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GENERAL TITLE:

CARBON REDUCTION MEASURES IN GERMANY: A COMPARATIVE ANALYSIS TO ACCELERATE CLIMATE NEUTRALITY THROUGH A SYSTEM CHANGE APPROACH

INDIVIDUAL TITLE:

CO2 EMISSION REDUCTION IN GERMANY – FROM A SCIENTIFIC PERSPECTIVE

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Abstract

Following the Paris Agreement, Germany set targets and interim goals in its Climate Action Plan to become climate neutral by 2045, but the implementation lacks behind. This thesis analyzes CO2 reduction measures that Germany takes from the perspective of scientific research, compared with the public sector, private companies, start-ups, and NGOs. Based on a grounded theory approach, analyzing case studies and interviews, a comparative analysis of the examination reveals that systemic change is required. One important recommendation is the unification of climate targets on all levels. Furthermore, new laws, regulations, and financial recourses are necessary to develop strategies and innovations to steer the system toward a net-zero future.

Key Words

Germany, CO2 reduction measures, systemic change, climate neutrality

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1. Introduction

'Humanity is heading for an abyss, a warming of more than 2.5 degrees, with devastating effects on our lives on the only planet we have.'

These are the words used by German Foreign Minister Annalena Baerbock at the COP27 World Climate Conference in Egypt to describe the priority Germany should attach to mitigating climate change (DW 2022). In Germany, CO2 emissions are one of the biggest contributors to climate change. With per capita emissions of 9.6 tons of CO2 per year, German emissions are almost twice as high as the international average of 4.9 tons of CO2 (BMUV n.d.). Therefore, Germany is the largest emitter in the EU, with a 1.8% share of global CO2 emissions (Statista 2022) (Appendix 1). This development is reflected in a general increase in awareness of climate change among the German population. Thus, around 70% of Germans are convinced that stronger measures are needed to combat climate change, but this attitude rarely turns into sustainable behavior due to costs and motivation. Although German households are responsible for an essential third of CO2 emissions, an industrial and corporate revolution toward climate-friendly approaches is urgently needed (BMUV 2022b; Venghaus, Henseleit, and Belka 2022, 8). But, due to the complexity of the climate challenge, there are not enough concepts and initiatives in politics and business to curb climate change and CO2 emissions. To get off this 'highway to hell,' as Ursula von der Leyen, President of the European Commission, describes the situation, it will now take the cohesion and cooperation of the entire political, social, and business communities as well as society to achieve Germany's goal of greenhouse gas (GHG, see list of abbreviations in Appendix 22) neutrality by 2045 (Spiegel 2022; BMUV 2020).

As can be heard on the streets at Friday for Future demonstrations in Germany, it will take 'system change, not climate change' to solve this challenge sustainably (Thiele-Eich 2022). Because the need for collaboration is growing through globalization, various players worldwide must collaborate and exercise collective leadership to fight sustainability challenges such as CO2 emissions. A diverse group of partners must engage collectively to create successful collaborative systemic change (Senge et al. 2007). According to Ripley (2019), systemic change 'means that change has to be fundamental and affects how the whole system functions.' It focuses on changes that spread and behaviors that adopt a 'new normal' instead of transformations and benefits remaining restricted to a small group. The members of 'Catalyst 2030', a global movement of people and organizations committed to achieving the United Nations (UN) Sustainable Development Goals (SDGs) by 2030, have explored systemic change approaches to accelerate collective efforts to achieve the SDGs. They found that the laws, practices, power dynamics, social norms, or attitudes that form the basis of the societal issue must be altered or transformed for systemic change. In addition, it can be seen in Appendix 2 that system change is composed of incremental, structural, and transformational processes that often remain invisible. Appendix 3 demonstrates a framework that illustrates the usual characteristics of system change, including - amongst others - the following three criteria: addressing underlying root causes, solving big social issues, and strengthening capacity and processes to engage (Grady et al. 2018).

Based on these findings, this thesis utilizes a system change approach that affects the functioning of the whole system by improving the 'profundity of problem-solving approaches', increasing the 'effectiveness of the applied strategy,' and enhancing the 'management of resources and collaborations' of multiple stakeholders in the system.

The main objective of this thesis is to provide an outlook on how Germany could intensify its effort to reduce CO2 emissions and achieve GHG neutrality in a shorter timeframe. First, important background information, such as the Agenda 2030 and SDG 13, as well as the causes and consequences of climate change, are discussed. Then, to enable a qualitative and broad analysis, the individual parts of this thesis examine possible solution approaches using five stakeholder perspectives as examples. Among these cases are a scientific institution, German municipalities, a large and established company, a green-tech start-up, and an environmental non-profit organization (NGO). These five case study analyses follow a grounded theory approach to structure the data collected, draw specific key insights, and develop recommendations. After the individual analysis of each case, a comparative analysis and discussion of the previously described cases are carried out, followed by recommendations to accelerate the achievement of SDG 13.

2. Germanys attempt of achieving carbon dioxide neutrality

2.1. Germany's role in fighting climate change

Germany plays a significant role in fighting climate change to stop global warming and its pernicious consequences, as it is the biggest emitter in Europe (European Parliament 2021). Beyond that, 196 parties complied with the in 2015 to limit global warming below 2 °C, preferably even 1.5 °C compared to pre-industrial levels. To reduce GHG emissions as soon as possible is a legally binding international treaty agreement (UN n.d.). Germany played a central role in this agreement because it was one of the first nations to submit to the long-term low GHG strategy by developing and implementing the German Climate Action Plan.

Between the summer of 2015 and March 2016, the German government drew up a climate protection plan based on scientific studies and scenarios following the Paris Agreement. The initial

plan was to achieve climate neutrality by 2050. Though, the Federal Constitutional Court (Bundesverfassungsgericht 2021) announced in its verdict that the current climate protection law is unconstitutional, which is why Germany adjusted their climate targets and is now aiming to be GHG emission-free by 2045 (Stolten et al. 2022). The Climate Protection Plan describes a modernization strategy to implement the transformation toward a low-carbon economy in Germany. It highlights the GHG interim targets for 2030 while considering impact and cost analyses. The implementation considers sustainable resource use and conservation for long-lasting and sustainable climate protection. Reducing GHG emissions could be feasible if Germany considers increasing its energy efficiency (BMUV 2020). They set interim targets and milestones to reach the goals by 2030, which serve as orientations for reducing emissions and are divided into individual action segments. The heads of state and government agree to reduce GHG emissions by 65% compared to the level from 1990 until 2030 (BPA 2022b; Umwelt Bundesamt 2022). Furthermore, the German government has set sector targets for the necessary reduction in emissions. This follows from the conviction that target achievement is only realistically possible if Germany takes action in all sectors (Bundesverfassungsgericht 2021). However, Germany is in danger of falling short of its 2030 climate targets. If Germany continues to emit as many greenhouse gases as it does now, the climate targets for 2030 will not be achievable. According to the Expert Council on Climate Issues, the amount of emissions saved would have to more than double for this to happen (Tagesschau 2022).

Today, Germany is still the leading nation in the EU regarding industrial production, with Germany having 27% of the EU value of sold industrial production in 2021 (Eurostat 2022). With the EU being the third largest emitter of GHG from energy worldwide in 2021 (Tiseo 2022c)

(Appendix 4), Germany's significance in this context becomes clear (European Parliament 2021). If Germany reaches its goal of lowering the country's GHG emissions and becoming climate neutral by 2045, Germany can serve as a role model for other countries since Germany has a history of being the forerunner in innovative technologies and system solutions. For instance, the country's energy transition towards renewable energy with intelligent control technology and storage technology can contribute to achieving GHG neutrality globally (BMUB 2016). Due to Germany's leading role in emitting GHG and its potential to act as a guiding model for other countries on their way to becoming climate neutral, this thesis will focus on Germany and its climate actions.

2.2. Carbon dioxide as a central factor of climate change

Globally aligned climate action requires a central focus on reducing GHG, especially CO2 emissions, to limit global warming and prevent climate change. When addressing climate change, GHG emissions are particularly crucial because they trap heat radiating from the earth's surface and increase global warming (Herzog, Eliasson, and Kaarstad 2000).

The primary driver of human-caused GHG emissions resulting in the earth's warming is the CO2 emissions from burning fossil fuels. Specifically, 81% of all GHG emissions are caused by CO2 emissions. Examples of the non-CO2 GHG emitted from human activity are methane (10%), nitrous oxide (7%), and fluorinated gases (3%) (World Business Council for Sustainable Development 2011). According to figures released in 2020, China is the most significant contributor to fossil-fuel CO2 emissions, accounting for about 30.9% of global GHG emissions, followed by the United States with 13.5% and the European Union with 7.3%. The top ten CO2 emission emitters contribute to more than two-thirds of global emissions (Statista 2022a; Tang 2022, 21) (Appendix 1). According to the EU, Germany, with 809,799 kilotons of CO2 in 2019, is

the most significant contributor of CO2 emission, followed by France with 453,101 kilotons and Italy with 442,958 kilotons in the EU (European Parliament 2021) (Appendix 5).

Looking at the distribution of CO2 among the various sectors in Germany, the energy sector is the leading source of GHG emissions, accounting for around 32.5% of all emissions. Furthermore, the industry sector, with 23.8% of CO2 emissions, and the transportation sector, with 19.4%, are the largest emitters of German emissions. The agricultural sector also contributes to rising CO2 emissions at 15.2% (Friedrich, Ge, and Pickens 2020; Tiseo 2022a) (Appendix 6).

Therefore, to avoid the worst effects, it is commonly acknowledged that the world needs to reduce those emissions quickly (Ritchie, Roser, and Rosado 2020). For this reason, industrialized nations must strive as soon as possible to develop technologies that no longer release CO2 and other GHG emissions into the environment. On the other hand, developing countries must ensure that they minimize the growth of CO2 emissions and work with industrialized nations to create effective technologies that are as affordable as possible (MacCracken 2012).

Global guidelines became necessary to guide decision-makers worldwide to sustainably fight the most significant global challenges of all time. Specific targets had to be set in place by a centralized unit. Therefore, in September 2015, the UN published 'The 2030 Agenda for Sustainable Development,' which aims to transform the world by guiding people's actions. The agenda 2030 seeks to solve the world's greatest challenges by enabling global peace and freedom, ending poverty and hunger, combating inequalities, upholding human rights, and ensuring the planet's long-term preservation of its natural resources. It includes a set of 17 comprehensive, people-focused, and far-reaching goals and objectives. The UN asks all people and organizations

to put up an effort to enable the implementation of the agenda until 2030 in all three of its facets - economic, social, and environmental - in a coordinated and balanced way. An important principle stated by the UN is that implementing the agenda is a collective journey in which 'no one will be left behind' (UN 2015). The goals and objectives of the 2030 agenda are meant to be met for all nations, all people, and all social groups. All plans are universal and apply to developed and developing countries to the same extent.

To break down the Agenda 2030 into specific targets and required actions, a set of global Sustainable Development Goals (SDGs) with 17 goals and 169 targets was suggested at the UN in New York by the Open Working Group, which was established by the UN General Assembly (Hák, Janoušková, and Moldan 2016, 564). The five Ps - Prosperity, People, Planet, Peace, and Partnership - are the main time-bound goals of the SDGs (Sachs et al. 2019, 805), which came into force on January 1st, 2016, to serve as a guideline for actions and decisions around the world over the coming 15 years (UN 2015). In sum, the 17 SDGs are intended to end poverty and hunger and fight inequalities, strengthen people's self-determination, ensure gender equality and a good and healthy life for all, promote prosperity for all and make lifestyles sustainable worldwide. Goals are, for example, 'no poverty,' 'zero hunger,' or 'good health and well-being' (Appendix 7).

Another central aspect is 'climate action,' defined as SDG 13. SDGs are often connected and depend on each other. 'Climate action,' for example, is connected to other SDGs, such as 'life below water' (SDG 14) and 'life on land' (SDG 15) (Fuso Nerini et al. 2019, 674). Since this thesis aims at evaluating current climate action with a focus on CO2, SDG 13 (climate action) will be of specific relevance. The extent of global threats caused by climate change requires broad international cooperation and collaboration. This is why the threat posed by climate change and

environmental degradation is a central aspect of the agenda for 2030 (UN 2015). The SDG' climate action' targets include strengthening resilience to climate-related natural disasters by implementing disaster risk reduction policies, supporting less developed countries with climate actions monetarily, and assisting them in effective climate-change management and planning. But, most importantly for the course of this thesis, goal 13 includes the targets to 'Integrate climate change measures into national policies, strategies and planning' and to 'Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaption, impact reduction and early warning' (UN n.d.) (Appendix 8). According to Fuso Nerini et al. (2019, 674), taking steps to fight climate change can support all 17 SDGs.

Because GHG emission reduction is vital for adequate climate action, the indicators of target SDG 13.2 specifically mention the reduction of GHG emissions. These indicators are:

- '13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans and adaptation communications, as reported to the secretariat of the United Nations Framework Convention on Climate Change (UN n.d.)
- 13.2.2 Total greenhouse gas emissions per year' (UN n.d.).

The only way to slow the speed of global warming is to cut emissions of carbon dioxide and other GHGs. Therefore, this thesis will focus on measures taken at diverse levels to reduce GHG and combat climate change.

As described above, this thesis focuses on SDG 13, 'climate action,' and the challenges caused by climate change. Climate change can be described as the continuous and long-term variation of a region's temperature and expected weather patterns. This can occur in a specific area or the entire world, whereby weather patterns and natural events become less predictable and more

extreme (National Geographic Society 2022; IPCC 2021b). These changes could be, on the one hand, caused by natural factors, such as shifts in the solar cycle, but especially in the last decades' human impacts and the rising usage of fossil fuels like oil and gas have been the leading cause of climate change (UN n.d.). On the other hand, factors contributing significantly to global warming, mainly caused by GHG emissions, include deforestation, agriculture, transportation, and private household consumption patterns (UN 2022a; Malhi, Kaur, and Kaushik 2021). However, generating power and producing goods create vast amounts of CO2 and other GHGs (European Commission n.d.).

Thus, climate change brings enormous natural consequences, social effects, and threats. One of the significant effects of climate change is global warming and temperature rise. Since 1880, the Earth's temperature has increased by 0.08° Celsius every decade, and since 1981, the degree of warming has increased by 0.18° C, which is more than twice as much (Lindsey and Dahlman 2022). This rise leads to heat waves, an alteration in the distribution of climatic regions, and the melting of glaciers. In addition, there are droughts and forest fires, which primarily affect the water supply, biodiversity, and agriculture.

Furthermore, climate change impacts freshwater availability as sea levels rise, evaporation rates increase, and rainfall patterns change. Besides that, floods are destroying natural habitats and entail severe economic losses. Furthermore, sea levels are rising due to ocean warming and melting ice and glaciers, which will increase the risk of erosion and floods in the coastal area, negatively affecting the local economy, environment, infrastructure, and people. Correspondingly, the world's biodiversity, with all its animal species and plants, is endangered by the effects of climate change. In addition to the natural consequences, climate change poses various social risks. For example, an

increase in hunger and poor nutrition worldwide is attributed to climate change and extreme weather occurrences. Similarly, it is one of the most significant health risks to humanity. Air pollution, life-threatening weather incidents, forced relocation, and stress on mental health are already harming people's health. This increases the vulnerability of the populations living in low-income metropolitan areas with weak infrastructure. Demographic folks with fewer assets and incomes are more sensitive to the effects of climate change and have less ability to deal with them. In sum, climate change is enlarging the chance for people to fall into and stay in poverty (UN 2022a; European Commission n.d.; Rocque et al. 2021; National Geographic Society n.d.; Umwelt Bundesamt 2021b).

Furthermore, being aware of unforeseen circumstances and crises that can impact a country's economic and social situation at any time is crucial. For example, a global problem like the ongoing COVID-19 pandemic intersects and complicates compliance with the set goals. The pandemic has caused severe social and economic disruptions, impacting Agenda 2030 and Germany's Climate Action Plan in many ways. While the progress for some of the SDGs is threatened to be slowed down or even reversed, it can be argued that the global pandemic has positively affected the process towards achieving goal 13 amongst negative ones. According to a study by the International Monetary Fund in early 2021 on the attitudes to climate change and support for climate policies, the COVID-19 pandemic has positively affected the field under study. Both the concern for climate change among the respondents and the public support for a green recovery have increased (Mohommad and Pugacheva 2022, 3). However, the decline in GHG emissions is likely to be only temporary, and the aim of the industrial nations to return to their

stable economy could cancel out the original effect and even lead to increased levels of GHG emissions (Kumar et al. 2021).

Additional to the consequence of the COVID-19 pandemic, the Russian invasion of Ukraine and the resulting war since February 2022 is another example that is imposing threats to climate targets. Firstly, the direct emissions from weapons, jets, tanks, and trucks used in the war contribute to increasing GHG emissions. Secondly, the war in Ukraine has indirectly led to an energy crisis, with the Russian Federation being the leader in exporting gas and the second-leading nation in exporting oil (UN 2022b). Since the start of the war, economic sanctions against the Russian government have been imposed by countries worldwide. These include sanctions aiming at the energy sector to discontinue oil and gas revenues for Russia that can be invested in the war. But the high dependency on Russian fossil fuels, especially for EU member states including Germany, makes it very difficult to enforce those sanctions without having to deal with scarcity in oil and gas and unprecedented price rises in fossil fuels (Benton, Froggatt, and Wellesley 2022). Germany is committed to securing the energy supply with recourse to coal and oil to rapidly reduce the dependency on Russian gas supplies and prevent a shortage in energy. With a resolution dated June 08, 2022, Germany has introduced ‘The Act on the Provision of Replacement Power Plants’ to reduce gas consumption in the electricity sector and aims to establish a gas replacement reserve by March 31, 2024. In an emergency, oil and coal-fired power plants have to produce electricity if the volume of gas supplies is insufficient for enough electricity from gas and there is a so-called gas shortage (BPA 2022a). This replacement plan contradicts the coal phase-out that Germany wanted to complete in 2022 and 2023 and sets the climate targets further back. The federal government of Germany states that they will complete the coal phase-out by 2030. They additionally comment

that reenacting the coal power plants will only happen in case of emergency (BPA 2022a). Nevertheless, chances are high that Germany's emissions will rise due to enforcing the gas replacement reserve.

2.3. Multiple stakeholder perspectives affecting carbon emissions in Germany

Organizations with different institutional backgrounds are implementing various measures to meet the challenge of CO2 neutrality in Germany by 2045 (United Nations 2015). However, these stakeholders have different perspectives and multiple approaches to reducing CO2 emissions and face other challenges. This thesis examines different perspectives through representative case studies to demonstrate the need for a unified and cross-level approach by all German stakeholders in dealing with CO2 emissions. Hence, this thesis will focus its analysis on the five stakeholder groups of scientific research, public actors, private enterprises, start-ups, and non-governmental organizations. As these stakeholders either count as the largest emitters of GHG emissions or are among the essential contributors to solving the challenge of climate change in the future, they got chosen. The role of these five actors in addressing GHG emissions is described in the following:

Firstly, 79% of Germans believe that the warnings about climate change issued by scientists and academic institutions are correct. This shows that scientific research organizations significantly impact raising awareness about climate change, and they can illustrate the pathway to a climate-friendly policy. Therefore, it is increasingly essential for scientific and academic research to find sustainable solutions to limit GHG emissions and combat climate change and to answer public questions to raise and keep awareness and initiative in society (Rosen 2021; Appunn 2021; Deutscher Ethikrat 2019).

Secondly, climate change is becoming politically increasingly important in Germany. Since the effects of human-caused climate change are now not only measurable but also tangible, young people in Germany and throughout the world have been protesting for increased climate protection. As a result, the German government and other public institutions are discussing climate change more and, above all, differently than before, recognizing the situation as drastic. Thus, 70% of Germans support stricter government regulations encouraging people to change their behavior. Accordingly, German public actors face significant challenges in meeting citizens' demands for climate protection and play a prominent role in meeting the German climate targets (Anzlinger n.d.; Riedl 2021; BMUV 2022a).

Thirdly, the German private sector is one of the country's largest emitters of GHG emissions. In addition, climate change entails economic risks for companies. But only about half of the DAX 30 companies disclose these risks publicly. According to that, many German companies are underestimating the challenges coming with climate change. Germany is one of the strongest economies in the world, but if large private companies fail to shift to more sustainable, zero-emissions operations, Germany's economy could suffer. To this end, private companies need to strive towards CO2 minimization to strengthen their position in the German and global economy and to increase their contribution to combating climate change in Germany (Clark 2022; Umwelt Bundesamt 2021a; Kielon 2020).

Fourthly, the start-up scene in Germany is growing steadily. The 'Global Entrepreneurship Monitor' report for Germany states that in 2021, the start-up rate in Germany increased by 2.1% to 6.9 %. In addition, the topic of sustainability has been a focus for young, innovative companies in Germany in recent years. Promoting ideas to prevent climate change is the primary motivator

for German companies, accounting for 38% of all start-up funding. Green start-ups are driving the transformation of the German economy with their tremendous capacity for innovation, and because of that, German green-tech start-ups are one of the future stakeholders for achieving Germany's climate targets (Raidl 2021; BMWK 2022b; 2022c).

Fifthly, climate action has been a top priority for the past few years on Germany's national agenda. Among the organizations driving this movement are social and non-profit organizations, which use a strong voice and actions to urge Germany to achieve its climate goals. Their role in the fight against GHG emissions mainly draws attention to unpleasant issues for society, politics, and business. However, many NGOs also issue recommendations and action plans to show a possible way to improve climate protection. Because of that, it is essential to take social organizations and NGOs into account when discussing climate actions (Osborne 2016; Sengupta 2020).

These five perspectives provide an overview of the stakeholders relevant to climate protection and their problem-solving approaches. However, it is essential to note that the categorization of stakeholders used does not claim to be exhaustive and focuses on organizations and the public sector, as they significantly influence national decisions. In brief, the five levels are a means to break down climate actions in Germany and are used as a tool to derive recommendations for action aiming at more efficient climate actions within and between the levels.

3. Methodology

3.1. Data Collection Methods

For the common part of the work, primary and secondary literature is used to collect data, which is then processed within the grounded theory (GT) approach. Secondary sources include, for example, websites, articles, journals, academic papers, and studies that relate or discuss the content of the original source.

In the individual parts of this thesis, a total of five different organizations are examined, and their strategy for achieving the climate goals in Germany is analyzed. For this purpose, both types, but mainly the primary literature of the organization itself, are used. This can be a published study, an article, or information from the organization's website or annual report. If needed and possible, semi-structured interviews are used to access additional qualitative information granting different organizational points of view and form a critical analysis with the interviewees. These findings create a case study for each of the selected organizations.

All these case studies are structured similarly to facilitate the later comparative analysis. After a brief introduction, the challenges addressed by the specific organization are first described. Next, their strategy, as well as the value proposition, will be explored in more detail. This is followed by the 'profundity of the problem-solving approach'-section. Here, it will be investigated to what extent the root causes of the addressed problem are being fought. More precisely, whether the organization's services or projects only address the symptoms caused by CO2 emissions or fight the actual cause is discussed. The next section,'Effectiveness of the applied strategy', evaluates the effectiveness of the organization's contribution to achieving carbon neutrality in Germany. It assesses the impact and extent to which the services, projects, or measures lead to a

reduction in CO2 emissions. In addition, the institution's handling of the resources and the partnerships and collaborations will be assessed in the 'Management of resources and collaborations' section. First, it will be analyzed whether the institution has the resources needed to reduce CO2 emissions and achieve its organizational objectives. Secondly, it is investigated which collaborations the organization has entered into to close possible capacity gaps or to benefit from synergies and whether there are dependencies on other organizations. From these, level-specific characteristics and key insights are identified from which CO2-reducing recommendations can be derived.

3.2. Grounded Theory Approach

This thesis will use some key elements of the Grounded Theory (GT) to carry out the case studies mentioned above and comparative analysis. The Grounded Theory is a social science approach originating from the Chicago School, which is used for collecting and evaluating qualitative data. It was developed in the 1960s by Anselm Straus and Barney Glaser. The GT is based on an inductive research technique because, unlike traditional approaches, it does not attempt to disprove or verify an existing hypothesis but instead uses insights from the collected data to develop new substantive theories. This approach consists of several steps and runs as follows: 'Open coding' is the first step of this method. The initial data is collected here. Examples of such data may include transcripts from interviews and other sources, such as documents, literature, observations, etc. This step breaks the collected files into specific parts (codes) that describe or classify the investigated topic. The next step is called 'axial coding'. Here, the researcher tries to find or establish connections between these codes. The codes are divided into categories and then linked to each other. These steps are repeated iteratively until the achievement of a theoretical saturation. This is

the case when additional iterations do not provide new insights on the topic. Finally, selective coding follows. In this process section, all categories are connected to a core category, which describes the central thesis or offers the basis for deriving a new theory on the investigated subject area. The application of comparative analysis (constant comparative method) is part of all the mentioned phases above. In open coding, the comparison of the collected data snippets helps in the creation of the 'codes.' These get compared and lead to the corresponding categories in the second step. In the last stage, the categories are compared to each other to identify the core category. GT is usually used to gain an understanding and insights into a complex topic or issue (Charmaz 2006, 42; Delve 2022; Glaser and Strauss 1967, 101; Miller 2015, 197).

As a result, the GT approach was chosen for this thesis as climate change is an entanglement that requires systemic change to be solved. Its high complexity arises from the urgency to get all stakeholders involved to engage and take action. The stakeholders in the system include private individuals, companies, NGOs, research institutions, and governments, among others. All these parties originally had different purposes, tasks, and capacities, which made this endeavor even more difficult. In addition, the data collection for this work is exclusively qualitative, which also supports this approach's application.

The gathering of data and its analysis will be performed in each individual part separately (Appendix 9). In the discussion part, all individually collected, coded, and categorized data will be compared with each other, but this time in the context of all perspectives considered. By performing multiple iterations at the individual level and executing a comparative analysis in the common part, the aim is to identify potential differences and similarities between the perspectives and to derive specific measures to improve their sustainability strategy or, more precisely, their contribution to

reducing CO2 emissions in Germany. It is important to emphasize that for the elaboration and analysis of data, the approach and key elements of the GT have been used in a way that they are compatible with the premises of this thesis. However, the GT was not applied to its full extent in each section of this thesis, but only in the individual part.

4. Case Study analysis of CO2 emission reduction measures in Germany– from a scientific perspective

4.1. Relevancy of scientific climate research in Germany and relevancy of chosen study

Several studies summarized by the Intergovernmental Panel on Climate Change (IPCC)-in a report in 2021 have shown that achieving net-zero CO2 emissions is crucial to stop the progressive effects of climate change. The report represents the current state of scientific climate research and states that without a drastic decrease in CO2 emissions, global surface temperatures will further increase and cause irreversible damage to the planet (IPCC 2021a).

The effects of climate change, which have already progressed to this day, are becoming more and more severe and above all, more visible and tangible. The consequences are broad and range from the physical impact to ecological aspects and socio-economic aspects. However, even before the consequences of global warming became evident, the findings of scientific research played a significant role in proving the existence of climate change in the first place. A few years ago, dramatic weather events and natural disasters were interpreted as expressions of natural forces, whereas today, it is known that they are part of the world's climate. Moreover, nowadays, it is proven that humanity is responsible for changes in the climate due to its excessive energy consumption, and humanity has accepted that it is necessary to change its behavior by signing climate treaties worldwide. This paradigm shift would not have been possible without the efforts and findings of scientific research (Weingart, Engels, and Pansegrau 2007, 41).

International climate research goes back to the 19th century when the French mathematician Joseph Fourier made the first hypotheses about the role of carbon dioxide in the atmosphere. In 1979 the first global climate conference was held in Genf after following the research of the World

Meteorological Organization (WMO) and United Nations Environment Program (UNEP). As a result of the conference, Germany set up their first national climate research program, but it took until 1984 to implement it fully, which leads to the conclusion that Germany considered climate change not as urgency at that time. Until the late 20th century, Germany was always a little behind with their research compared to the United States, but by the 1990s, German scientists caught up. This development is also reflected in the fact that in this decade, numerous German climate institutions have been founded, the number of climate researchers has grown steadily, and the number of publications regarding climate change increased fivefold in Germany between 1990 and 1995 (Weingart et al. 2007, 42). Today, climate research in Germany has grown even more and has taken a leading role in Europe (DWIH n.d.).

In Germany, the findings of scientific climate research have contributed to raising awareness of climate change among the public and, above all, politically. After the first national climate research program was implemented, German scientists and their institutions began to speak publicly about the threatening consequences of climate change. They started to urge the government to enforce more CO2-reducing politics by publishing alarming reports about an impending climate catastrophe. Hence, the start of a German climate policy can be traced back to the findings and warnings of those scientists. Furthermore, an analysis of the political discourse has shown that German research had more significant influence on politics in Germany than internationally renowned research. Besides being the initiator of German climate policies and plans, the findings of scientific climate research are still of great importance today, if not more than ever. Both the public and politics expect science to be able to provide reliable forecasts of future developments that can be used to legitimize political decisions and programs (Weingart et al. 2007, 45). Hence, it can be conclded that the actions, concepts and technologies to achieve carbon neutrality rely on the work and findings of scientific research organizations.

"We will only be able to meet the challenge of the climate crisis if […] we take science and its variously redeemed claims to exactitude, and its communication challenges seriously; if we defend what it can and should do about the climate crisis."

This statement of the German Ethics Council Chairman Peter Dabrock highlights the importance of taking science seriously in the climate debate (Deutscher Ethikrat 2019). Besides, research institutions play a large part in making the population understand the seriousness of the situation since almost 80% of the German society believes that the findings regarding climate change issued by scientists and academic institutions are correct (Appunn 2021). Multiple research organizations in Germany dedicate all or part of their work towards climate research and are impacting political decisions. But climate research, like almost all scientific research, relies on funding. In 2020, the German federation spent 1,373 Mio euro on climate research and 1,871 Mio euro on energy research (BMBF 2020).

In the course of this work, a study conducted by the Wuppertal Institute (WI) in 2020 will be illuminated in more detail to give insight into how scientific research can help Germany on its way to carbon neutrality and whether their targets are even feasible. The Wuppertal Institute for Climate, Energy, and Environment was founded in 1991 and is a non-profit limited company (gGmbh) that focuses its research on sustainability and its central challenges of development, such as climate change or the increasing scarcity of resources. The WI is mainly funded by the state of North Rhine Westphalia but relies on external funding as well (Wuppertal Institut n.d.). The study 'CO2-neutral by 2035: key elements of a German contribution to meeting the 1.5 °C limit' conducted by the WI was chosen for the analysis since it contributes to the political and societal discussion and reflects the current state of climate science in Germany. Different institutes have conducted several studies about the achievement of carbon neutrality in Germany, such as the Ariadne Report about Germany's way towards climate neutrality until 2045 or the McKinsey net-

zero Germany study. Those studies represent climate measures to achieve carbon neutrality in the most relevant sectors. Nevertheless, the study conducted by the WI has gained the most media attention to this date since it was commissioned and published by the movement Friday's for Future and aimed directly to influence the political discourse about climate change. The German president of the German Renewable Energy Federation, Dr. Simone Peter, pointed out the importance of taking the study's findings seriously to avoid the risk of crossing irreversible tipping points in the climate system (Treuer 2020).

Furthermore, the WI's influence in Germany can also be seen in its achievement of the ninth place in the 2020 'Global Go To Think Tank Index' Report in the Top Environment Policy Think Tanks issued by the University of Pennsylvania. 'The Think Tanks and Civil Societies Program (TTCSP) conducts research on the role policy institutes play in governments and civil societies around the world' (McGann 2021). The ranking highlights the importance and the potential influence that the WI has on political decisions and societal behavior. Because of the reasons listed above, the study by the WI was chosen as a representative study for climate research in Germany.

Through an analysis of the challenge of the study, the value proposition, the proposed strategy, followed by an analysis of the contribution of the WI toward carbon neutrality, the following work aims to derive recommendations for Germany on how scientific research can accelerate the achievement of the SDG 13 and carbon neutrality faster than the current pace.

Due to the scope of this work, only one study was analyzed, hence, the conclusions and drawings that derive from that analysis are limited. To give a holistic picture and more profound recommendations, more studies and scientific papers would have to be included. The selected study is supposed to serve as a representative for climate research in Germany. However, it has to be pointed out that one study cannot cover all the scientific research progress in Germany.

4.2. Challenge addressed, value proposition and strategic approach of the study: 'CO2-neutral by 2035: key elements of a German contribution to meeting the 1.5 °C limit'

Germany has committed itself under the Paris Agreement in 2015 to contribute to keeping global warming under 2 ° Celsius, below 1.5 °C compared to pre-industrial levels, to prevent more heatwaves, heavy rains, and other consequences of global warming in the future. According to calculations by the IPCC in 2018, to limit global warming to 1.5 °C, the world had only 580 Gt of CO2 left to emit, or else the goal would not be feasible. Counting from 2020, that leaves Germany with a leftover budget of 4.2 Gt CO2. Hence, emissions would have to fall particularly sharply in the next few years to stay within this budget (Wuppertal Institut 2020). In order to be able to achieve this, effective climate measures need to be taken by the German government. However, German climate politics are being sharply criticized and often considered as ineffective and not progressive enough (Deutscher Bundestag 2022; Fridays for Future 2020; Pritzl 2020, 701). Especially the climate strike movement Friday's for Future is demanding much stricter climate policies in Germany and increased political focus on the topic. For this reason, the movement commissioned the study to deliver ways of improvement to German climate politics. For instance, the research has shown that the achievement would call for Germany to be CO2neutral by 2035 and not later (Wuppertal Institut 2020).

The value proposition of the selected study is to deliver approaches to make the achievement of CO2 neutrality until 2035 in Germany feasible. It states that reaching this goal would be extremely challenging but possible. The work was conducted for Friday's for Future Germany with the financial support of the GLS bank and aims to contribute to the political discussion in Germany and provide building blocks for Germany's path to CO2 neutrality. It addresses issues for consideration of whether and how drastic changes in Germany's energy and economic system are possible within around 15 years. It focuses on the most significant national

GHG emitters and especially on CO2. The non-CO2 GHG emissions that occur predominantly in agriculture - mainly methane and nitrous oxide - are not explicitly considered. The study presents measures with which significant contributions to the desired objective of CO2 neutrality can be achieved. In addition, it discusses the obstacles that need to be overcome to achieve the implementation of CO2 neutrality. The study aims to guide Germany on how carbon neutrality can be feasible until 2035 regarding the most relevant sectors: energy, industry, transport, and buildings, leaving agriculture out. However, it does not develop a consistent scenario for the year 2035 nor propose a prioritization of individual options for action. Overall, the analyses in the study suggest that achieving CO2- neutrality by 2035 would be extremely demanding from a technical and economic point of view, but in principle, the target would be feasible. Nevertheless, achieving this target not only depends on the feasibility of economic and technological factors but also requires society's willingness to make massive changes in its behavior and thinking. Additionally, the political will to change processes with a consistent focus on implementing economic and technological changes, as well as other framework conditions such as increased international cooperation, are crucial for achieving Germany's carbon neutrality by 2035 (Wuppertal Institut 2020).

In order to deliver possible economic and technological approaches and cornerstones that are supposed to provide an impetus for further political discussion, the study analyzes the need for improvement and acceleration in four CO2-emitting sectors: energy, industry, transport, and building.

First and foremost, the energy sector plays a significant role towards Germany's carbon neutrality. The energy industry is one of the most significant GHG emitters in Germany and was responsible for around 30% of Germany's GHG emissions in 2020 (BMU 2021). In order to achieve carbon neutrality, a full shift to renewable energy would need to be completed by 2035.

For this shift to be possible, a significantly faster expansion of wind power and photovoltaics would be necessary compared to recent years. This, in turn, would require new and revised energy policies by the German government. For instance, an obligation to install and use photovoltaic systems not only in new construction but also in renovations or stronger participation of the municipalities in the revenue of onshore wind energy in order to accelerate their expansion. However, at least part of the German demand for carbon-neutral fuels probably needs to be imported from countries with good renewable energy conditions. To ensure sufficient availability and create the necessary conditions for such imports, cooperation with relevant countries have to be established at an early stage (Wuppertal Institut 2020).

For the industry sector, which is the second largest emitter in Germany, causing 24% of the total GHG budget in 2020, the shift towards carbon neutrality will be a particularly tough challenge, according to the study. It would require a fast substitute for fossil energies and chemicals by replacing fossil power plants through renewable energies, the electrification of heat and steam generation, and the replacement of fossil fuels in the chemical industry through closed-loop recycling and biogenic materials. Furthermore, the study highlights the importance of allowing only GHG-neutral solutions for new installations and investments. Additionally, the study proposes the expansion of a circular economy (definition see Appendix 10) in order to reduce the need for energy-intensive primary material production. Another suggested measure is to introduce a significantly higher price per ton of CO2 in order to advance the transformation towards climate-friendly technologies faster (Wuppertal Institut 2020).

The transport sector also plays a significant part in Germany's GHG emissions, with stagnant values in regard to its impact for the past 30 years and is responsible for about 20% of the country's total CO2 emissions in 2020 (BMU 2021). According to the study, several actions need to be taken in this sector to achieve the target. Firstly, transport and traffic have to be reduced in

general. This could be achieved by traffic-avoiding urban and regional planning as well as the promotion of virtual mobility (e.g. home office) and an increase in the cost of air traffic for instance. Furthermore, current motorized transport must be shifted towards more climate-friendly solutions, and car traffic has to be made less attractive (Wuppertal Institut 2020).

Even though the GHG emissions within the building sector sunk by nearly 40% between 1990 and 2014, since then, there has not been a further downward trend, and the sector can still be made accountable for about 16% of Germany's total GHG emissions (BMU 2021; Wuppertal Institut 2020). In order to achieve carbon neutrality, a significant reduction in the heat demand, as well as a rapid and comprehensive switch to heating technologies based on renewable energy, is necessary, according to the study. To achieve this, the energetic renovation rate would need to be increased. Currently, only 1% of the building stock is renovated by implementing heating systems that rely on renewable energies. This number would have to increase to at least 4%. For the building sector, achieving GHG neutrality requires a policy mix of incentives, regulations, and information (Wuppertal Institut 2020).

The study shows that there are opportunities in all four relevant sectors to achieve the transformation toward carbon neutrality faster than the federal government's current pace. The central aspect of the study is that the current and planned measures that are taken toward carbon neutrality need to be accelerated and implemented much faster than they are right now by the German government. However, there are many barriers when it comes to implementing each one of them. The presented approaches and suggestions are more of a best-case scenario rather than a coherent strategy to follow through.

4.3. Analysis of the Wuppertal Institute's contribution towards carbon dioxide neutrality

4.3.1. Profundity of the problem-solving approach

In the following, an analysis of the problem-solving approach and the capacity management in regard to the proposed measures of the study will be carried out. Firstly, the problem-solving approach will be examined, looking at whether the strategic approaches address the root causes of the problem and focus on the real problem rather than fighting the symptom. According to the study, the central aspect is accelerating current climate actions, particularly the switch to a climate-friendly energy system in Germany to make the achievement of carbon neutrality in 2035 possible. The switch from current fossil fuels and nuclear energy to renewable energies would in fact, tackle the leading cause of CO2 emissions and present a solution to the biggest obstacle in the climate policy in Germany. The need to accelerate the current efforts that are carried out by the German government so far in order to achieve their targets in the climate policy is also an important finding that evolved from a study by the Fraunhofer Institute on Germany's way toward a climate-neutral energy system from 2021 (Fraunhofer ISE 2021). But the WI's study also lists measures in the other three sectors that are trying to fight the root causes of GHG emissions. Building up a circular economy or supplementing environmentally harming chemicals through climate-neutral ones would be examples of the industrial sector. In the transport sector, the reduction of traffic and the switch to climate-friendly vehicles would be another. And in the building sector, the renovation towards more efficient and less heat-demanding buildings would solve the problem as well. Still, some measures are proposed that fight the symptoms of GHG emissions rather than impacting the root causes. Increasing the prices of CO2, for instance, would only help reduce some emissions, but does not solve the problem itself. But altogether, it could be argued that there are many

problem-solving approaches to the study, and it does aim to fight the root causes of CO2 emissions and not only the symptoms.

4.3.2. Effectiveness of the proposed strategic approaches

As mentioned above, the study by the WI does not deliver a coherent strategy that can be adapted by the German federal government but rather shows ways for improvement. Additional measures or barriers to overcome are supposed to serve as guidelines and inspiration for political discourse in order to be included in the climate policy. The implementation of all the proposed measures in the study could be a very effective solution strategy in becoming carbon neutral by 2035, but this is a best-case scenario from a scientific point of view. There are many barriers that make the implementation of all the measures almost impossible, for instance, the lack of financial resources. In order to achieve carbon neutrality by 2035, a massive structural change would need to happen.

Firstly, all of the measures listed in the study require a political will to shape the future of Germany's energy consumption and a consistent focus on its implementation. The German government would have to pass several new laws to make renewable energy use mandatory for all sectors. The expansion of renewable energies, such as photovoltaic and wind energy, would have to be pushed and supported significantly more than today (Wuppertal Institut 2020). The fact that there is a lot of room for improvement by the German government, even two years after the study was conducted, can be taken from a special report by the German Federal Court of Auditors that sharply criticized German climate policy in March 2022. According to the ruling, the German government should ensure that future climate protection programs only contain measures that `demonstrably and economically´ contribute to reducing GHG. With regard to the existing programs, the auditors criticized, the lack of specifications for almost all climate protection measures adopted since 2015 as to how much GHG they are intended to save. Secondly, the court

criticized that only a few of the projects included in the climate protection programs to date actually led to savings (Deutscher Bundestag 2022). This highlights the need for new and effective climate measures that need to be taken according to the study.

Secondly, the implementation would require not only a political focus but also heavy investments. According to the study by the Frauenhofer Institute, the shift towards a climate-neutral energy system would amount to between 440 and 2,330 billion euros. However, taking into consideration possible environmental costs that result from the progressing climate change, the investment sum would be significantly reduced (Fraunhofer ISE 2021). Still, the investment that needs to be made would be immense, and once again, a political will would need to be present to take those. Thirdly, German companies would need to be willing to participate in the structural change. They would have to transform towards renewable energies and use climate-friendly resources only to make carbon neutrality happen.

Lastly and most importantly, changes in the thinking and behavior of Germany's society are crucial for the proposed measures to work. A change in values would need to happen that has the effect of more awareness of the consequences and causes of climate change. On the one hand, society should be made even more aware in order for them to reduce their energy consumption in general. Secondly, for new climate-friendly technologies to be implemented and, more importantly, to be effective, greater acceptance and willingness to adapt to changes would need to be present. This would result in a significantly lower amount of technical equipment for conversion, storage, distribution and use of renewable energies (Wuppertal Institut 2020). To sum it up, the study provides suitable and effective approaches to achieve climate neutrality in Germany, but this can only happen if all parties involved participate.

4.3.3. Management of resources and collaborations

The third part of the analysis focuses on the capacity and collaborations of the study. It will be examined whether the WI has the capacity to influence the problem-solving by itself, where capacities are lacking and what role other stakeholders have played in the development and possible execution of the study. Firstly, scientific research usually relies on funding to perform its examinations. Third-party funds and essential funding from the state of North Rhine-Westphalia finance the WI (Wuppertal Institut n.d.). But to conduct extensive studies such as the analyzed one, it relies on additional funding. Most of the institutes studys are therefore commissioned by a third party and thereby financially supported. For example, in the case of the carbon neutrality study, the socio-ecological bank GLS Bank financially supported the work. It can be assumed that without the state's and other sponsors's financial support, well-founded climate research with recommendations for actions would not be possible.

Furthermore, collaboration or consultation with other scientific research specialists and institutes is of great importance for a result-generating study. In the case of the carbon neutrality study, the WI has drawn many conclusions and recommendations from the work of the Fraunhofer ISE on Germany's energy transition. But besides the financial support and the insights of other climate research to get the study conducted in the first place, it is vital to get an audience for the findings and the proposed measures so that there is a chance of actual implementation in the climate policy. The carbon neutrality study was commissioned by the climate strike movement Friday's for Future Germany with the purpose of contributing to the discussion about climate actions in Germany. The global youth-led climate movement that started in August 2018 demands better and tougher climate policies worldwide. The German branch of the movement openly criticizes the past climate policy and the measures of the federal government in Germany. According to their website, 26,000 scientists agree with their standing that the current climate actions are not sufficient to

achieve climate neutrality in the near future. In order to give more basis to their demands and to be able to propose concrete measures for improvement, they commissioned the study (Fridays for Future 2020). For the study to affect climate policies, it needs to be spread out to a broad audience, and the main aspects need to be understood by the public and politics. The Friday's for Future movement can serve as a good channel for this matter since the movement so far counts more than 5,000,000 people that went on the streets to support its demands (Fridays for Future 2020). In addition, studies have proven that the movement in fact, influenced German climate policies (Andres et al. 2022). Even though the government is not taking over all the proposed measures so far, at least they adjusted the original target to reach carbon neutrality from 2050 to 2045. In conclusion, the study alone does not have the capacity to have an impact on the desired recipients. Only if the study gets enough attention from the public and the pressure on politics increases, it can have the power to influence climate politics.

4.4. Key insights and recommendations to accelerate the achievement of climate neutrality

The study conducted by the WI has shown that the German federal government's targets are inadequate for meeting the 1.5 °C goal. To be able to still meet this goal, Germany would have to reach carbon neutrality by 2035 and not later. Hence, the transformation of the energy- and industry system must happen at a much faster pace and the measures have to be accelerated. This would require a political will to implement more climate actions and measures as well as accelerate existing ones. Furthermore, the industry would need to be willing to join the transformation and become carbon-neutral by switching to renewable energies, implementing a circular economy, and through increased innovation dynamics. Overall, the analysis in the study suggests that achieving CO2 neutrality by 2035 would be highly challenging from a technical and economic perspective

but still possible. However, in addition to the technical and economic challenges of a transformation toward CO2 neutrality, key challenges also exist in institutional and cultural terms. The public has to be made more aware of the causes and consequences of climate change. Behavioral changes in large parts of society in the sense of economical use of energy could have a significant effect on the transformation of the energy system and substantially reduce costs (Fraunhofer ISE 2021). Hence, even if a drastic acceleration of the energy transition happens and the proposed measures are taken, the desired effects cannot be achieved without participation and a change in society. And on the other hand, the structural changes that need to be made in the German system should be carefully reflected before being implemented. This is because an unreflective implementation of such a transformation could be accompanied by worsening social inequalities and disadvantages for individual social groups. (Wuppertal Institut 2020).

Deriving from the key insights of the conducted study, the following recommendations from the scientific perspective are given to accelerate the achievement of carbon neutrality in Germany.

Firstly, the proposed measures or technologies that are presented by scientific research would have to be implemented in German climate policies to have an effect. This could be achieved by the government working closer together with scientific research institutes, by commissioning tailored studies and setting the focus on their implementation from the beginning. However, even though scientific knowledge is an important resource for political demands for more ambitious climate policy, if politics and science are too closely intertwined, there is a risk that science will become politicized and thus is at risk of losing credibility in the long term (Schenuit 2021). Therefore, keeping scientific climate research unbiased is important, whilst increasing the collaboration between politics and science. Another way to strengthen the political will to implement the proposed measures could be by the public demand. Hence, secondly, the public needs to be made more aware and educated about the consequences of climate change. It is

important that organizations or movements such as Friday's for Future speak publicly about those findings and raise awareness for climate actions. Only then society's pressure on politics can increase to such an extent that politics are forced to act (Unger and Oppold 2021).

Additionally, since climate research institutes rely on funding, collaborations with other stakeholders are essential for their work. In order to further expand and improve current knowledge and measures to achieve climate neutrality by 2045, public and private funding for climate science would need to be increased. A possible way to increase funding was presented at the climate conference COP27 in Egypt. It suggests skimming ten percent of the profits of oil and gas corporations and investing it in climate protection (Mihatsch 2022).

Overall, the discussion and the social and political debate for the right solutions and approaches that derive from scientific research findings are necessary to achieve the goal of GHG neutrality and contribute to the achievement of SDG 13. Moreover, they must be conducted with the greatest possible transparency and honesty across the entire society. As a basis for this, further investigations, concepts and studies are needed, such as the analyzed one by the WI. Therefore, it is of great importance that the federal government as well as private enterprises, entrepreneurs, or social organizations, work together with research institutes. The commitment and efforts of those institutions are vital to finding the adequate measures that need to be implemented by the federal government to reach climate neutrality, as well as to find innovative technologies that make the transformation to a GHG neutral energy- and industry system possible.

5. Comparative analysis of different approaches to carbon neutrality in Germany

5.1. Analysis of the profundity of the problem-solving approach from different perspectives

The following chapter compares the profundity of the previously described problem-solving approaches from different perspectives and their contribution to achieving climate neutrality in Germany.

Firstly, the purpose of institutions on the five different levels is compared. The three levels of scientific research, public and environmental NGOs (ENGO) have in common that they do not work profit-oriented but create a positive environmental contribution. The Wuppertal Institute (WI) and scientific research, in general, aim to develop new theories and publish scientific knowledge. With its study, the WI contributes to the political and social discussion on how Germany can better implement the path to CO2 neutrality (Wuppertal Institut 2020). On the other hand, the public sector aims to serve society and the economy by creating framework conditions. By implementing laws and regulations, the public sector tries to protect the different levels from overwhelming threats like the climate crisis (BMUV n.d.; Jones 2022). ENGOs aim to protect the environment through their work and provide a communication bridge between society, politics, and other organizations (Born, Burghaus, and Ellmann 2021). In contrast, companies and start-ups primarily aim to generate revenues through their core business and are profit-oriented (MAN 2022). However, many start-ups from the green-tech sector pursue both purpose and profit goals. The example of Planetly illustrates that they follow the overarching purpose of reducing CO2 emissions while generating revenues simultaneously (Raidl, Rauffmann, and Stiens 2021).

One of the case study analysis findings is that all levels must also take voluntary responsibility for continuing to work towards a climate-neutral future. The public sector, private companies, and start-ups are partly guided in their climate actions by the German Climate Action Plan. But scientific research and ENGOs have more freedom in designing their climate actions since German climate regulations mostly do not apply to NGOs and academia. However, guidelines that apply to the economy often do not cover all types of private organizations. For example, only companies with an annual turnover of at least 40 million euros or more than 250 employees will be obliged to disclose their sustainability information from 2024 onwards (European Parliament 2022). Companies that do not fulfill these criteria, such as start-ups, are under current and planned law not required to report their emissions and, thus, have less motivation to reduce them.

Additionally, for institutions and organizations at all levels, it is necessary to adjust their climate targets to the superior German Climate Action plan, which outlines a roadmap to achieve climate neutrality by 2045. The calculations conducted by the IPCC have revealed that from 2020 on, Germany only has a budget of 4.2 Gt of GHG emissions left to keep global warming beneath 1.5 °C. However, the WI study shows that the German government's current targets are insufficient. Germany will only stick to the targets if it has already reached the climate neutrality goal by 2035 (Wuppertal Institut 2020). These targets show that treating the root causes of CO2 emissions must be accelerated and adapted at all levels. Nonetheless, the targets of the public sector and the three other levels differ from WI's. The public set their target in the 'Climate Protection Law' to achieve neutrality by 2045 (Stolten et al. 2022). At the private company level, most pursue the same goal. A survey by Microsoft Germany found that 82% of German companies want to be climate neutral by 2045, and 53% use technology already to make their supply chain more sustainable (Chambers 2022). Even for NGOs, the Paris Agreement serves as a guideline. In

addition, some NGOs like Atmosfair have their targets, which include developing e-kerosene to make air travel more sustainable (Atmosfair 2022a). In conclusion, it becomes clear that while there are targets at all levels, they are not uniform.

To fight the root causes of CO2 emissions and climate change, Germany set a long-term goal to become climate neutral by 2045. More specifically, this means that GHG emissions are reduced by 80-95% compared to 1990, and only the remaining percentage of emissions gets offset (BMUB 2016). To achieve this goal, stakeholders on different levels must focus on fighting root causes by committing to CO2 reductions instead of compensating for them. While the public sector and scientific research mainly provide framework conditions, guidelines, and recommendations for climate neutrality, private companies, start-ups, and NGOs are more focused on implementing required changes in the economy and society. Nevertheless, scientific research can and does contribute to German climate goals by proposing measures that enable the transition to climate neutrality. For example, research suggests switching entirely to renewable energy (Wuppertal Institut 2020). As recommended by the WI, a complete switch to renewable energy is the most sustainable solution, and the analysis of this thesis shows such a switch could address the root causes of excessive emissions. In addition, the public sector can contribute to fighting the root causes of CO2 by introducing plans and guidelines that force other stakeholders to take reduction measures. In comparison, many private companies mainly concentrate on fighting symptoms of CO2 because their traditional business models are often not built on recent climate targets. Therefore, these companies compensate for their CO2 emissions by fighting symptoms, such as the CCUS technology by MAN. Accordingly, many private companies must revise their business models to become net-zero. Moreover, start-ups, such as Planetly, have developed business models to enable a net-zero economy by focusing on CO2 reduction, complemented by an offsetting

service. Also, ENGOs, such as Atmosfair, was recently founded to focus on root causes and fighting symptoms by preventing, reducing, and offsetting CO2 with their services (Atmosfair 2022b).

5.2. Analysis of the effectiveness of the applied strategy

This section discusses various aspects that influence the effectiveness of the solution approaches of the different levels to achieve climate goals and carbon neutrality in Germany. The discussion aims to identify differences and similarities between the levels mentioned above.

Firstly, the extent to which voluntary support from politics, society, and other organizations is needed to increase the effectiveness of the solution offered by the respective level is examined. Then, the influence of other factors, such as compliance with standards and the ability to scale and measure impact, will be evaluated. Finally, the funding of the organizations also plays a significant role in influencing the effectiveness of the problem-solving approaches. However, this aspect will be explored in the next section, namely the analysis of capacity and collaboration.

Politics create the framework conditions for all players operating in Germany. Hence, it significantly influences the design and effectiveness of the various solutions. In addition to providing capital and resources to start-ups and ENGOs, it can also subsidize certain technologies that lead to more GHG savings or reductions. An example of this is the carbon capture industry. Its effectiveness depends to a large extent on its transport and storage potential, as could be seen in the MAN case study. In this sector are still many logistical and legal obstacles, high costs, and at the same time, too little support and incentives for urgently needed investments by the government. However, policymakers are also responsible for implementing measures developed by scientific research. Therefore, legislation is the duty of politics, and it can strongly influence the pace of implementation. The WI case study has shown that a political will is crucial for

implementing the measures (Wuppertal Institut 2020). The stronger the will, the stronger and faster could the achievement of the German climate targets take place. In addition, the selection of implemented measures is also of great significance. Up to now, the measures have mainly been aimed at optimizing the energy sector in a climate-friendly way, but this sector only accounts for about one-third of Germany's CO2 emissions (Tiseo 2022b).

Implementing all climate protection projects without overcoming specific challenges is impossible. In some cases, laws and regulations make implementation more complex, leading to a reduction in effectiveness. This does affect not only the private sector or NGOs but also municipalities that want to implement their projects as their competence and decision are limited by laws (Paar et al. 2022a; 2022b). Next to the German government, other bodies issue regulations relevant to climate protection projects. In addition, many new laws have been added with the introduction of the Paris Agreement of the UN, especially concerning the issuance of environmental certificates, and, as already described in the Atmosfair case, facilitate a double counting of saved emissions. This has far-reaching consequences for organizations operating in this sector and can lead to reduced effectiveness.

With society’s help, effectiveness can also be increased in some sectors. NGOs often rely on the support of volunteers such as students due to their high dependence on external funding and scarce resources. In addition, NGOs pursue many campaigns to raise awareness in society, which only have an impact if a large proportion of society’s members voluntarily decide to change their lifestyle. In general, many environmental protection measures only develop their full potential when implemented by as many individuals and private households as possible. A collective change in German society’s thinking and behavior must happen to successfully implement most of the measures identified by scientific research (Wuppertal Institut 2020). This is why it is crucial to

sensitize society to climate challenges. Some German municipalities go one step further and actively involve their residents in shaping the local climate protection strategy. As a result, such projects gain more approval, and there are fewer backlashes (Hansel et al. 2017; Hemmati and Schmidt 2020). If awareness rises in German society, political changes can also be observed because as soon as climate protection gains importance among the majority of the population, climate-protecting parties will likely also gain ground in their polls and strengthen their position. This, in turn, could lead to more climate protection measures and laws being passed. All these points illustrate how important it is to raise awareness in society to get people to participate in climate protection actively.

In addition to politics and society, organizations such as NGOs, private companies, scientific or public institutions can also provide voluntary support. Although the German state determines the amount and period of CO2 emissions of private companies with its laws and rules, there is a social market economy in Germany (Erhard 2016). Therefore, the state does not want to interfere too much with competition. Switching to environmentally friendly production processes usually requires high expenditures and could therefore lead to a competitive disadvantage, which could have serious consequences, especially in an international context. It is therefore important that companies take the initiative voluntarily and do even more to protect the climate than is required by law. This is especially true for established companies in the private sector, which often have the necessary resources and liquid funds. Younger companies rarely have the resources to do this. Therefore, they can use the help of other organizations. However, the topic of collaboration between organizations and the exchange of resources will be addressed in detail later in this thesis.

The scaling potential is another factor that can influence the achievement of the climate targets. Due to the non-achievement of the German climate targets in 2021 and 2022, scaling of

the planned measures by the government is urgently needed, as otherwise, it is unlikely to achieve climate neutrality by 2045 (Stober 2022). To accomplish climate neutrality, however, it would also be advantageous if private companies, as well as social or academic institutions, would scale up their problem-solving approaches to achieving the German climate targets. NGOs in this area are also interested in generating as much impact as possible, but they primarily depend on external donations, severely limiting the potential for scaling. In addition, for NGOs, it is often more important to make decisions about projects and the organization's strategy and to maintain their independence than to accept money from anyone willing to donate. Atmosfair states in its report from 2021, for instance, that it only accepts donations if the donor's values match the organization's values (Born, Burghaus, and Ellmann 2021). On the other hand, young start-ups receive funding from investors who usually demand interest or shares in the company for this service. Similarly, they even aim for a decisive growth phase in which the company seeks to bring its services to as many customers as possible (Adhanan 2022). Since the private sector in Germany is in the social market economy system and thus exposed to competition, it can be assumed that patents and technologies are less likely to be shared voluntarily between companies. After all, these could bring important competitive advantages and thus contribute to maximizing profits. This limits the scaling potential.

Compliance with standards dramatically impacts the solution's effectiveness, especially with ENGOs and start-ups that issue certificates for saved CO2 emissions. The purchasers of the certificates usually want to have them officially credited. Otherwise, they would not be able to use them for official offsetting purposes. The certificates are generally only accepted by society and the government if the certifications have been carried out according to recognized standards. NGOs like Atmosfair and start-ups like Planetly that are active in this sector use, for example, the

certification standards of the UN, the Gold Standard, or the GHG Protocols (Born, Burghaus, and Ellmann 2021; Planetly 2022). Both start-ups and NGOs usually aim to make their brand better known and thereby introduce their standards through certification systems. After all, if the brand itself gains recognition and is considered trustworthy by society, this can have a similar effect. Planetly itself tries to accomplish this because companies that fulfill the seal policy of Planetly receive the status of a carbon-conscious or carbon-neutral company from them. These companies can then use this seal to show their customers which climate goals they pursue and the values with whom they can identify. Established companies usually already have a reputation and trust among customers and society. Compliance with standards is also indispensable for such companies. Still, they probably play a much more critical role for start-ups and small to medium-sized NGOs, as their brand recognition is lower.

The ability to measure the impact of the projects and activities carried out is of great importance and can, under certain circumstances, improve effectiveness. Especially for social organizations, it is essential to show their donors which achievements have been made with their financial support. This allows them to retain their current donors and clients and attract new ones. For other organizations, such as start-ups and established companies, measuring the impact of their climate protection projects is also indispensable, as there is now a strong dependency between a business's financial and social performance. Furthermore, measuring impact can create systemic and sustainable change, but it can also enhance an organization's value creation. It also increases the trustworthiness of an organization and is therefore of great importance, especially for young companies and social organizations (GBM 2020). Institutions and businesses whose business model is focused mainly on social aspects such as climate protection often use official and reputable partners such as TÜV to confirm their organization's impact. In general, the effects of

climate protection projects that either compensate, reduce, or capture CO2 can be measured well and accurately with the help of such partners, as seen in Planetly and Atmosfair. It is more complicated with campaigns or projects that raise awareness of CO2 emissions, as is often the case with NGOs. But even these can be measured with the help of surveys and other awareness metrics (Weiner n.d.).

5.3. Analysis of resources and collaborations required for the different perspectives

In the following section, the capacities of the different perspectives will be compared, looking at the resources they supposedly already have and, on the other hand, resources that they are often lacking and hence call for collaborations in order to accelerate the achievement of climate targets in Germany. Three main aspects derived from the analyses are financial-, human-, and technical resources. Furthermore, a need for revised laws and legislation was a result. Lastly, it will be looked at the credibility and the targeted stakeholders of the scientific, the public, the private company, the NGO, and the start-up perspective.

Firstly, the analyses for the five selected perspectives have all revealed that financial resources play a central role in achieving carbon neutrality and hence in reaching climate neutrality. Based on the findings of the analyses, it can be assumed that in particular scientific research, NGOs and start-ups are relying on investments and/or funding to contribute to climate neutrality. At the same time, there is potential for public and private enterprises to invest their financial resources in climate actions. Scientific research and NGOs are arguably the most dependent stakeholders regarding funding since they are primarily non-profit-focused. Scientific research institutions like the WI, in particular, depend on external financial support since they cannot carry out their work without external funding. In the case of the WI, it is supported by the state and independent financiers. Therefore, it can be argued that the continuous efforts of scientific climate research that

are essential to delivering appropriate measures and new technologies to achieve carbon neutrality can only be guaranteed if external stakeholders provide financial resources. The case of NGOs differs a little from scientific research. Even though NGOs are often non-profit, they might generate revenue compared to most research institutions and can therefore finance at least part of their work by themselves. But like Atmosfair, the organizations are still often dependent on individual external donations, the support of private companies, governmental funds, or charitable foundations in addition to their revenues (Folger 2022). Even though Atmosfair has managed to be financially independent of public donors, they still rely on other external donations. Hence, it can be concluded that for NGOs that have set it as their goal to combat climate change and contribute to SDG 13, it is essential that private investors and companies, as well as individuals and the government, provide financial resources to secure the contribution of NGOs towards carbon neutrality in Germany. In comparison to NGOs and research institutions, start-ups are mostly profit-focused. But the analysis of the selected start-up Planetly has shown much potential for contributing to achieving SDG 13 in the green-tech sector. It could be even more successful if government funding were increased. According to the German Energy Agency, about 22.7 billion euros would have to be provided annually for green-tech start-ups to achieve the German climate goals (Deutsche Energieagentur 2021). Overall the analyses have shown that large investments would be needed to achieve Germany's climate goals feasible. In addition to funding climate research and the support of NGOs and green-tech start-ups, the transition to a climate-neutral renewable energy system would require investments between 440 and 2,230 billion euros. According to the Fraunhofer Institute (Fraunhofer ISE 2021), investments as high as five trillion euros would have to be made to achieve climate neutrality in general in Germany. Meeting the large total investment requirements for a climate-neutral Germany by 2045 would require private and public capital. For the challenge to

succeed, public investment funds must be targeted, and private investment must be mobilized since the financial resources lie within those two sectors (KFW 2021).

Secondly, human resources play a significant part in all five different perspectives. The analyses have revealed that the know-how within the five levels and the lack of personnel are relevant factors to be considered. Regarding the know-how within the level, a high degree of profound knowledge for accelerating carbon neutrality in Germany is the strength of scientific research. Still, it can also be found within private companies, the green-tech start-up community, and NGOs. Since climate research is committing all its efforts towards accelerating the climate targets and the analyses have shown that it influences political discussion, it can be concluded that know-how is a vital skill of this level. Looking at the know-how of private companies regarding climate actions, the case study by MAN has shown that there can be a high-level knowledge within the company by investing in R&D departments and projects that dedicate their efforts towards developing innovative technologies or concepts to combat climate change. But it has to be mentioned that this, once again, is strongly connected to financial resources and often also the size of a company. Hence, it is difficult to conclude from MAN to the whole landscape of private companies in Germany. Many private enterprises are heavily dependent on external knowledge and technologies since they do not have the capacities to research climate-friendly technologies or concepts on their own. On the other hand, many business models in the green-tech industry excel through innovative technologies and can contribute to combating climate change in Germany. Additionally, NGOs often have specific knowledge at their disposal through qualified personnel and experts. But a way for the three levels to effectively put their knowledge to use is by collaborating with one another since there are often gaps within one organization or business that can be closed by another. For the public sector, in contrast, it can be argued that it is more dependent

on external knowledge, like the findings conducted by climate researchers or experts, to adapt or improve their climate action policies. Especially in energy, buildings, and infrastructure, the government needs efficient solutions based on profound research and proven to be effective (BMUV 2022b).

The second aspect in the human resources field that has been derived from the analyses is a lack of personnel that would need to be overcome to achieve German climate targets. This factor is especially relevant for the public sector and is also linked with knowledge since the public sector requires more qualified personnel to implement more efficient climate measures (Paar et al. 2022a; Rösler 2019, 6). Therefore, a problem that NGOs often must deal with is a lack of personnel. In this case, the lack of personnel is once again linked to financial resources since the number of donations or funding is directly related to the amount of paid staff an NGO can hire. Hence, a lack of financial resources leads to a shortage of staff. However, NGOs often also hire voluntary workers for projects, but it can be assumed that there are usually not enough volunteers to cover an NGO's projects. To sum it up, the transition towards climate neutrality in Germany requires educated and skilled personnel currently lacking in the public sector, as well as NGOs and the private sector. This may not be a very concerning problem for large companies like MAN. Still, the switch to renewable energies would, for instance, require many new installers for heating systems, electricians, and energy consultants (Oldeland 2022).

Thirdly, technical resources like machinery and technologies have proven to be essential factors in Germany’s way toward climate neutrality. This aspect is mostly regarding private companies and green-tech start-ups. However, it has to be mentioned that this is also related to the know-how of an organization and financial resources. The selected case study of MAN has shown that there is great potential in larger companies with the financial and human resources to put in

R&D and hence can innovate technologies and positively impact GHG emissions. They can develop and establish technical resources that are very important for climate neutrality with their existing resources. On the contrary, financial and human resources are often not given to start-ups, and they have to get investments first to develop and establish their innovations, technologies, and machinery. Once they have achieved this, they also have promising potential with technologies like the Planetly software and green hardware to achieve the climate targets in Germany. Furthermore, scientific research can contribute to the process of developing such innovative technologies by joining forces with private companies, start-ups, NGOs, or all together.

Another aspect that has proven to be crucial for the different levels, according to the analyses, is that revised laws and legislation would have to be set up by the German government to help the levels accelerate their efforts. This is especially important for start-ups, NGOs, private companies, and the public sector. As already described above, the government has the capacity to change, adapt or introduce laws and legislation that can pave the way for innovative business models, technologies, or approaches that can help Germany achieve its climate targets.

Lastly, another relevant factor was the credibility of the organizations, businesses, or institutions in connection with the target group. Scientific research and NGOs depend on their credibility and must reach the right audience. For science, reaching the right audience is of great importance to ensure that the findings can impact politics and behaviors and NGOs because they depend on external support and funding to run their projects. On the other hand, a factor that the public sector sometimes must deal with is a lack of credibility. They depend on public participation in their measures and the acceptance of their decision-making. This is another reason the government relies on scientific research to justify its measurements.

6. Recommended strategic actions for all levels regarding the achievement of climate neutrality

6.1. Recommendations based on the profundity of the problem-solving approach

For Germany to achieve its climate goals and climate neutrality by 2045 even more effectively, systemic change is required as strategic, multi-stakeholder approaches must come together across systems. On each level, the discussion suggests that underlying root causes must be addressed effectively while collaborative capacities must be strengthened (Catalyst 2030 2021). In this context, the analysis and discussion carried out previously give rise to various points based on which realistic proposals for action and recommendations can be made. The first part relates to the gaps identified in the discussion based on the profundity of the problem-solving approach.

The analysis shows that many organizations in the economic and public sectors are not fulfilling their responsibility to reduce CO2 and have not yet presented and implemented concrete strategies (Day et al. 2022). In this regard, it is up to the overarching federal government to redistribute responsibilities between the states and local municipalities and provide financial and personnel support. In the process, organizational structures must also be revolutionized, and, for example, new partially independent climate departments must be created that deal specifically with climate protection (Read 2020). Moreover, the climate problem is not only a German problem. Because of Germany's European influence, EU-wide regulations and laws must be adopted that aim at a united fight against climate change (BMWK 2022a). Furthermore, the private sector often hinders stricter CO2 measures through increased lobbying. This naturally puts the government in a dilemma since, on the one hand, it wants to maintain the industry's strength. Still, on the other hand, it will not succeed in achieving the climate targets without a change in large corporations, especially in the automotive and energy sectors. Accordingly, the government must rethink the

existing decision-making processes to reduce the decision-making influence of large corporations (Cann and Katzemich 2020).

Secondly, the analysis of the case studies reveals that CO2 reduction must be accelerated at all levels. Still, specific targets of the public sector, NGOs, start-ups, and corporations often differ from those recommended by scientific research institutions. While most companies and organizations at all levels have their specific climate targets, it becomes clear that these goals lack uniformity. To accelerate the achievement of climate neutrality by 2045, according to the European Comission (n.d.), the economy and society must realign their CO2 targets and measures according to the newest climate targets recommended by scientific research. Additionally, all organizations must adapt their strategies and operations according to these adjusted climate targets.

Furthermore, to support climate neutrality, companies can reduce their CO2 and offset remaining emissions that cannot be decreased. However, to reach the German climate targets and fight the root cause of GHG emissions, all levels must focus on CO2 reduction instead of offsetting. Offsetting should only serve as a backup solution for emissions that cannot yet be reduced, for example, due to lacking innovations and technologies in production processes. The long-term goal of each organization and institution must be to become net-zero, which means that emissions across the whole value chain must be reduced by 90-95% compared to the base year. Only the remaining 5-10% of CO2 emissions should be offset. Specifically, the Corporate net-zero Standard of the SBTi encourages companies worldwide to halve emissions before 2030 and achieve net-zero emissions before 2050. Good practice elements for high-integrity voluntary compensation include prioritization of own mitigation action, robust quantification of carbon footprints, use of high-quality carbon credits, avoidance of double counting, transparent and accurate reporting, and clear and truthful claims and marketing (Science Based Target Initiative 2022).

6.2. Recommendations based on the effectiveness of the applied strategies

Further recommendations for action can be concluded in the area of the effectiveness of the strategies applied. These mainly refer to suggestions that the public sector and, above all, politics can undertake to revolutionize public and economic life and system to achieve German climate neutrality by 2045. However, it also requires the initiative and cooperation of other stakeholders.

Foremost, there are insufficient incentives or support to encourage the free market to adjust its CO2 reduction goals and a lack of political will to adopt stricter CO2 regulations. To create a particular motivation and pressure for better CO2-saving measures at the private, entrepreneurial and nongovernmental levels, it is up to the higher government to build a framework with new regulations and laws (Wuppertal Institut 2020; Tiseo 2022a). According to this, it is crucial that the government declares and legally establishes an existential state of emergency, which sets the issue of climate protection as a priority and, on this basis, gives it the authority to take new, more effective measures (WiWo 2019; Climate Alliance n.d.). Building on this, existing laws and regulations need to be revised, and Germany's Climate Action Plan needs to be adapted to reduce the hurdles that companies face. This could be done through environmental taxes and tax reductions for emission-friendly business practices. Tax incentives suggest that the government compromises tax revenues to encourage fewer polluting investments and consumption to realize ecological policy objectives and thereby manage positive externalities (Köppl and Schratzenstaller 2021).

In addition, the political will would have to increase so that the German climate targets can be achieved stronger and faster and generate acceptance for more support for the market economy. However, this is difficult, as the political will predominantly depend on public demand. This could be overcome by introducing a state of emergency as described above, as this would define emissions as a direct threat to citizens and the economy and thus may motivate them to act (WiWo

2019; Leiserowitz 2020). Another way to increase political will would be to deepen and spread information. Political decisions, as well as economic decisions, are built on knowledge. Thus it is crucial to give decision-makers solid evaluations, neutral and trustworthy economic facts, and accurate projections with realistic scenarios. Moreover, there is the possibility to create a behavioral change through minor environmental adjustments, such as the introduction of educational programs and social media campaigns, which can be built based on scientific findings (Hernandez 2022). This task would increasingly fall to the scientific institutes and NGOs, which must be supported with financial resources.

Moreover, the need to improve the communication of this information is urgent. Transforming complex facts and numbers into an easily approachable language to all can make it more straightforward for society. If not, it will be challenging to persuade society and decision-makers to contribute to the costs today to prevent the long-term consequences of climate change (Gurría 2008; Leiserowitz 2020). In addition, strengthening a public climate expert council could bring the topic closer to society and simplify it (Expertenrat für Klimafragen n.d.). Furthermore, many emission reduction measures are only reaching their full potential once they are adopted by most individuals and households (Wuppertal Institut 2020). Therefore, a fundamental change in people's behavior is necessary, which takes time and the right incentives. Most people will only engage in climate adaptation activities if the financial benefits outweigh the expenses, if it is a social issue that affects their community, or if their social network recognizes this behavior as usual (Blanchard 2010). Foremost governments and businesses should therefore place the most significant effort into making environmental behavior simple behavior. By doing so, they ensure that costs properly represent the carbon footprint, that climate-friendly goods exceed alternatives

in terms of their impact on the environment, and that carbon labels are reliable and understandable so that consumers can make climate-friendly decisions more easily (Thøgersen 2021, 9).

However, since Germany is a social and free market economy, the state does not want to intervene too much in economic activity. Accordingly, it also requires changes in the economic system as a whole. Hence, companies must also take voluntary initiatives to achieve the German climate targets. In the economic area, politics, companies, and start-ups are mainly faced with the challenges of switching to renewable energies, recycling waste materials, and reducing emissions, especially CO2 (Erhard 2016; Pennington 2022). One solution could be to switch to a circular economic model, bringing the various stakeholders together and increasing their capacity and commitment. The concept of circular economy is described in Appendix 10. Additionally, there is enormous potential for a 39% reduction in world emissions when switching to a circular economy. According to estimates, it can fill about half of the emission gaps between existing regulations and the 1.5 °C targets established by the Paris Agreement. But therefore, it is evident that to change corporate structures and market frameworks, considerably bolder measures and more substantial commitments are required (Stefanakis, Calheiros, and Nikolaou 2021; Masterson 2022). Therefore, it would be necessary for all stakeholders to integrate sustainable practices into their core strategy, for example, using climate change consulting services that accompany, advise, and monitor the company on the path to voluntary restructuring. In this context, governmental aid and financial incentives could help to link consulting and business (Hope 2022).

Furthermore, in addition to direct political measures, other levels of the economy must also contribute to Germany's overall climate neutrality. Hence, due to Germany's failure to meet its climate targets in 2021 and 2022, there is an urgent need for the German government and other stakeholders, such as private companies and social or scientific institutions, to scale up the planned

measures and problem-solving approaches. In addition, specific dependencies, such as the NGO's reliance on external donations, or increased competition among private companies, such as patent and technology constraints, limit effective scalability (Stober 2022; Adhanan 2022). To precisely increase this effectiveness, start-ups with innovative ideas must work closely with large companies to increase the pace of innovation and simplify scalability, and leverage collaboration effects (Marra, Antonelli, and Pozzi 2017). This enhanced collaboration can, for example, take the form of a co-creation process. Co-creation should always be fair and equal, and the strengths and influence of the individual players should be shared and used in the best possible way. In this case, this includes the authority to make decisions (government), access to resources (private businesses), the capacity to influence the public's opinion (NGOs), or the ability to develop reasonable arguments (science). Therefore, this co-creation process requires a clear structure that addresses the root causes and penetrates complex approaches and systems. A successful implementation can lead to the exchange of knowledge and resources. For example, start-ups can gain new customers and scale up their emissions savings approach by networking with larger companies (Fagiewicz et al. 2021, 556).

Lastly, measuring each level's impact is essential to make the topic more tangible and to create systemic change. However, the measurement of the CO2 impact is not self-evident in the private economy as well as in public. According to research findings, there is no proof that voluntary climate reporting by businesses has any impact on decreasing emissions. Compared to voluntary disclosure, mandatory corporate reporting of GHG emissions results in much larger company emissions reductions. Accordingly, there will likely be no way to avoid disclosing the CO2 emissions required in the future (Schiemann et al. 2019), even though there will be an EU CO2-reporting obligation for companies with more than 250 employees from 2024 onwards. It will

still be the company's choice to decide how to implement this. Furthermore, this regulation primarily aims to curb greenwashing and not to create pressure to reduce CO2 emissions further. Accordingly, the government must take further steps to improve impact measurement. This could take, for example, the form of requiring large companies by law to disclose their annual sustainable impact figures, which would create an obligation and control (European Commission n.d.). In this respect, certificates and standards are also significant in measuring an organization's impact and gaining the trust and acceptance of society and investors. However, these are very expensive to obtain, especially for start-ups and NGOs, and there are often difficulties with the control and value of these certificates (Born, Burghaus, and Ellmann 2021; EPA 2022). Stricter regulations are needed that prescribe the highest standards for implementing climate protection projects and measuring their effects to circumvent these challenges. To make it easier for smaller start-ups to acquire certificates, they could be graded according to the size of the company, thus reducing or increasing the price.

6.3. Recommendations based on the management of resources and collaborations

This section of the thesis focuses on recommendations regarding the management of resources and collaborations of the different levels based on key findings of the case study analyses. Key areas for recommendations are financial resources, human resources, technical resources, and audience.

In financial resources and scientific research, NGOs, as well as start-ups, are mainly relying on investments. At the same time, the public sector and private corporations have the potential to invest their comparably greater financial resources. Therefore, these five levels must trade financial resources against other assets. First, the government should provide tailored financial support programs, especially for NGOs and scientific research, because they are particularly reliant on funding. However, NGOs must remain independent from the government concerning their goals

and decision-making. In return for financial support, scientific research organizations can offer know-how and credibility by designing studies and research that build the theoretical basis for government decisions. Furthermore, the public sector can use credibility and power to influence the behavior of society through scientific research to justify their choices because almost 80% of the German society believes that the findings regarding climate change issued by scientists and academic institutions are correct (Appunn 2021).

Similarly, NGOs can support the public sector in exchange for financial support because they tend to have high legitimacy and can help promote public decisions and goals if they fit the NGOs purpose (Atack 1999, 855). However, scientific research must remain unbiased, and researchers have to be entirely neutral when looking for new hypotheses, regardless of the goals of institutions that provide financial support. Furthermore, NGOs can use their strong voice to influence their followers in their decisions and actions (Banks and Hulme 2012, 3-5) because they have many supporters who voluntarily want to stop climate change. This power is necessary for systemic change since it requires many people who think and act systematically (Catalyst 2030 2021).

In addition to scientific research, green-tech start-ups need government support to reach their targets even faster, even though they usually generate profits. Access for start-ups to EU funding programs to increase innovation should be simplified to support green-tech start-ups. Furthermore, the German government should provide so-called matching grants, in which the state uses public money to double the investments collected privately (Raidl, Rauffmann, and Stiens 2021). Green-tech start-ups can offer the public sector, in return, access to new soft- and hardware technologies that will be available in the market and can support the economy in reaching its climate targets. However, the public sector needs to support climate-oriented NGOs, start-ups, and

academic research financially. One possibility could again be the introduction of environmental taxes, which have been shown to play a significant role in carbon abatement in other countries (Tao et al. 2021, 1).

In addition to the state, private companies can support NGOs, scientific research organizations, and start-ups by providing financial resources. In return, NGOs can, for example, offer services to enable the reduction and offsetting of emissions in exchange for donations and can provide CO2-related certifications to companies as proof of their commitment to climate change. In contrast, scientific research organizations can offer access to firm-specific and relevant research that enables innovations and technologies used by the private company to improve the sustainability of its processes, products, and services.

For the collaboration between corporates and start-ups, there are several possibilities. Some collaborative models to exchange financial resources between private companies and start-ups are outsourcing carbon management by founding a start-up, investments in start-ups or venture capital funds, or a merger and acquisition. When entering a merger and acquisition, corporations can offer corporate funding, resources, and customer access to start-ups. At the same time, they can profit from the possibility of innovating through disruption and access to new technologies that reduce CO2 emissions (Hornung 2021). To collect enough funding, NGOs, start-ups, and scientific research must concentrate on private and public capital. To persuade public and private investors to finance their efforts, organizations should focus on offering relevant, required, and valuable resources in return, such as access to cutting-edge technology. In addition, start-ups can increase their chance of attracting public and private investors by generating purpose and profits because this ‘for purpose for profit’ strategy attracts clean-tech and conventional investors. Investors could be incentivized to invest in climate companies by offering a tax benefit for green investments.

In addition, the different levels can support each other with regard to knowledge. Since know-how about climate-impacting technologies and solutions is distributed between NGOs, start-ups, corporates, and scientific research, knowledge must be shared between these players to reach new findings. This is because system change requires strategic, multi-stakeholder approaches coming together across systems (Catalyst 2030 2021). One way to achieve knowledge sharing is the concept of open innovation: It focuses on the requirement for businesses to open up their innovation processes and combine internal and outside-produced technologies to provide business value (Elmquist, Fredberg, and Ollila 2009, 326). Chesbrough defines open innovation as 'a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology' (Chesbrough 2006, 1). If a private company tries to become climate neutral, they could, for example, introduce a hackathon and invite members from society, start-ups, NGOs, and scientific research organizations. In return for the ideas that the participants come up with, the corporate could offer price money.

Additionally, there is great potential in the German economy and public sector to implement more far-reaching CO2 measures. Many levels are interdependent, but there is no actual exchange and accessibility of know-how (Born, Burghaus, and Ellmann 2021). The solution to this challenge with the government is to create incentives and promote the exchange and acquisition of knowledge. But science significantly contributes a great deal to developing new knowledge and opportunities. Accordingly, the government should promote increased investment and cooperation with scientific research institutes, for example, to obtain new technologies for the energy transition (BMBF 2022). The current challenge is that many scientific and research institutes have intensely focused their work on demonstrating the effects and risks of CO2 emissions. However, being aware

of the problem does not necessarily imply knowing how to solve it or putting appropriate measures in place. Accordingly, it is also essential for the economy and politics that real and more 'usable' scientific measurements are found. In this respect, better climate models need to be developed, which give more input on strategy adaptations, measures, risk management, and relevant technologies. Therefore, it will be vital to focus on local climate information and sector-specific needs in gaining this scientific knowledge. In addition, increased linkages between disciplines will be essential to promote the cross-disciplinary development of concepts and methodologies to maximize knowledge exchange, and address stakeholder needs better (Jasanoff 2021, 36; Knutti 2019, 21).

Moreover, scientific research is often conducted in collaboration with companies. To increase success, they may adopt a long-lasting, collaborative model. Such an adoption enables businesses to collaborate with scientific research organizations in a way that allows them to stay constantly connected to early-stage research and to hasten the translation of that research into new products that stimulate economic growth (Havard Business Review 2018). In this exchange, companies can offer their network and financial resources, while scientific research organizations can provide disruptive innovations, know-how, and technology. In addition, the public sector could subsidize the organization's R&D investments to incentivize start-ups and companies to increase their know-how through R&D regarding CO2 reduction. One example of such an initiative is the 'Horizon Europe' program by the European Commission, which has a budget of 95.5 billion euros and is the primary EU funding program for research and innovation. It combats climate change, aids in accomplishing the SDGs set forth by the UN, and increases the EU's competitiveness and growth. More similar programs could be set up on an international and national level.

Furthermore, it is central to develop and implement innovations in addition to the already existing innovations. Thereby, innovation is strongly related to improving the flow of knowledge, as the technologies, concepts, and measures developed by scientific institutions contribute significantly to the generation of innovation (OECD 2014). But the government can also create incentives to promote innovation in the economy and beyond. For one thing, the government can act as a bulk buyer of innovations by purchasing needed products, systems, or services. Thereby, the free competition must always be preserved, but this is where the government could encourage greater collaboration with promising innovative start-ups. In addition, the government could reduce innovation risk by making it easier to protect intellectual property or, for example, by launching more financial support programs (Savchuk 2019; Boghani and Jonash n.d.). Another vital point in promoting innovation is the creation of attractive business locations. Examples such as Silicon Valley have shown that industrial clusters become innovation centers where competition and cooperation between companies positively affect innovation and, for example, improve supply chains. To achieve this, the government could encourage the formation of technology and science parks and support the establishment of public research institutions (Cameron 2022).

Next to know-how, personnel is a scarce resource that must be increased to accelerate the achievement of carbon neutrality. Germany's transition towards climate neutrality requires knowledgeable and skilled personnel, which is currently lacking in public, NGOs, and private sectors. Private Companies could try to increase recruiting success by strengthening their employer brand through CO2 reduction and other climate actions. Recent studies show that about 75% of workers favor employers with a climate plan, and even more would stay with their firm longer (Hornung 2021). On the other hand, organizations can reduce the required personnel by decreasing manual processes. Artificial intelligence can simplify manufacturing, operative processes, and

decision-making by performing human-like cognitive tasks and automating physical processes, thus reducing the need for human personnel (Benbya, Davenport, and Pachidi 2020, 1). In addition, systemic change requires all stakeholders' participation, which challenges companies to influence their employees toward a more sustainable mindset. For this, the company's internal culture must change to incorporate a greener and environmentally conscious mindset into the company's DNA. Every person involved must live this mindset in their daily work. This can be implemented by introducing a change management task force in private companies focusing on climate change CO2 emissions. Furthermore, leaders and employees could be trained regarding climate action, employees can be incentivized to act environmentally, and HR departments can try to hire environmentally conscious employees.

Technical resources are often prevalent in the private sector because start-ups and corporates mainly produce innovations for CO2 reduction. To increase collaboration and develop more technological innovations, green-tech companies can create clusters to share human, financial, and technical resources. Green-tech company clusters are increasingly recognized as a technique to support innovative production and R&D activities. Therefore, enterprises in the green-tech industry often tend to aggregate geographically in specific locations of the world. The same agglomeration economies that have long benefited businesses in other sectors are also anticipated to help green-tech companies. Therefore, green-tech is also expected to produce innovation and economic spillovers supporting business growth, market opportunity, R&D, and complementary innovation (Marra et al. 2017, 1038). The public sector in Germany could support the formation of green-tech clusters by building the required infrastructure for innovation hubs to incentivize green-tech start-ups to choose cluster locations.

7. Limitations

From the discussion above it can be concluded that a faster achievement of the climate goals in Germany depends on many different factors. While this thesis focuses on the critical aspects of climate change and different solution approaches to reduce CO2 emissions in Germany, it does not map the complete system that needs to be changed. Besides the public and private sectors, scientific research, and social organizations, many other participants play an essential role in this endeavor. An example of this could be media organizations, which strongly impact society and, therefore, many individuals and can significantly influence the German climate policy. However, this thesis will not analyze organizations of this kind and other system members in more detail, as this would exceed the available volume. In addition, the perspective of society is not examined since it is composed of the opinions of all individuals, which in turn can be significantly influenced by the levels assessed above. Therefore, it is treated in this work more as a passive but, at the same time, vital factor. In addition, it is essential to emphasize that climate change is not only a global problem beyond Germany's influence. Germany accounts only for a share of the whole system. Due to the scope of this work, however, it was decided to look at Germany in more detail rather than conduct a global analysis.

Furthermore, it is essential to note that the case studies are only representative examples of an organization of the respective level. Still, they do not represent the entire level they are operating. For instance, the private sector is composed of so many companies from different industries that this comprehensive analysis of all contributors would not be possible. This applies to all five perspectives considered. Hence, the conclusions drawn from the case studies may only relate to institutions similar to the organization examined.

Due to the huge amount and variety of stakeholders and other influencing factors, the complexity of the described issue is too high to be covered in the context of this thesis. Therefore, the purpose of this work is to present the problem in a simplified form and to provide the reader with an understanding of the issue of CO2 emissions and possible recommendations for action that could contribute to the faster achievement of the German climate targets. Still, the measures presented are only a subset of all possible measures and are not the only way to achieve this. The work also does not give any precise details on how these could be implemented, as this would exceed the scope of this thesis.

8. Conclusion

This qualitative research aimed to identify effective recommendations to accelerate climate neutrality in Germany by analyzing carbon reduction measures from five different perspectives. The analysis was focused on the five stakeholder groups of scientific research, public actors, private enterprises, start-ups, and non-governmental organizations. Because they either count as the largest emitters of GHG emissions or are among the most essential contributors to solving the climate change problem. By carrying out case studies in the context of a grounded theory approach, followed by a comparative analysis of the case studies, it was concluded that systemic change is necessary to accelerate the achievement of climate neutrality in Germany by 2045. Furthermore, the results indicate that carbon reduction measures within each level must fulfill the following criteria, which were identified as characteristics of a systemic change approach: ‘Profundity of the problem-solving approach,’ ‘Effectiveness of the applied strategy,’ and ‘Efficient management of resources and enhanced collaborations.’ Therefore, the overarching goal of climate neutrality in

Germany requires a multi-stakeholder approach, with the five levels coming together across systems and trading resources in an interconnected manner.

This thesis focused on carbon reduction measures in Germany since Germany is responsible for the most significant part of CO2 emissions in the EU due to its industrial production power and energy consumption. Additionally, Germany was one of the first nations to implement a long-term emission-lowering strategy with their Climate Action Plan following the Paris Agreement. Furthermore, since it has been a forerunner in innovative technologies and solutions, the industrial nation can serve as a role model with its CO2 reduction measures. Carbon dioxide was identified as the central factor causing progressive climate change since it accounts for 81% of all the GHGs released into the atmosphere. CO2 reduction measures, among other harmful GHGs, were therefore made a central factor of the SDG13' climate action', introduced by the UN. This thesis was specifically conducted considering SDG 13.2.2, which states integrating GHG-reducing measures in policies, strategies, and planning. Driven by this goal, Germany aims to reach carbon neutrality by 2045 to prevent further progress of a rise in temperatures which would lead to irreversible damage to the earth. This can be seen as urgent since climate change's consequences seriously threaten human health, ecosystems, biodiversity, and the economy.

Five case studies were created, aiming to represent the perspectives of scientific research, public actors, private enterprises, start-ups, and non-governmental organizations to give recommendations on how Germany could accelerate the achievement of carbon neutrality. Those case studies examined the challenges addressed by each organization, the strategy, and the value proposition. Followed by an analysis of the 'profundity of the problem-solving approach,' the 'effectiveness of the applied strategy,' and 'management of resources and collaborations.' Finally,

after gathering enough information, a grounded theory approach was used to derive key insights and profound recommendations for each level.

The analysis of the study conducted by the Wuppertal Institute to represent the efforts of scientific climate research on Germany's way to achieve climate neutrality has shown that the government must adapt its climate policies and implement more effective measures. Furthermore, future climate action measures must be proven effective by scientific research. Otherwise, Germany will be unable to reach its climate targets in time.

The analysis of the municipal potential for CO2 reduction, a representative for the public sector, revealed the importance of the federal government in creating legal guidelines and frameworks for the entire business community and the public. However, these are particularly challenged by financial, legal, and human resources, and society's acceptance of more robust measures needs to be strengthened.

Private companies in Germany account for a large share of CO2 emissions. However, although many companies already have promising reduction strategies and technologies, this does not apply to all. Cooperations between companies, start-ups, NGOs, and the government are helpful to collaboratively overcome these challenges to achieve the set climate targets by 2045.

An analysis of the green-tech start-up industry has shown that start-ups play a significant role in carbon neutrality in Germany because they have the power to create new innovative business models and technologies. However, start-ups require the support of private companies, the public sector, and investors with regard to scaling, impact, and funding.

The research on NGOs has shown that social organizations can help create essential communication bridges between different sectors. In this way, they make projects happen that

would not take place otherwise. However, due to their nature, they often depend on external donations and cooperation with other institutions, as they have limited financial resources.

After the case study of each perspective was examined, a comparative analysis between the different levels was conducted. The discussion identified the potential at each level to accelerate carbon neutrality while highlighting scarce resources and collaboration, which could lead to even more tremendous potential. Three main factors derived from this were a lack of unification of climate targets, a lack of laws and regulations that form a framework to enhance better CO2-reducing measures, and a lack of financial resources to implement those measures, build strategies or develop technologies.

Based on these findings, recommendations were elaborated to overcome these obstacles and hence contribute to accelerating the achievement of Germany's climate targets through a system change approach. Among other results, it was concluded that climate targets must be realigned and unified, especially within the economy. Furthermore, all climate targets should be based on scientific evidence to guarantee that they are effective and their achievement is realistic. Secondly, the government must build a framework by introducing regulations that create incentives to implement CO2-reduction measures across industries. Therefore, it was recommended to make corporate reporting of GHG emission results mandatory for private enterprises. Thirdly, scientific research, NGOs, and start-ups that often lack the financial resources to exploit their full potential in contributing to carbon neutrality should trade resources with public and private institutions in exchange for funding or investments. Those resources would include knowledge about effective CO2 reduction measures, innovative technologies, or the organization's credibility among the public. These recommendations overlook how individual measures can contribute to the goal of carbon neutrality. Still, most importantly, the analyses have shown that systemic change is the

overarching solution to the problem in this thesis. As mentioned above, the five levels involved must improve their strategies in a way that they are treating the root causes of CO2 emissions, they need to make their applied strategies more effective, and, most importantly, they need to expand their collaboration as well as strengthen each other's capacities to change the whole system toward a more sustainable future. Only by exchanging resources and more interconnected goals and actions the achievement of the climate targets in Germany can be accelerated.

Though, it must be made clear that this is a very demanding and multigenerational task that would require not only a strong will and focus of all the stakeholders mentioned above but also the participation of society as a whole. Unfortunately, due to the scope of this work, the perspective of private households and societal behavior was left out in this thesis, which would have been an exciting view that could also contribute to the recommendations.

Furthermore, even if Germany can reach its climate targets by 2045, the fight against climate change is still a global challenge that can only be combated if all nations worldwide are equally involved. However, this thesis has shown that Germany has the potential to achieve its climate goals. If the country succeeds, Germany can serve as a role model and guide for other nations, and the earth will be one step closer to becoming a climate-neutral ecosystem.

References

Adhanan, Ella-Tamar. 2022. “What Are the Three Stages of a Startup?” Silicon Valley Bank. 2022. https://www.svb.com/startup-insights/startup-growth/what-are-the-three-stages-of-a-startup.

Andres, Leander, Marc Fabel, Matthias Flückiger, Markus Ludwig, Helmut Rainer, Maria Waldinger, and Sebastian Wichert. 2022. “Trägt die Fridays-for-Future-Bewegung zum politischen Klimawandel bei?” 05/2022. ifo Schnelldienst. https://www.ifo.de/DocDL/sd-2022-05-andres-etal-fridays-for-furture.pdf.

Anzlinger, Jana. n.d. “Wie der Bundestag den Klimawandel verdrängte.” Süddeutsche Zeitung. Accessed September 17, 2022. https://www.sueddeutsche.de/projekte/artikel/politik/wie-der-bundestag-ueber-klimapolitik-spricht-e704090/.

Appunn, Kerstine. 2021. “Majority of Germans Believe Scientists’ Climate Change Warnings Are Correct.” Clean Energy Wire. August 13, 2021. https://www.cleanenergywire.org/news/majority-germans-believe-scientists-climate-change-warnings-are-correct.

Atack, Iain. 1999. “Four Criteria of Development NGO Legitimacy.” *World Development* 27 (5): 855–57.

Atlantic Ventures. 2021. “Next Generation Carbon Management.” https://www.atlantic-ventures.com/insights/report-carbon-management-software.

Atmosfair. 2022a. “Project Overview.” Atmosfair. 2022. https://www.atmosfair.de/en/climate-protection-projects/.

Atmosfair. 2022b. “What Is Atmosfair?” Atmosfair. 2022. https://www.atmosfair.de/en/about_us/what_is_atmosfair/.

Banks, Nicola, and David Hulme. 2012. “The Role of NGOs and Civil Society in Development and Poverty Reduction.” *Brooks World Poverty Institute Working Paper*, no. 171: 3–5.

BCG. 2021. “New BCG GAMMA Survey Reveals That Only 9% of Organizations Are Able to Measure Their Total Greenhouse Gas Emissions Comprehensively.” BCG Global. October 13, 2021. https://www.bcg.com/press/13october2021-only-nine-percent-of-organizations-measure-emissions-comprehensively.

Benbya, Hind, Thomas H Davenport, and Stella Pachidi. 2020. “Artificial Intelligence in Organizations: Current State and Future Opportunities.” *MIS Quarterly Executive* 19 (4): 1–2.

Benton, Tim G, Antony Froggatt, and Laura Wellesley. 2022. “The Ukraine War and Threats to Food and Energy Security.” Chatham House. https://www.chathamhouse.org/sites/default/files/2022-04/2022-04-12-ukraine-war-threats-food-energy-security-benton-et-al_0.pdf.

Bergk, Fabian. 2022. Interview with Fabian Bergk, author of the study and research associate at IFEU focusing on national climate protection strategies as well as municipal climate protection.

Blanchard, Odile. 2010. “How to Achieve Climate-Friendly Behaviour Changes ? A Case Study of the University of Grenoble.” HAL, Post-Print. https://www.researchgate.net/publication/46478756_How_to_achieve_climate-friendly_behaviour_changes_A_case_study_of_the_university_of_Grenoble.

BMBF. 2022. “Forschung Zu Klimaschutz Und Klimafolgen.” Bundesministerium Für Bildung Und Forschung. February 28, 2022. https://www.bmbf.de/bmbf/de/forschung/umwelt-und-klima/klimaforschung/forschung-zu-klimaschutz-und-klimawirkungen.html.

BMBF, Team Datenportal des. 2020. “Tabelle 1.1.5 - Datenportal des BMBF.” BMBF. 2020. https://www.datenportal.bmbf.de/portal/de/Tabelle-1.1.5.html.

BMU. 2021. “Klimaschutz in Zahlen - Fakten, Trends und Impulse deutscher Klimapolitik, Ausgabe 2021.” Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU). https://www.bmuv.de/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutz_zahlen_2021_bf.pdf.

BMUB. 2016. “Climate Action Plan 2050. Principles and Goals of the German Government’s Climate Policy.” Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). https://www.bmuv.de/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutzplan_2050_en_bf.pdf.

BMUV. 2019. “Klimaschutzprogramm 2030 der Bundesregierung zur Umsetzung des Klimaschutzplans 2050.” Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz. 2019. https://www.bundesregierung.de/resource/blob/974430/1679914/e01d6bd855f09bf05cf7498e06d0a3ff/2019-10-09-klima-massnahmen-data.pdf?download=1.

BMUV. 2020. “Climate Action Plan 2050 – Germany’s Long-Term Low Greenhouse Gas Emission Development Strategy.” Federal Ministry for Environment, Nature Conservation, Nuclear Safety and Consumer Protection. October 6, 2020. https://www.bmuv.de/en/topics/climate-adaptation/climate-protection/national-climate-policy/climate-action-plan-2050-germanys-long-term-low-greenhouse-gas-emission-development-strategy.

BMUV. 2022a. “Umweltbewusstsein in Deutschland 2020.” Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz. https://www.bmuv.de/fileadmin/Daten_BMU/Pools/Broschueren/umweltbewusstsein_2020_bf.pdf.

BMUV. 2022b. “Indikator: Emission von Treibhausgasen.” Federal Ministry for Environment, Nature Conservation, Nuclear Safety and Consumer Protection. March 15, 2022. https://www.umweltbundesamt.de/daten/umweltindikatoren/indikator-emission-von-treibhausgasen#die-wichtigsten-fakten.

BMUV. n.d. “Wer Oder Was Verursacht Den Klimawandel?” Bundesministerium Für Umwelt, Naturschutz, Nukleare Sicherheit Und Verbraucherschutz. Accessed November 15, 2022a. https://www.bmuv.de/kids/artikel/details/es-ist-der-mensch.

BMUV. n.d. “Zentrum KlimaAnpassung - The New Federal Information Centre for Climate Adaptation.” Bundesministerium Für Umwelt, Naturschutz, Nukleare Sicherheit Und Verbraucherschutz. Accessed September 21, 2022b. https://www.bmuv.de/en/topics/climate-adaptation/climate-adaptation/zentrum-klimaanpassung-the-new-federal-information-centre-for-climate-adaptation.

BMWK. 2022a. “Germany’s Current Climate Action Status.” Berlin: Bundesministerium für Wirtschaft und Klimaschutz. https://www.bmwk.de/Redaktion/EN/Downloads/E/germany-s-current-climate-action-status.pdf?__blob=publicationFile&v=11.

BMWK. 2022b. “Green Startup Monitor 2022.” Bundesministerium Für Wirtschaft Und Klimaschutz. March 4, 2022. https://www.exist.de/EXIST/Redaktion/DE/Aktuelles/Nachrichten/Green-Startup-Monitor-2022.html.

BMWK. 2022c. “Global Entrepreneurship Monitor: Gründungen in Deutschland Wieder Im Aufwind.” Bundesministerium Für Wirtschaft Und Klimaschutz. May 27, 2022. https://www.bmwk.de/Redaktion/DE/Pressemitteilungen/2022/05/20220527-global-entrepreneurship-monitor-gruendungen-in-deutschland-wieder-im-aufwind.html.

Boghani, Ashok, and Ronald Jonash. n.d. “The Role of Government in Fostering Innovation.” Arthur Little. Accessed November 1, 2022.

https://www.adlittle.com/sites/default/files/prism/1993_q1_23-27.pdf.
Born, Diana, Kerstin Burghaus, and Bernhard Ellmann. 2021. “Annual Report 2020:” Atmosfair. https://www.atmosfair.de/wp-content/uploads/annualreport-2020-web.pdf.
BPA. 2022a. “Im Notfall: Kohle und Öl als Gasersatz | Bundesregierung.” Presse- und Informationsamt der Bundesregierung. Webseite der Bundesregierung | Startseite. July 12, 2022. https://www.bundesregierung.de/breg-de/themen/klimaschutz/gasersatz-reserve-2048304.
BPA. 2022b. “Ziel: Klimaschutz – Team: Europa EU soll bis 2050 klimaneutral sein.” Presse- und Informationsamt der Bundesregierung. Webseite der Bundesregierung | Energie und Klimaschutz. September 8, 2022. https://www.bundesregierung.de/breg-de/themen/klimaschutz/mehr-klimaschutz-in-der-eu-1790042.
Bundesverfassungsgericht. 2021. “Constitutional Complaints against the Federal Climate Change Act Partially Successful.” Bundesverfassungsgericht. 2021. https://www.bundesverfassungsgericht.de/SharedDocs/Pressemitteilungen/EN/2021/bvg21-031.html.
Cameron, Alicia. 2022. “6 Ways Governments Drive Innovation – and How They Can Help Post-Pandemic Resilience.” The Conversation. July 14, 2022. https://theconversation.com/6-ways-governments-drive-innovation-and-how-they-can-help-post-pandemic-resilience-186910.
Cann, Vicky, and Nina Katzemich. 2020. “Tainted Love. Corporate Lobbying and the Upcoming German EU Presidency.” Brussels, Cologn: Corporate Europe Observatory. https://corporateeurope.org/sites/default/files/2020-06/Corporate-lobbying-DE-presidency-web%20ENG.pdf.
Catalyst 2030. 2021. “What Is Systems Change.” *Catalyst 2030* (blog). 2021. https://catalyst2030.net/what-is-systems-change/.
Chambers, Alice. 2022. “65 per Cent of German Firms Aim to Be Climate-Neutral by 2035.” Technology Record. 2022. https://www.technologyrecord.com/Article/65-per-cent-of-german-firms-aim-to-be-climate-neutral-by-2035-132033.
Charmaz, Kathy. 2006. *Constructing Grounded Theory A Practical Guide through Qualitative Analysis*. Thousand Oaks, California: Sage Publications.
Chesbrough, Henry. 2006. “Open Innovation: A New Paradigm for Understanding Industrial Innovation.” *Open Innovation: Researching a New Paradigm* 400: 1–3.
Clark, D. 2022. “Gross Domestic Product at Current Market Prices of Selected European Countries in 2021.” Statista. July 27, 2022. https://www.statista.com/statistics/685925/gdp-of-european-countries/.
Climate Alliance. n.d. “The Climate Emergency Declaration – An Examination of Key and Oft Forgotten Aspects.” Climate Alliance. Accessed October 30, 2022. https://www.climatealliance.org/fileadmin/Inhalte/2_Municipalities/Climate_Emergency/2019-08-23_Analysis_-_Climate_Emergency_Declarations_EN.pdf.
Day, Thomas, Silke Mooldijk, Sybrig Smit, Eduardo Posada, Frederic Hans, Harry Fearnehough, Aki Kachi, Carsten Warnecke, Takeshi Kuramochi, and Niklas Höhne. 2022. “Corporate Climate Responsibility Monitor 2022.” NewClimate Institute for Climate Policy and Global Sustainability.
Delve. 2022. “The Practical Guide to Grounded Theory.” Delvetool.Com. September 21, 2022. https://delvetool.com/groundedtheory.
Deutsche Energieagentur. 2021. “Investing in Net Zero. Assessing Germany’s Venture Capital Potential in Climate Tech until 2030.” Deutsche Energie-Agentur. https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2021/Investing_in_Net_Zero.pdf.
Deutscher Bundestag. 2022. “Rechnungshof: Steuerung des Klimaschutzes ist „mangelhaft“.” Deutscher

Bundestag. 2022. https://www.bundestag.de/presse/hib/kurzmeldungen-887578.
Deutscher Ethikrat. 2019. “Wissenschaft Als Rettungsanker? Der Ethikrat Diskutiert Die Rolle Der Wissenschaft in Der Klimakrise.” Deutscher Ethikrat. October 24, 2019. https://www.ethikrat.org/mitteilungen/mitteilungen/2019/wissenschaft-als-rettungsanker-der-ethikrat-diskutiert-die-rolle-der-wissenschaft-in-der-klimakrise/?cookieLevel=not-set.
DW. 2022. “Baerbock Bei Weltklimakonferenz: ‘Menschheit Steuert Auf Abgrund Zu.’” DW. November 6, 2022. https://www.dw.com/de/weltklimakonferenz-cop27-klimawandel-klimakatastrophe-baerbock/a-63661854.
DWIH. n.d. “Klimaforschung in Deutschland | DWIH Neu-Delhi.” *DWIH New Dehli Land der Ideen* (blog). Accessed September 21, 2022. https://www.dwih-newdelhi.org/de/themen/staedte-und-klima/klimaforschung-in-deutschland/.
Elmquist, Maria, Tobias Fredberg, and Susanne Ollila. 2009. “Exploring the Field of Open Innovation.” *European Journal of Innovation Management*, 326–27.
EPA. 2022. “Double Counting.” United States Environmental Protection Agency. February 25, 2022. https://www.epa.gov/green-power-markets/double-counting.
Erhard, Ludwig. 2016. “Soziale Marktwirtschaft.” Bundeszentrale für politische Bildung. 2016. https://www.bpb.de/kurz-knapp/lexika/lexikon-der-wirtschaft/20642/soziale-marktwirtschaft/.
European Commission. 2015. “Closing the Loop - An EU Action Plan for the Circular Economy.” COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. 2015. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52015DC0614&from=ES.
European Commission.n.d. “Causes of Climate Change.” European Commission. Accessed September 13, 2022a. https://ec.europa.eu/clima/climate-change/causes-climate-change_en.
European Commission.n.d. “Consequences of Climate Change.” European Commission. Accessed September 13, 2022b. https://ec.europa.eu/clima/climate-change/consequences-climate-change_en.
European Commission.n.d. “Corporate Sustainability Reporting.” European Commission. Accessed October 29, 2022c. https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en#review.
European Parliament. 2021. “Greenhouse Gas Emissions by Country and Sector (Infographic).” European Parliament. October 28, 2021. https://www.europarl.europa.eu/news/en/headlines/society/20180301STO98928/greenhouse-gas-emissions-by-country-and-sector-infographic.
European Parliament. 2022. “New Social and Environmental Reporting Rules for Large Companies | News | European Parliament.” European Parliament. June 21, 2022. https://www.europarl.europa.eu/news/en/press-room/20220620IPR33413/new-social-and-environmental-reporting-rules-for-large-companies.
Eurostat. 2022. “Industrial Production Statistics.” Eurostat Statistics Explained. 2022. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Industrial_production_statistics.
Expertenrat für Klimafragen. n.d. “Expertenrat Für Klimafragen.” Expertenrat Für Klimafragen. Accessed October 29, 2022. https://expertenrat-klima.de/ueber-uns/.
Fagiewicz, K., P. Churski, T. Herodowicz, P. Kaczmarek, P. Lupa, J. Morawska-Jancelewicz, and A. Mizgajski. 2021. “Cocreation for Climate Change—Needs for Actions to Vitalize Drivers and Diminish Barriers.” *Weather, Climate, and Society* 13 (3): 555–70. https://doi.org/10.1175/WCAS-D-20-0114.1.

Focus 2030. 2019. “What Are the Sustainable Development Goals?” Focus 2030. September 2, 2019. https://focus2030.org/What-are-the-Sustainable-Development-Goals.
Folger, Jean. 2022. “How Do NGOs Net Funding?” Investopedia. 2022. https://www.investopedia.com/ask/answers/13/ngos-get-funding.asp.
Fraunhofer ISE. 2021. “Studie: »Wege zu einem klimaneutralen Energiesystem«.” https://www.ise.fraunhofer.de/de/veroeffentlichungen/studien/wege-zu-einem-klimaneutralen-energiesystem.html.
Fridays for Future. 2020. “Fridays for Future Pressestatements.” Fridays for Future. 2020. https://fridaysforfuture.de/pressestatements-vorstellung-der-studie-co2-neutral-bis-2035-eckpunkte-eines-deutschen-beitrags-zur-einhaltung-der-15-c-grenze/.
Friedrich, Johannes, Mengpin Ge, and Andrew Pickens. 2020. “This Interactive Chart Shows Changes in the World’s Top 10 Emitters.” World Resources Institute. December 10, 2020. https://www.wri.org/insights/interactive-chart-shows-changes-worlds-top-10-emitters.
Fuso Nerini, Francesco, Benjamin Sovacool, Nick Hughes, Laura Cozzi, Ellie Cosgrave, Mark Howells, Massimo Tavoni, Julia Tomei, Hisham Zerriffi, and Ben Milligan. 2019. “Connecting Climate Action with Other Sustainable Development Goals.” *Nature Sustainability* 2 (8): 674–80.
GBM. 2020. “THOUGHTS—Why Is Impact Measurement Important?” Good Business Matters. October 14, 2020. https://goodbusinessmatters.com.au/thoughts/why-is-impact-measurement-important/.
Glaser, B. G., and A. L. Strauss. 1967. *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Chicago: Aldine.
Grady, Heather, Edwin Ou, Federico Bellone, and Kathy Reich. 2018. “Scaling Solutions Toward Shifting Systems: Approaches for Learning, Approaches for Impact.” Scaling Solutions Toward Shifting Systems Initiative. Rockefeller Philanthropy Advisors. https://www.rockpa.org/wp-content/uploads/2018/10/10-20-RockPA-Scaling-Solutions-02-WEB-1.pdf.
Gurría, Angel. 2008. “Climate Change: A Matter of Political Will.” OECD. June 3, 2008. https://www.oecd.org/env/tools-evaluation/climatechangeamatterofpoliticalwill.htm.
Hák, Tomáš, Svatava Janoušková, and Bedřich Moldan. 2016. “Sustainable Development Goals: A Need for Relevant Indicators.” *Ecological Indicators* 60 (January): 564. https://doi.org/10.1016/j.ecolind.2015.08.003.
Hansel, Mareike, Greta Link, Christine Krüger, Niko Hübner, and Annerose Hörter. 2017. “Akteure im kommunalen Klimaschutz erfolgreich beteiligen.” Berlin: Service- und Kompetenzzentrum: Kommunaler Klimaschutz. https://www.klimaschutz.de/sites/default/files/Difu_SKKK_Broschuere_Beteiligungsprozesse_barrierefrei-.pdf.
Havard Business Review. 2018. “Why Companies and Universities Should Forge Long-Term Collaborations.” 2018. https://hbr.org/2018/01/why-companies-and-universities-should-forge-long-term-collaborations.
Hemmati, Minu, and Celia Schmidt. 2020. “Beteiligung und Mitwirkung im kommunalen Klimaschutz: Erkenntnisse und Ergebnisse aus dem Vorhaben Klima-KomPakt.” Berlin: Institut für Energie- und Umweltforschung Heidelberg. https://www.klimaschutz.de/sites/default/files/Beteiligung_Klimaschutz_Klima-KomPakt%20barrierefrei_1.pdf.
Hernandez, Mindy. 2022. “Is Behavioral Science the Secret Ingredient for Effective Climate Action?” World Resources Institute. February 18, 2022. https://www.wri.org/insights/behavioral-science-effective-climate-action.
Herzog, Howard, Baldur Eliasson, and Olav Kaarstad. 2000. “Capturing Greenhouse Gases.” *Scientific American* 282 (2): 72–79. https://doi.org/10.1038/scientificamerican0200-72.

Hope, Blaise. 2022. “Top 10 Sustainability Consultants.” Sustainability. June 16, 2022. https://sustainabilitymag.com/top10/top-10-sustainability-consultants.
Hornung, Stefanie. 2021. “Nachhaltigkeit: Interview mit Anna Alex.” June 1, 2021. https://newmanagement.haufe.de/organisation/nur-was-wir-messen-koennen-wir-managen.
IPCC. 2021a. “Climate Change 2021 The Physical Science Basis.” https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf.
IPCC. 2021b. “Climate Change Widespread, Rapid, and Intensifying – IPCC.” IPCC. August 9, 2021. https://education.nationalgeographic.org/resource/climate-change.
Jasanoff, Sheila. 2021. “Knowledge for a Just Climate.” *Climatic Change* 169 (3): 36.
Jones, Timothy. 2022. “Environment Agency Gives Germans Top Green Marks.” DW. February 11, 2022. https://www.dw.com/en/environment-agency-gives-germans-top-green-marks/a-60747308.
KFW. 2021. “KfW Research: Klimaneutralität bis Mitte des Jahrhunderts erfordert Investitionen von 5 Billionen EUR | KfW.” KfW Research. 2021. https://www.kfw.de/Über-die-KfW/Newsroom/Aktuelles/Pressemitteilungen-Details_673344.html.
Kielon, Kristin. 2020. “Die Top 5 der CO2-Verursacher Deutschlands nach Sektoren.” mdr Wissen. January 22, 2020. https://www.mdr.de/wissen/deutschland-top-fuenf-klima-emissionen-100.html.
Knutti, Reto. 2019. “Closing the Knowledge-Action Gap in Climate Change.” *One Earth* 1 (1): 21–23.
Köppl, Angela, and Margit Schratzenstaller. 2021. “How to Design Environmentally Beneficial Tax Incentives.” CEP. March 4, 2021. https://www.cepweb.org/how-to-design-environmentally-beneficial-tax-incentives/.
Kumar, Abhinandan, Pardeep Singh, Pankaj Raizada, and Chaudhery Mustansar Hussain. 2021. “Impact of COVID-19 on Greenhouse Gases Emissions: A Critical Review | Elsevier Enhanced Reader.” September 17, 2021. https://doi.org/10.1016/j.scitotenv.2021.150349.
Leiserowitz, Anthony. 2020. “Building Public and Political Will for Climate Change Action.” Yale School of the Environment. June 30, 2020. https://environment.yale.edu/news/article/building-public-and-political-will-for-climate-change-action.
Lindsey, Rebecca, and Luann Dahlman. 2022. “Climate Change: Global Temperature.” Climate.Gov. June 28, 2022. https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature.
MacCracken, Michael C. 2012. “Prospects for Future Climate Change and the Reasons for Early Action.” *Journal of the Air & Waste Management Association* 58 (6): 735–86.
Malhi, Gurdeep Singh, Manpreet Kaur, and Prashant Kaushik. 2021. “Impact of Climate Change on Agriculture and Its Mitigation Strategies: A Review.” MDPI. January 27, 2021. https://www.mdpi.com/2071-1050/13/3/1318/htm.
MAN. 2022. “Future in the Making - Company, Products and Services.” MAN Energy Solutions. 2022. https://www.man-es.com/company/about-us#:~:text=MAN%20Energy%20Solutions%20is%20the,turbines%2C%20compressors%20and%20chemical%20reactors.
Marra, Alessandro, Paola Antonelli, and Cesare Pozzi. 2017. “Emerging Green-Tech Specializations and Clusters–A Network Analysis on Technological Innovation at the Metropolitan Level.” *Renewable and Sustainable Energy Reviews* 67: 1037–46.
Masterson, Victoria. 2022. “What Is the Circular Economy and Why Does It Matter?” World Economic Forum. June 14, 2022. https://www.weforum.org/agenda/2022/06/what-is-the-circular-economy/.
McGann, James G. 2021. “2020 Global Go To Think Tank Index Report.” https://think-asia.org/handle/11540/13130.
Mihatsch, Christiann. 2022. “Staaten werden beim Klimageld kreativer.” klimareporter°. November 8, 2022. http://www.klimareporter.de/klimakonferenzen/staaten-werden-beim-klimageld-kreativer.

Miller, Wendy. 2015. “Understanding Grounded Theory,” Clinical Laboratory Science, 28: 197–200.
Mohommad, Adil, and Evgenia Pugacheva. 2022. “Impact of COVID-19 on Attitudes to Climate Change and Support for Climate Policies.” *IMF Working Papers* 2022 (023): 3. https://doi.org/10.5089/9798400200021.001.
Morgenroth, Maja Melina. 2022. Semi Structured, written, unpublished Interview with Maja Melina Morgenroth, Customer Suppot Specialist at Planetly - “Planetly and its way towards a net-zero economy.”
National Geographic Society. 2022. “Climate Change.” National Geographic. May 20, 2022. https://education.nationalgeographic.org/resource/climate-change.
National Geographic Society n.d. “Effects of Global Warming.” National Geographic. Accessed September 13, 2022. https://www.nationalgeographic.com/environment/article/global-warming-effects.
OECD. 2014. “The Innovation Imperative: A Call to Action.” Paris: OECD Conference Centre. https://www.oecd.org/innovating-the-public-sector/innovation-imperative-call-to-action.pdf.
Oldeland, Martin. 2022. “Scheitert die Klimaneutralität am Personalmangel? - Das Handwerk muss attraktiver werden.” 2022. https://www.forum-csr.net/News/17035/Scheitert-die-Klimaneutralitaet-am-Personalmangel.html.
Osborne, Louise. 2016. “NGOs Urge Germany to Beef up Climate Action.” DW. April 21, 2016. https://www.dw.com/en/ngos-urge-germany-to-beef-up-climate-action/a-19201684.
Paar, Angelika, Fabian Bergk, Miriam Dingeldey, Clemens Hecker, and Vanessa Herhoffer. 2022a. “Klimaschutzpotenziale in Kommunen: Quantitative Und Qualitative Erfassung von Treibhausgasminderungspotenzialen in Kommunen.” Dessau-Roßlau: Umwelt Bundesamt. https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/texte_04-2022_klimaschutzpotenziale_in_kommunen.pdf.
Paar, Angelika, Fabian Bergk, Miriam Dingeldey, Clemens Hecker, and Vanessa Herhoffer. 2022b. “Steckbriefe Kommunaler Klimaschutzpotenziale: Quantitative Und Qualitative Erfassung von Treibhausgasminderungspotenzialen in Kommunen.” Dessau-Roßlau: Umwelt Bundesamt. https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/texte_04-2022_klimaschutzpotenziale_in_kommunen.pdf.
Pennington, James. 2022. “3 Ways the Circular Economy Is Vital for the Energy Transition.” World Economic Forum. February 23, 2022. https://www.weforum.org/agenda/2022/02/3-ways-circular-economy-renewables-energy-transition/.
Planetly. 2021. “About Planetly.” Planetly. 2021. https://www.planetly.com/about.
Planetly. 2022. “Planetly Seal Guide.” https://assets.website-files.com/607eb8347bdddb2bc8178ad3/62ea84261d124ab48d60d053_Planetly%20Seal%20Guide_v1.1%20updated.pdf.
Pritzl, Rupert. 2020. “Realitätsillusion der deutschen Klimapolitik.” *Wirtschaftsdienst* 100 (9): 701–6. https://doi.org/10.1007/s10273-020-2741-0.
Raidl, Melanie. 2021. “Gründen Für Den Klimaschutz: Founderslane Bringt Start-Ups Und Konzerne Zusammen.” Handelsblatt. March 17, 2021. https://www.handelsblatt.com/unternehmen/energie/felix-staeritz-gruenden-fuer-den-klimaschutz-founderslane-bringt-start-ups-und-konzerne-zusammen/26985044.html.
Raidl, Melanie, Theresa Rauffmann, and Teresa Stiens. 2021. “Green Tech : Klamme Klima-Start-ups: Den Technologien der Zukunft fehlt Kapital.” *Handelsblatt*, October 22, 2021. https://www.handelsblatt.com/technik/thespark/green-tech-klamme-klima-start-ups-den-technologien-der-zukunft-fehlt-kapital/27722094.html.
Read, Claire. 2020. “Germany: National Government Vital to Local Authority Climate Change Action.”

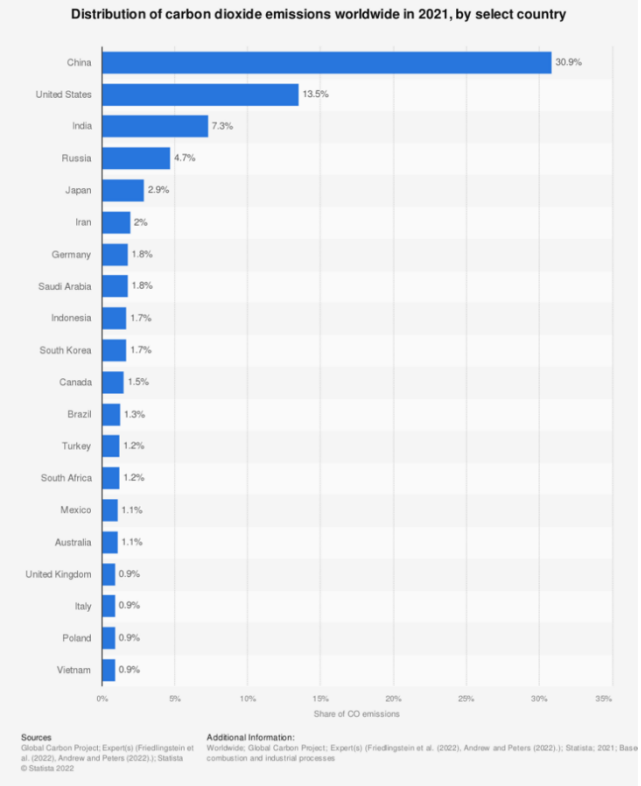
June 17, 2020. https://www.lgcplus.com/politics/climate-change/germany-national-government-vital-to-local-authority-climate-change-action-17-06-2020/.
Riedl, Donata. 2021. “63% of Germans in Favour of Stricter Government Measures That Impose Changes on People’s Behaviour.” European Investment Bank. 2021. https://www.eib.org/en/press/all/2021-356-63-percent-of-germans-in-favour-of-stricter-government-measures-that-impose-changes-on-people-behaviour.
Riess, Julia. 2022. Written Interview with Julia Riess, climate protection officer of the municipality of Oberhaching in Germany.
Ripley, Matt. 2019. “Systemic Change: Walking the Talk?” Publication. 2019. http://www.ilo.org/empent/areas/value-chain-development-vcd/briefs-and-guides/WCMS_718092/lang--en/index.htm.
Ritchie, Hannah, Max Roser, and Pablo Rosado. 2020. “CO_2 and Greenhouse Gas Emissions.” Our World in Data. May 11, 2020. https://ourworldindata.org/co2-emissions.
Rocque, Rhea J, Caroline Beaudoin, Ruth Ndjaboue, Laura Cameron, Louann Poirier-Bergeron, Rose-Alice Poulin-Rheault, Catherine Fallon, Andrea C Tricco, and Holly O Witteman. 2021. “Health Effects of Climate Change: An Overview of Systematic Reviews.” BMJ Open. https://bmjopen.bmj.com/content/bmjopen/11/6/e046333.full.pdf.
Rosen, Julia. 2021. “The Science of Climate Change Explained: Facts, Evidence and Proof Definitive Answers to the Big Questions.” The New York Times. 2021. https://www.nytimes.com/article/climate-change-global-warming-faq.html.
Rösler, Cornelia. 2019. “Gutes Gelingen Im Kommunalen Klimaschutz!” *DEMO Impulse*, no. 11 (March): 6.
Sachs, Jeffrey D., Guido Schmidt-Traub, Mariana Mazzucato, Dirk Messner, Nebojsa Nakicenovic, and Johan Rockström. 2019. “Six Transformations to Achieve the Sustainable Development Goals.” *Nature Sustainability* 2 (9): 805. https://doi.org/10.1038/s41893-019-0352-9.
Savchuk, Katia. 2019. “The Five Best Policies to Promote Innovation — And One Policy to Avoid.” Stanford Business. October 7, 2019. https://www.gsb.stanford.edu/insights/five-best-policies-promote-innovation-one-policy-avoid.
Schenuit, Felix. 2021. “Das Verhältnis von Klimawissenschaft und Politik.” bpb.de. 2021. https://www.bpb.de/shop/zeitschriften/izpb/klima-347/336209/das-verhaeltnis-von-klimawissenschaft-und-politik/.
Schiemann, Frank, Timo Busch, Alexander Bassen, Christian Klein, Ingmar Jürgens, Ulf Moslener, Marco Wilkens, et al. 2019. “Mandatory Climate Reporting as an Instrument for CO2 Emission Reduction.” Sustainable Finance Research Platform. https://www.diw.de/documents/dokumentenarchiv/17/diw_01.c.680028.de/sfrp_policybrief2_disclosure_en.pdf.
Science Based Target Initiative. 2022. “SBTI CORPORATE NET-ZERO STANDARD.” https://sciencebasedtargets.org/net-zero.
Senge, Peter M, Benyamin B Lichtenstein, Katrin Kaeufer, Hilary Bradbury, and John S Carroll. 2007. “Collaborating for Systemic Change,” 44–47.
Sengupta, Sayanti. 2020. “Climate Action in Germany- 6 Organisations Leading the Way.” Seventeen Goals Magazin. July 23, 2020. https://www.17goalsmagazin.de/en/climate-action-6-german-organisations-show-the-way/.
Spiegel. 2022. “»Die Nächste Industrielle Revolution Muss Nun Starten«.” Spiegel Wissenschaft. November 8, 2022. https://www.spiegel.de/wissenschaft/olaf-scholz-die-naechste-industrielle-revolution-muss-nun-starten-a-f868f88d-c469-4ed1-a193-2dc68272f74b.
Statista. 2022. “CO2-Emissionen: Größte Länder Nach Anteil Am Weltweiten CO2-Ausstoß Im Jahr

2021." Statista. November 11, 2022. https://de.statista.com/statistik/daten/studie/179260/umfrage/die-zehn-groessten-c02-emittenten-weltweit/.
Stefanakis, Alexandros, Cristina Calheiros, and Ioannis Nikolaou. 2021. "Nature-Based Solutions as a Tool in the New Circular Economic Model for Climate Change Adaptation." New Circular Economic Model for Climate Change Adaptation. https://link.springer.com/article/10.1007/s43615-021-00022-3#citeas.
Stober, Evelina. 2022. "Kommunale Konzepte Zur Erreichung Der Treibhausgasneutralität Vor 2045." Dessau-Roßlau: Umwelt Bundesamt. https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2022-08-24_cc_38-2022_kommunale-konzepte-erreichung-treibhausgasneutralitaet-2045_bf.pdf.
Stolten, Detlef, Peter Markewitz, Stefan Kraus, David Franzmann, Thomas Schöb, Thomas Grube, Heidi Heinrichs, Bastian Gillessen, Jochen Linssen, and Noah Pflugradt. 2022. "Neue Ziele Auf Alten Wegen? Strategien Für Eine Treibhausgasneutrale Energieversorgung Bis Zum Jahr 2045." 3958066275. Technoökonomische Systemanalyse.
Tagesschau. 2022. "Klimaziele für 2030 kaum erreichbar." https://www.tagesschau.de/inland/innenpolitik/klimaziele-deutschland-expertenrat-101.html.
Tang, Kuok Ho Daniel. 2022. "Climate Change Policies of the Four Largest Global Emitters of Greenhouse Gases: Their Similarities, Differences and Way Forward." *Journal of Energy Research and Reviews*, no. 10 (February). http://eprints.asianrepository.com/id/eprint/2633/1/30251-Article%20Text-56691-1-10-20220216.pdf.
Tao, Ran, Muhammad Umar, Ahsan Naseer, and Ummara Razi. 2021. "The Dynamic Effect of Eco-Innovation and Environmental Taxes on Carbon Neutrality Target in Emerging Seven (E7) Economies." *Journal of Environmental Management*, no. 299 (August): 1–2.
Thiele-Eich, Insa. 2022. "Wir Brauchen Einen Systemwandel – Aber Was Genau Soll Das Heißen?" Redaktionsnetzwerk Deutschland. October 29, 2022. https://www.rnd.de/wissen/systemwandel-gegen-klimawandel-was-heisst-das-O5OOMVRD2VHVHNYQ5L7WH6IB5U.html.
Thøgersen, John. 2021. "Consumer Behavior and Climate Change: Consumers Need Considerable Assistance." *Current Opinion in Behavioral Sciences*, no. 42 (February): 9–14.
Tiseo, Ian. 2022a. "Distribution of Greenhouse Gas Emissions in Germany in 2021, by Sector." Statista. May 19, 2022. https://www-statista-com.eu1.proxy.openathens.net/statistics/989341/greenhouse-gas-emissions-by-sector-germany/.
Tiseo, Ian. 2022b. "Carbon Dioxide Emissions in Germany in 2021, by Subsector." Statista. May 20, 2022. https://www-statista-com.eu1.proxy.openathens.net/statistics/1308999/carbon-dioxide-emissions-by-subsector-germany/.
Tiseo, Ian. 2022c. "Carbon Dioxide Emissions from Energy Worldwide from 1965 to 2021, by Region." Statista. July 5, 2022. https://www.statista.com/statistics/205966/world-carbon-dioxide-emissions-by-region/.
Treuer, Friederike. 2020. "Studie Des Wuppertal Instituts Für Fridays for Future: Einhaltung Der 1,5 Grad-Celsius-Grenze Nur Mit Ausbau Erneuerbaren Möglich." BEE-EV.DE. October 13, 2020. https://www.bee-ev.de/service/pressemitteilungen/beitrag/studie-des-wuppertal-instituts-fuer-fridays-for-future-einhaltung-der-15-grad-celsius-grenze-nur-mit-ausbau-erneuerbaren-moeglich.
Umwelt Bundesamt. 2021a. "Many Companies Underestimate the Risks of Climate Change Only around Half of DAX 30 Companies Report on Climate-Related Risks." Umwelt Bundesamt. January 28, 2021. https://www.umweltbundesamt.de/en/press/pressinformation/many-companies-underestimate-the-risks-of-climate.

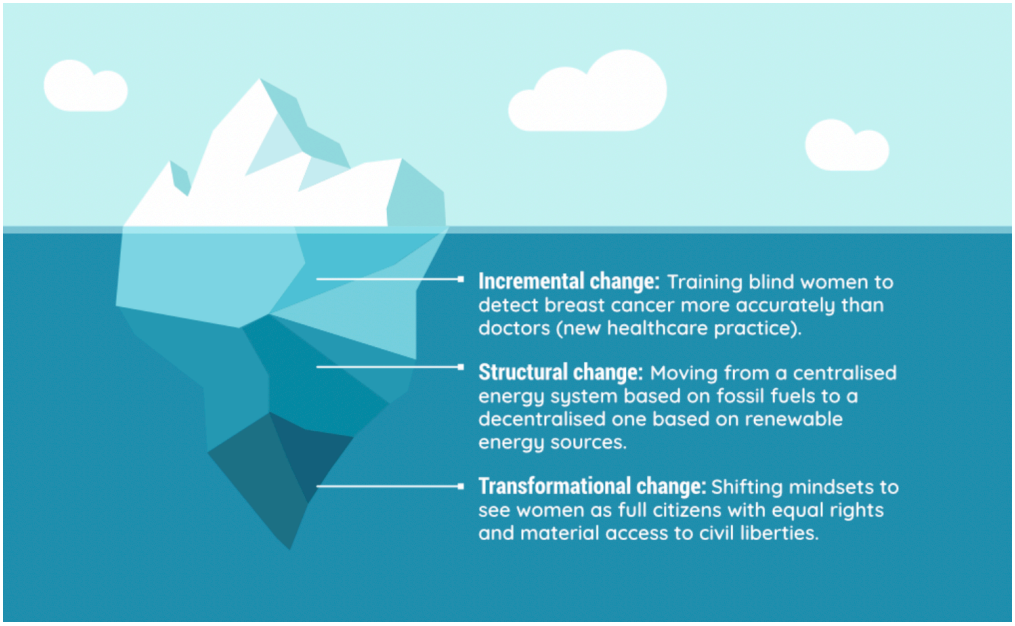
Umwelt Bundesamt. 2021b. “New Study Shows Risks of Climate Change in Germany.” Umwelt Bundesamt. June 14, 2021. https://www.umweltbundesamt.de/en/press/pressinformation/new-study-shows-risks-of-climate-change-in-germany.
Umwelt Bundesamt. 2022. “Treibhausgasminderungsziele Deutschlands | Umweltbundesamt.” Umwelt Bundesamt. February 9, 2022. https://www.umweltbundesamt.de/daten/klima/treibhausgasminderungsziele-deutschlands#nationale-treibhausgasminderungsziele.
UN. 2015. “Transforming Our World: The 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs.” United Nations. September 25, 2015. https://sdgs.un.org/publications/transforming-our-world-2030-agenda-sustainable-development-17981.
UN. 2022a. “Causes and Effects of Climate Change.” United Nations. 2022. https://www.un.org/en/climatechange/science/causes-effects-climate-change.
UN. 2022b. “Global Impact of War in Ukraine: Energy Crisis.” 3. United Nations. https://news.un.org/pages/wp-content/uploads/2022/08/GCRG_3rd-Brief_Aug3_2022_FINAL.pdf.
UN.n.d. “Goal 13 | Department of Economic and Social Affairs.” United Nations. Accessed September 6, 2022a. https://sdgs.un.org/goals/goal13.
UN.n.d. “The Paris Agreement | UNFCCC.” United Nations. Accessed September 16, 2022b. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.
UN.n.d. “What Is Climate Change?” United Nations. Accessed September 13, 2022c. https://www.un.org/en/climatechange/what-is-climate-change.
Unger, Charlotte, and Daniel Oppold. 2021. “Klimaschutz Als Aufgabe Für Politik Und Gesellschaft.” Bundeszentrale Für Politische Bildung. July 8, 2021. https://www.bpb.de/shop/zeitschriften/izpb/klima-347/336241/klimaschutz-als-aufgabe-fuer-politik-und-gesellschaft/.
Venghaus, Sandra, Meike Henseleit, and Maria Belka. 2022. “The Impact of Climate Change Awareness on Behavioral Changes in Germany: Changing Minds or Changing Behavior?” *Energy, Sustainability and Society* 12 (1): 8.
Weiner, George. n.d. “The 6 Ways to Measure Awareness Campaigns.” Whole Whale. Accessed October 17, 2022. https://www.wholewhale.com/tips/measure-awareness-campaigns/.
Weingart, Peter, Anita Engels, and Petra Pansegrau. 2007. *Von der Hypothese zur Katastrophe: Der anthropogene Klimawandel im Diskurs zwischen Wissenschaft, Politik und Massenmedien*. Verlag Barbara Budrich.
WiWo. 2019. “Greta Thunberg: Klimakrise Muss Als Notfall Behandelt Werden.” Wirtschafts Woche. December 29, 2019. https://www.wiwo.de/politik/ausland/umweltaktivistin-greta-thunberg-klimakrise-muss-als-notfall-behandelt-werden/25373408.html.
World Business Council for Sustainable Development. 2011. “A Corporate Accounting and Reporting Standard.” 2. World Business Council for Sustainable Development. https://ghgprotocol.org/corporate-standard.
Wuppertal Institut. 2020. “CO2-neutral bis 2035: Eckpunkte eines deutschen Beitrags zur Einhaltung der 1,5-°C-Grenze.” 2. Wuppertal Institut. https://epub.wupperinst.org/frontdoor/deliver/index/docId/7606/file/7606_co2-neutral_2035.pdf.
Wuppertal Institut. n.d. “Home - Wuppertal Institut Für Klima, Umwelt, Energie.” Wuppertal Institut. Accessed September 21, 2022. https://wupperinst.org/.

Appendix

Appendix 1: **Distribution of carbon dioxide emissions worldwide in 2021, by select country** (Statista 2022)

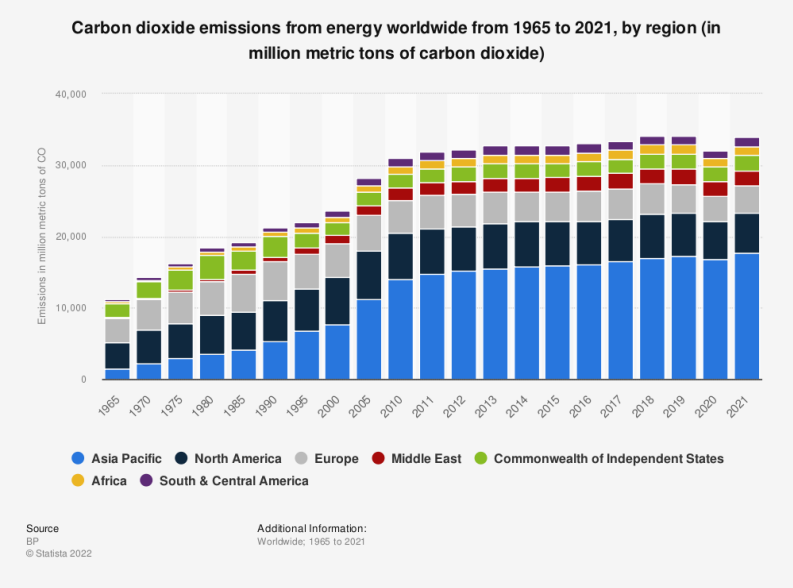


Appendix 2: **Levels of systemic change** (Catalyst 2030 2021)

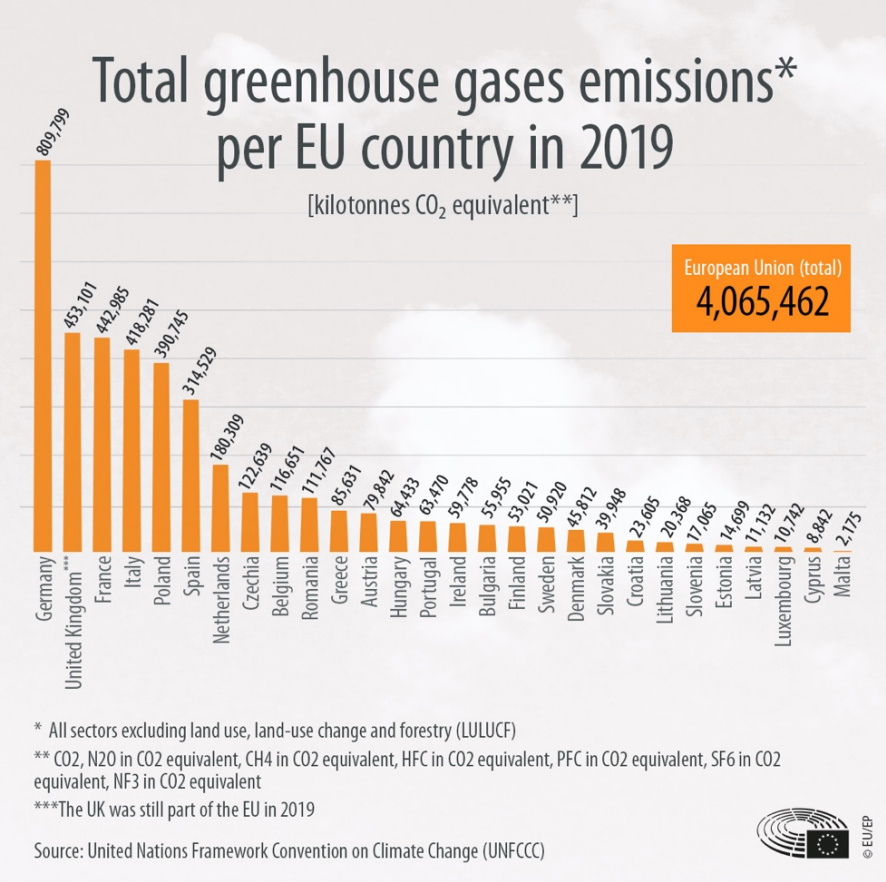


Appendix 3: **Systems change characteristics into a framework** (Catalyst 2030 2021)

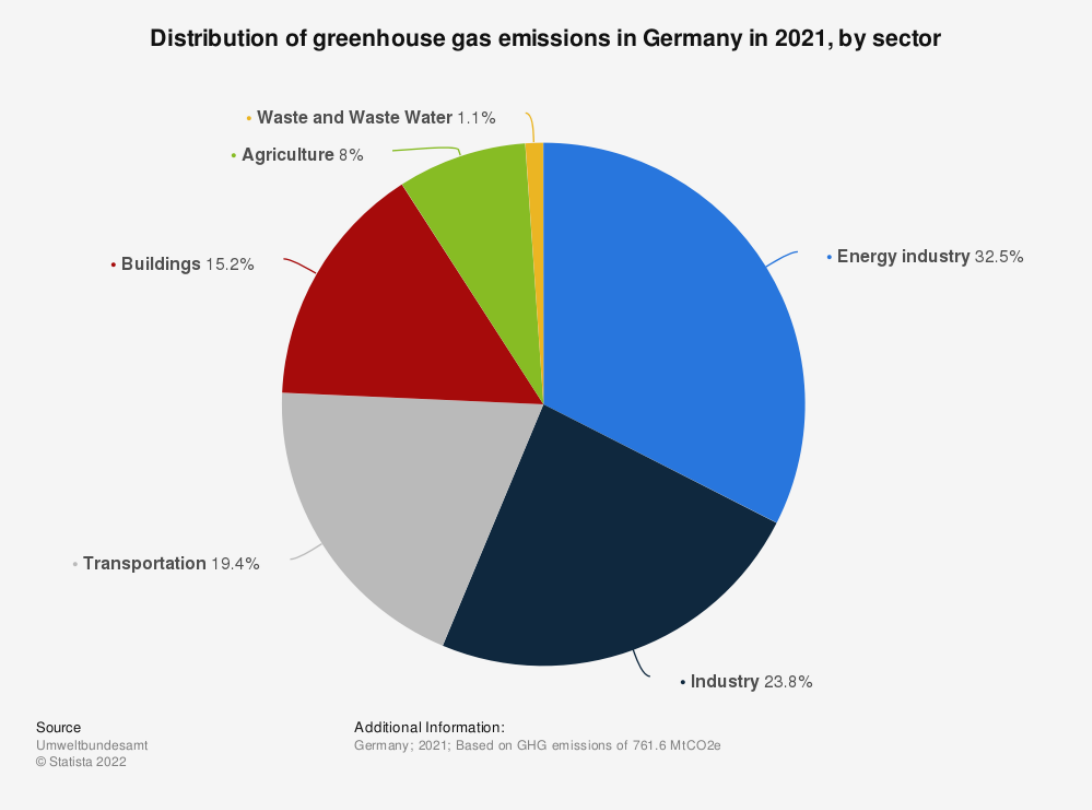
Appendix 4: **Carbon dioxide emissions from energy worldwide from 1965 to 2021, by region** (Tiseo 2022c)



Appendix 5: **EU countries by total greenhouse gas (GHG) emissions in 2019** (European Parliament 2021)



Appendix 6: **Distribution of greenhouse gas emissions in Germany in 2021, by sector** (Tiseo 2022a)



Appendix 7: **The UN Sustainable Development Goals (SDGs)** (Focus 2030 2019)

Appendix 8: **Targets of SDG 13: "Take urgent action to combat climate change and its impacts"** (UN n.d., 13)

- "13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
- 13.2 Integrate climate change measures into national policies, strategies and planning
- 13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
- 13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly US$100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible
- 13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities"

Appendix 9: **Data Table for Grounded Theory Approach**
-Please see excel attached-

Appendix 10: **Circular Economy Definition** (European Commission 2015)

Definition of the EU Action Plan for the Circular Economy: In a circular economy the value of products and materials is maintained for as long as possible; waste and resource use are minimized, and resources are kept within the economy when a product has reached the end of its life, to be used again and again to create further value.

Appendix 22: **List of Abbreviations**

- CCS = Carbon Capture and Storage
- CCUS = Carbon Capture, Utilization, and Storage
- CDM = Clean Development Mechanism
- CO2 = Carbon dioxide
- CR = Corporate Responsibility
- CTS = Clean Technology Scenario
- ENGO = Non-governmental organization in the field of environmental protection
- ESG = Environmental, Social and Governance
- ETS = Emission Trading Scheme
- EU = European Union
- GHG = Greenhouse Gas
- Green-tech = Green technology
- GT = Grounded Theory
- Gt = Gigatons
- IEA = International Energy Agency

- IPCC = Intergovernmental Panel on Climate Change
- KPIs = Key-Performance-Indicators
- NGO = Non-Profit Organization
- R&D = Research and development
- SaaS = Software as a Service
- SBTi = Science Based Targets-Initiative
- SDGs = Sustainable Development Goals
- SDS = Sustainable Development Scenario
- TTCSP = Think Tanks and Civil Societies Program
- TÜV = Technischer Überwachungsverein
- UN = United Nations
- UNEP = United Nations Environment Program
- VC = Venture Capital
- VW = Volkswagen
- WCED = World Commission on Environment and Development
- WI = Wuppertal Institute
- WMO = World Meteorological Organization