respective archives. The keywords searched for were ’climate engineering’, ‘geoengineering’, ‘geo-engineering’, ‘Klima-engineering’ and ‘negative Emissionen’. This list contains very few German expressions, because English terms are dominating the discourse.

After extracting all articles that contained one or more of the keywords, I read the articles to determine if their main topic was CE or if they discus CE in another context. After this final step of the process, my sample contained 34 articles. I provide a list in the appendix. Two of the articles have been written in 2015, three in 2016, twelve in 2017 and 17 in 2018. No article has been published in January and February of 2019. Roughly a third of the article have been published during or a week before/after UN climate conferences (nine articles) or a week before/after the launch of SR 1.5°C (two articles).

The articles were written by a total of 16 authors or author teams. 20 of the articles were written by men, two were written by a team of two male authors and one by a team of three male authors. Four of the authors were female, writing a total of eight articles. The gender of three authors is unknown, because the author of the articles is unknown. Here it is important to note that, like in the gender analysis of the experts, I identified the gender of the authors myself, and this assessment might differ from the gender that the authors identify as.

Considering that I discussed power dimension in the discourse and in newspaper articles in the previous section, it is worthwhile pointing out that Fairclough (2001, 42) questions who is exercising power in an article: the journalist, the editor or the institutional collective? Although power structures within a newspaper setting play an important role and are worth investigating more thoroughly, I decided to treat each article individually. The reason for this is that I did not analyse differences between the newspapers due to the scope of the thesis. Additionally, one of the authors, Johann Grolle working for *Der Spiegel*, is permanently based in the US which influence his articles and sets him apart from other authors (Spiegel n.d.), a point I will come back to in the discussion.

Another interesting observation is that one article has been written by Oliver Geden (German Institute for International and Security Affairs and Oxford University) and Stefan Schäfer (Institute for Advanced Sustainability Studies, IASS) and one by Marc Lawrence (IASS). The three of them are referred to as expert in other articles, blurring the lines between experts and authors.

4.4. Positionality and limitations

I briefly engaged with CE in spring 2018, about a year before starting this thesis but only dived deeper into the topic, the different methods and possible implications connected to their deployment as part of this project. I chose to engage with it more deeply as I was critical of CE being the appropriate response to climate change. However, I have tried to keep an open mind and to not only look for material that would confirm my initial assessment.

I identify as a feminist and believe who we are influences what we think and how others perceive us. It is therefore important to me, to apply a gender lens as one of many lenses when looking at a problem. I try to do this by conducting a limited gender analysis and by including feminist thought, because it provides valuable insight beyond a gender analysis.

Although I conducted a Critical Discourse Analysis, I am neither a linguist nor an expert for language, therefore my analysis of discursive characteristics can only be limited. The scope of this thesis is furthermore limited by the available time and the wordcount.

The majority of the articles were downloaded via Nexis Academics, which does not include pictures that might have accompanied the articles. Therefore, pictures or figures that might have been illustrating the articles are not included in the analysis, although they play an important role in how an article is perceived.

I am regularly reading some of the newspapers that I sampled my articles from, whereas there are others I never engage with. Nevertheless, I put in an effort to be open minded towards all of them and tried to not be biased.

5. Climate engineering in German newspapers

In this chapter I present the findings of my analysis. My findings are structured in the three sections, (1) experts cited or referred to, (2) arguments made and (3) linguistic characteristics such as metaphors. This structure is informed by my research questions (see Chapter 1.1) and aims to provide clarity in the chapter. However, I am well aware that the sections are intertwined, which I will engage with in the discussion in the following chapter.

5.1. Expert voices

Before diving into the arguments made in the articles, it is important to examine whose voices are presented and who therefore holds the power to shape the discourse. Table 2 gives an overview of the seven individuals that are most widely cited or referred to. Henceforth, I refer to them and the other individuals as ‘experts’. Overall, the authors refer to 68 experts, of which 54 are men and 14 women. This gender imbalance of only 21% female experts gets even bigger when considering that women only make up 17% of all references to experts. Generally, scientists make up about 72% of all the references throughout the sampled articles (35 men, ten women). The second biggest group is policymakers, which make up 10% (five men, two women). Of the people referred to, 6% are currently or were at the time the articles were published, employed at a CE company (three men, one woman). The smallest group is representatives of NGOs (one man, one woman) which makes up 3%. The remaining six individuals (all men) are not part of any of these groups and include Bill Gates, Richard Branson and the Dalai Lama.

Table 2 Experts cited or referred to
‘Articles’ indicates to the number of articles that refer to the expert, ‘Mentions’ shows how often the last name of the expert has been mentioned in total

Articles	Mentions	Name, Affiliation
7	11	Oliver Geden, German Institute for International and Security Affairs and permanent fellow at Oxford University
6	46	David Keith, Harvard University
6	11	Paul Crutzen
4	10	Klaus Lackner, Arizona State University
3	7	Andreas Oschlies, GEOMAR Helmholtz Centre for Ocean Research Kiel
3	5	Ulrike Niemeier, Max Planck Institute for Meteorology
3	4	Lilly Fuhr, Heinrich Böll Foundation

The expert most referred to, in seven of the analysed articles, is Oliver Geden. He is introduced as being affiliated to the German Institute for International and Security Affairs, but also is a permanent fellow at the Oxford Geoengineering Program. He is followed by Paul Crutzen and David Keith with six articles each. Whereas Paul Crutzen is exclusively presented as the Nobel laureate that pushed CE by publishing his famous article arguing for more research into SRM, David Keith (Harvard University) is widely engaged with for example as an interview partner. His prominent role is also reflected in overall 46 mentions of his last name in all articles, which clearly stands out. Compared to Geden and Crutzen he is mentioned more than four times as much, and more than eleven times as much as Lilly Fuhr.

Klaus Lackner is a German physicist and the director of the Center for Negative Carbon Emissions at the Arizona State University. Closing the list of the leading voices in the CE discourse with mentions or citations in three articles are Andreas Oschlies from the GEOMAR Helmholtz Centre for Ocean Research Kiel, Ulrike Niemeier from the Max Planck Institute for Meteorology and Lilly Fuhr from the Heinrich Böll Foundation (affiliated with the German green party).

Table 3 Institutions cited or referred to
'Articles' indicates the number of articles referring to the institutions: articles mentioning the institution plus articles mentioning experts affiliated with the institution

Articles	Name
17 (17+0)	International Panel on Climate Change (IPCC)
9 (3+6)	Institute for Advanced Sustainability Studies (IASS)
7 (0+7)	Harvard University
7 (4+3)	Carbon Engineering
6 (0+6)	Potsdam Institute for Climate Impact Research
5 (0+5)	GEOMAR Helmholtz Centre for Ocean Research Kiel
5 (1+4)	ETH Zürich
5 (2+3)	Institute for World Economics

At the institutional level (see Table 3), the IPCC is by far most often referred to (17 times). The popularity of the Institute for Advanced Sustainability Studies (IASS) is both reflected in direct references to the Institute itself (three) as well as to its researchers (six). The same applies for 'Carbon Engineering' (see page 11) with four mentions of the company and three of its employees and the Institute for World Economics (two direct references plus three expert references). Some institutions on the other hand do not seem popular at first but become so by considering the affiliations of cited experts. This is the case for Harvard University (seven expert references), the Potsdam Institute for Climate Impact Research (six expert references), GEOMAR Helmholtz Centre for Ocean Research Kiel (seven expert references) and the ETH Zürich in Switzerland (one direct reference plus four expert references).

5.2. Arguments

Following this overview on voices represented in German newspapers, in this section I engage with the arguments made in the articles. The main arguments are that CE is necessary to limit global warming to a maximum of 1.5°C, but politicians ignore the technologies. Furthermore, justice is rarely engaged with, while the question of who is expected to pay for the implementation of CE remains unanswered.

5.2.1. Climate engineering is necessary to meet the 1.5°C goal

Throughout most of the articles it is argued, either by the authors or by experts, that some sort of CE, with a focus on CDR, is 'inevitable' to meet the Paris Agreement by staying below 1.5°C or 2°C of global warming and therefore avoiding catastrophic effects of climate change. This assessment is based on the IPCC, which represents the 'state of scientific knowledge', and included CDR in all of the 1.5°C pathways. The authority of the IPCC is challenged only twice, when Schaper (2018) points out that the pathways are "predominantly economical models which overestimate negative emissions" and when Geden and Schäfer (2017) criticise that the illustration of 'Responsible Concentration Pathway' 2.6 in the fifth Assessment Report focuses on the net balance, creating the illusion that negative emissions are a topic for the future.

Within this line of argument, the time to decide if 'we' should deploy CE has passed and 'we' have 'no choice'. Some authors argue that social change leading to significant reductions of emissions is 'utopian' and 'unrealistic' and would not be enough anyway, because of the large quantities of CO_2 already emitted. Others weight the risks of climate change with the risks of CE and assert that CE is favourable to other alternatives with the serious potential to mitigate climate change, like an 'eco-dictatorship' (Lossau 2018).

Several articles present or refer to pilot projects or companies already deploying CDR methods, especially to 'Carbon Engineering' and 'Climeworks'. With an exception of 'Orkuveita Reykjavíku', a company in Iceland that uses particular geological conditions to convert CO_2 into solid material stored underground, none of the presented projects is currently reducing the emissions in the atmosphere. The authors point out that the plants are not carbon neutral or causing negative emissions yet, due to the energy the plants use and that 'Climeworks' and 'Carbon Engineering' are planning to use or sell the captured carbon.

However, while acknowledging that the IPCC considers CDR necessary, many authors remain sceptical of the 'dangerous' and 'questionable' technologies. General scepticism against technological innovation is also reflected in the conclusion, that it is safer to rely on already developed CE methods than to hope for "technical revolutions (…), that increase the efficiency of renewable energies" (Nester 2016).

5.2.2. Climate engineering is 'ignored' in climate politics

The second line of argument, that CE is 'ignored' in German politics and internationally at UNFCCC negotiations, is closely connected to the argument previously presented according to which CE is necessary to meet the Paris Agreement. Politicians shy away from CE because "[t]he necessity of NET [CDR] is neither socially understood nor accepted" (FAZ 2017) and CE technologies are 'unpopular'. Wilfried Rickels (in FAZ 2017) from the Institute for World Economics claims that "Unfortunately, apparently out of fear to lose votes, none of the four big parties wants to burden (*zumuten*) the voters with the truth".

In contrast to those demanding CE play a bigger role in climate politics, others fear that focussing on CE 'distracts' and takes attention from 'conventional mitigation'. They argue that trusting in CDR and rendering it impossible to reach a maximum of 1.5°C global warming without it, can lead to countries not taking any climate action and waiting for big scaled technological solutions.

Several authors point out that CE is largely ungoverned, as it remains disregarded at international climate negotiations. While few refer to existing regulations like the London Convention and the ENMOD Convention [2] those raising the issue agree that the implementation of CE should be controlled by the UNFCCC. The biggest concerns are conflicts arising from 'unilateral implementation' and 'different interests'. I will engage more with these in the next section that deals with justice.

5.2.3. Justice

Justice is rarely dealt with outside the context of how to regulate CE. Questions about who takes responsibility for 'failures' or how 'losers' of CE should be compensated, illustrate why many authors are concerned with single or a small group of countries implementing large scale CE.

Nonetheless, justice is often discussed with a Eurocentric lens. For example, Heckning et al. (2016) consider it unlikely that "[a]ll those Asians and Africans, that just overcame scarcity" would restrict themselves, while listing 'sports aircrafts' and 'cruise ships' among the items 'we' need fuel for. The other way around, this becomes evident by considering that only one article (Geden and Schäfer 2017) questions what the position of countries that are expected to produce the big share of biomass necessary to achieve the amount of BECCS modelled in the 1.5°C pathways is.

Few other articles raise questions of intergenerational justice. Future generations will experience the consequences of CE and bear the 'risks' resulting from trust in future implementation of 'technologies that do not yet exist'.

5.2.4. Who is supposed to pay for it?

Similarily to justice issues, questions regarding the costs and funding of CE research and technologies are particularly interesting when looking at what is not asked. The 'enormous' costs are considered to be the determining characteristic when it comes to the decision if CE is implemented. Still the question of who pays for it often remains unanswered. In one interview Klaus Lackner, who developed a material to capture CO_2, discusses the costs of CE in the context of historic emissions and states that those who have caused the emissions should pay for their removal (Lackner in Haas 2018a). However, in the same article Lackner claims that an increase of 6 or 7 cents per litre of gas is no problem for consumers. In regard to SRM, many articles highlight that it is 'cheap', which leads Mäder (2018) to conclude that it can be "financed by rich countries".

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[2] The *Convention on the prohibition of military or any hostile use of environmental modification techniques* (ENMOD) bans the military application of environmental modification techniques (UN 1976).

Only three authors (Grolle 2017, 2018; Haas 2018a, 2018b; Simonis 2018) critically engage with who is funding CE technologies and who is benefiting from their implementation. In an interview, David Keith for example states that he is happy to be privately funded (Grolle 2017). When introducing 'Carbon Engineering', Grolle (2018) points out that the company is, among others, financed by Bill Gates and Murray Edwards and both him and Haas (2018b) bring up the Virgin Earth Challenge (see Chapter 2.3) financed by Richard Branson. The promise to launch a 'multi-billion-dollar-industry' is for example reflected in Steve Oldhams (CEO of Carbon Engineering) plans to sell licences to oil companies. This is an example of how CE "strengthens groups and industries that are climate politically most reactionary" (Simonis 2018).

5.3. Discursive elements

In this section, I mainly engage with metaphors, but I also bring in some linguistic particularities are not included in the arguments section. Generally, most articles are very rich with metaphors, while Tilz (2015) does not use any. The predominant group is related to 'house or household' in a wider sense; less frequently metaphors out of the 'medical context' or others are used.

5.3.1. House or household

Generally, CE is described to be an 'emergency exit' or a 'backdoor' and when applying SRM, aerosols will be injected in the 'top floor' of the atmosphere. Climate engineers become 'weather plumbers' or 'wannabe world-redevelopers' that mess with the 'craftsmanship' (*Handwerk*) of the 'weather god'. The 'global thermostat' has to be set and '(particle) sunshades' help to regulate the temperature. Because CO_2 became a 'blanket in the atmosphere' functioning like the 'lit of a thermal jug' a second 'blanket' has to be 'constructed', using SRM. CE is like a 'fire extinguisher' or the 'waste collection' and CDR technologies are called 'oversized washing machine' or 'gas sucker', which is derived from the German word for vacuum cleaner *Staubsauger* ('dust sucker').

5.3.2. Medical context

Medical metaphors are often related to SRM and range from 'injections' and 'symptoms' to 'universal remedy' or 'miracle cure'. The 'emergency doctor' might 'resuscitate' the earth or apply a 'pressure bandage' but they generally highlight how the authors do not consider them a cure.

5.3.3. Other metaphors or discursive elements

Several times CE is referred as 'plan B' or 'plan C' for when mitigation fails. The conflict between considering CE as a serious option and dismissing the technologies is reflected in calling CE 'pure idiocy' or climate engineers 'true visionaries' and ascribing engineers the role to 'save the world'.

The metaphor of 'Playing God' only plays a minor role. However, Grolle (2018) referred to the 'climate community' as "*Gemeinde der Klimaschützer*" which leads to church associations, supported by "*eine neue Industrie aus der Taufe heben*", an expression for 'launching a new industry' which draws comparisons to a baptism.

6. Discussion

Subsequent to the presention of my findings, here I discuss them in the broader context and in relation to the background and theory presented in Chapter 2 and 3.

My findings show that the actors dominating the recent discourse on CE in German print media are in line with previous analyses of newspapers (Buck 2013, 174). Although Oliver Geden might at first stand out, his affiliation with the Oxford Geoengineering Program closes the circle and reflects how he is part of the group of institutions prevailing at international conferences on CE. The fact that the Institute for Advanced Sustainability Studies (IASS) and Harvard University are among the top institutions mentioned, indicates that Biermann's and Möller's (2019, 6) findings of the three institutions, Oxford University, IASS and Harvard Univesity, dominating international conferences is also reflected in German mainstream media discourse.

The role that David Keith plays in the analysed articles, only being outranked by Oliver Geden regarding the number of articles referring to him but being mentioned more than four times as often, reaffirms his prominent position in the 'Geoclique' (cf. Kintisch 2010, 8). Against this background, his engagement with 'Carbon Engineering' is problematic. Keith spends roughly a third of his time with 'Carbon Engineering', where "he helps lead" the company, as it is formulated in his description in the 'Ecomodernist Manifesto' (Asafu-Adjade et al. 2015, 4). His role as board member and acting chief scientist of the company that stemmed from his research makes him a prime example of a 'scientist-entrepreneur' (cf. Moore et al. 2011, 512–13). His advocacy for scaled-up implementation of CE technologies has to be understood in the context of resulting personal financial benefits, especially since the CEO of 'Carbon Engineering' plans to sell licenses of the technology to fossil fuel companies (Grolle 2018).

The articles confirm that the IPCC is perceived as an authority in the field (cf. Corbera et al. 2015, 1). The panel is not only widely referred to, but the references also make clear that its assessments are not challenged. However, although many articles mention a wide range of CE technologies, most of them don not engage with the methods dominating in the latest two IPCC reports, BECCS and Afforestation (Clarke et al. 2014, 486; Rogelj et al. 2018, 121–23). Additionally, the important point that CE can only be an addition to reductions in emission and does not allow business as usual is not made clear in most articles. On the other hand, giving a platform to companies that engage with CE out of commercial interests and that plan to *use* captured carbon instead of *storing* it creates the illusion that the current level of emissions is still acceptable.

The important role that the IPCC and Paris Agreement, with its declared goal to limit global warming to 1.5°C or well below 2°C, plays in the articles corresponds to the time in which most of the articles were published. While only two articles were published before the adoption of the Paris Agreement, the numbers have been increasing since, with 17 articles published last year, coinciding with the year SR 1.5°C was presented.

Even though my gender analysis differs compared to Buck's (2013, 174) sample of English articles published between 1990 and 2010, women play a bigger role when it comes to presenting CE in the media. Buck found that women make up 3% of the statements, whereas my analysis reflects that 21% of the experts referred to in the articles are female and that these women compile 17% of the references to experts. While there is a positive trend, voices of women continue to be in the minority in the public discourse around CE. Future studies have to show if this trend also applies to research. Especially for the authority figure IPCC with its widespread impact, it would be interesting to see if attendants rates of females at CE meetings exceed 15 % as it was in 2011 (cf. Buck et al. 2013, 654).

Interesting cases regarding dominant voices and experts in the German mainstream discourse are two articles written by researchers who are referred to as experts in other articles. One article has been written by Marc Lawrence (2017), scientific director of the Institute for Advanced Sustainability Studies (IASS) and the second one by Oliver Geden and Stefan Schäfer (2017) also from the IASS. Considering that Geden is the expert most often referred to and the IASS is the only outranked by the IPCC regarding institutions, they further amplify their dominant voices by being the authors of articles. However especially the article by Geden and Schäfer (2017) differed from many other articles in its political focus and detail, for example in a discussion about the implications of 'Responsible Concentration Pathway' 2.6 from the fifth Assessment Report.

On the other hand, Geden and Schäfer (2017) are the only ones bringing in the perspective of countries, that are expected to produce the major share of biomass necessary to achieve the amount of negative emissions accounted for in the IPCC emission pathways. They thereby go beyond the Eurocentric lens which otherwise dominates the articles.

This example illustrates that the problem with the overrepresentation of certain voices within the CE discourse in not that the research they produce or the arguments they make are wrong, it is that is incomplete and 'partial' (cf. Haraway 1988, 584-89). Since the discourse is dominated by actors with vested interests, the important argument that CE can only be an addition to serious reductions in emissions, but never a replacement only plays a minor role. A greater variety of actors could open up the discussion and lead to a more diverse set of arguments.

Grolle's (2017, 2018) articles exposes why the position of the knower is so important cf. Haraway, 1988). The author is based in the US (Spiegel n.d.) which could explain why both of is articles focus on North America. More importantly however, he uses the term 'climate intervention', introduced by the US National Academy of Sciences (NAS 2015a, 2015b), which the other authors do not use.

Although justice was not absent in the material (cf. Buck 2013, 176), it was for the most part still discussed on a clean sheet (cf. McLaren 2016, 144–46, 150). For instance, Heckning et al.

(2016) did not question how colonialisation and exploitation shaped the existing wealth imbalance when asserting that it is unlikely that "[a]ll those Asians and Africans, that just overcame scarcity" would restrict themselves. Similarly, Mäder (2018) did not question the source of the global wealth imbalance when suggesting that SRM could be "financed by rich countries" but rather illustrates Hornborg's (2016, 125, 2013, 9) argument that the access to technology is limited by financial means and further increases inequality.

How the existing societal system is taken for granted is also reflected when Heckning et al. (2016) treat 'sports aircrafts' and 'cruise ships' as if they are a necessary feature of our society and not free time activities of privileged groups that play a role in reinforcing climate change. Furthermore, a privileged perspective is evident when looking at Lackner's assessment that consumers would not face problems if gas prices increased by 6 or 7 cents per litre, as a consequence of Carbon Capture and Storage. Although this holds true for rich people, poorer groups in society would be disproportionately burdened.

These examples, of how justice is discussed in the articles, correspond with the concept of 'machine fetishism', according to which specific questions of technical feasibility are discussed but not broader global implications (cf. Hornborg 2013, 9). In this case for example, the focus is on whether the technology is ready to be upscaled. Additionally, technical feasibility does not mean social feasibility (Hornborg 2016, 114). As the articles confirm, CE is perceived to be 'dangerous', 'questionable' and 'unpopular', an assessment that is supported by Braun et al. (2018, 475-76) which find that Germans do not agree with the implementation of CE technologies.

Discussing 'technological utopianism', Hornborg (2016, 115) lists three types of constraints – cultural, economic and political – restricting the implementation of a new technology, all of which are revealed in the articles. Cultural constrains are reflected in the hesitance towards new technologies, for example when Nester (2016) concludes that it is safer to rely on CE than to hope for technical innovations in other areas reducing the energy demand. Economic constrains are manifested in the judgment that costs will determine if CE will be implemented at large scale, whereas political contains are found in politicians' unwillingness to engage with CE and in concerns about international regulation.

The dominance of the house metaphor too can be understood as an expression of the mechanistic worldview (cf. Merchant, 1989). On the one hand, metaphors like 'backdoor', 'washing machine' and 'sunshade' make CE very approachable by relating the technologies to things the readers know, which is important for new topics like engineering (cf. Charteris-Black 2004, 8). On the other hand, the way especially plumbing metaphors are used, reflects that human knowledge about environmental processes remains to be limited and that the climate is no machine that can easily be fixed. Similarly, medical metaphors might treat the earth like an organism, however, by assigning the role of a physician to climate engineers, humans do not take a subordinate position in this logic (cf. Merchant, 1989, 1-2).

Linking metaphors back to justice, calling CE 'Plan B' or 'Plan C' oversimplifies the technologies, highlights extreme positions and feeds in to technological optimism. Additionally the expressions neglect that CE has to be combined with reductions in emissions, but cannot replace them (Fragnière and Gardiner 2016, 15). If one were to use the metaphor, plan X,Y or Z would be more accurate (Preston 2016, xiii). Another point that makes me question whether the authors of the articles have understood the severity of the situation are questions and suggestions about wheter the carbon can be used in the beverage industry.

A more diverse description of CE technologies, including their limitations and their relation to mitigation strategies, is needed for readers to get a realistic understanding of CE. Against this background it can be beneficial if NGOs and actors with a clear focus on justice play a more dominant role in the discourse, as they still remain largely absent and have shown to introduce such arguments in other countries (Uther 2014, 156-58).

6.1. Future research

Considering that I analysed articles whose main topic was CE, an interesting task for further research would be to compare articles that focus on CE with articles that discuss CE in the context of climate change. While I did not focus on the newspaper that the articles were published in, it would be a promising task for future research to analyse similarities and differences between the different newspapers. Also, as I analysed mainstream media, it could be interesting to compare the findings to discourse in subgroups, for example newspapers or magazines with a clear agenda.

While I have demonstrated that voices from the civil society are missing in the public discourse around CE, the only German NGO engaging with CE at a deeper level appears to be the Heinrich Böll Foundation. Therefore, future research has to show why CE does not play a more central role among German environmental NGOs and what barriers to their participation in the discourse might exist.

7. Conclusion

In this thesis I provided an overview over the CE methods the IPCC addresses in SR 1.5°C and includes in its emission pathways. Although the technologies are not fully developed and ready to be up-scaled, they play a significant role in plans to reduce global warming to 1.5°C above pre-industrial levels (Rogelj et al. 2018, 121-22). I furthermore demonstrated how CE research is dominated by the 'Geoclique', a small group of, mainly male, researchers from Europe and North America (Kinitsch 2010, 8; Biermann and Möller 2019, 151-55). While the project *Climate Engineering: Risks, Challenges, Opportunities?*, currently the most relevant research program in Europe, is funded by the German state (Oomen Forthcoming, 25, 134) a lot of research in the US is funded by philanthropists like Bill Gates or by the fossil fuel industry (Muffett and Feit 2019, 10-14).

My analysis of German newspaper articles shows that dominant voices in the research community are also dominating the mainstream discourse. The public discourse is overshadowed by voices from researchers while other voices, for example from NGOs or policymakers, remain underrepresented. Oliver Geden from the German Institute for International and Security Affairs and permanent fellow at Oxford University as well as David Keith from Harvard University, who has been identified as informally leading the 'Geoclique' (Kinitsch 2010, 10), are the dominating actors referred to in the articles.

On an institutional level the IPCC is referred to the most, often in the context of the inclusion of CDR methods like BECCS and afforestation in emission pathways. Another institution widely referred to is the Institute for Advanced Sustainability Studies (IASS), which also plays a dominating role at CE conferences, together with Harvard and Oxford University (Bierman and Möller 2019, 156).

The main argument presented in the articles is that CE is necessary to not exceed 1.5°C of global warming compared to pre-industrial levels and thereby meet the Paris Agreement. Considering that limiting global warming to 1.5°C is widely recognized as a necessity to advert catastrophic effects of climate change, the assessment that CE is necessary to meet the Paris Agreement equates the argument to the 'avoiding catastrophe' frame described by McLaren (2016, 144). However, while negative emissions play a "substantial role" in the IPCC emission pathways (Rogelj et al. 2018, 121) the authors of the articles point out that they have so far been 'ignored' by politicians, both on national level as well as internationally at climate negotiations.

Justice remains to be a rather minor topic discussed in the articles (cf. Buck 2013, 176) and tends to be addressed with a Eurocentric lens. Additionally, the question of who should pay for the implementation is mostly posed rhetorically and not discussed in the context of historic responsibilities.

The articles reflect that Hornborg's (2013, 9) concept of 'machine fetishism' applies to CE. Specific questions of technical feasibility, for example if the technologies are ready to be upscaled, are discussed while broader global implications are not addressed. Furthermore, assessments of CE technologies as being 'dangerous', 'questionable' and 'unpopular' show that social feasibility is not given (cf. Hornborg 2016, 114).

Most metaphors used to refer to CE technologies are related to 'house' or 'household', for example 'backdoor', 'washing machine' and 'sunshade', which make it easy for the reader to relate to the relatively new topic of CE. Especially metaphors related to 'plumbing' can be understood as an expression of the mechanistic worldview (cf. Merchant, 1989), but their use also reflects that humans have not fully understood the complexity of the earth system. Other metaphors are related to medicine like 'symptoms' and 'miracle cure' or refer to CE as 'Plan B'.

CE technologies can play a role to achieve climate justice by limiting global warming to 1.5°C above pre-industrial level. However, as I have demonstrated in this thesis, justice considerations do not play a central role in the discourse. In the current form, CE rather seems to be an excuse for business as usual and a way for fossil fuel companies and other powerful actors to expand their wealth.

Within the public discourse around CE, it is very important to emphasise that even large-scale deployment of CE can never replace massive reductions in emissions and only complement other mitigation strategies. Although CE can help to achieve climate justice, it can also deepen existing inequalities if it continues to be dominated by male actors from Europe and North America. Human Ecologists, social scientists in general and other actors such as NGOs, which generally bring justice into conversations, therefore have to play a bigger role in the public debate around CE to make sure justice considerations take centre stage.

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