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Scenario Analysis for Net Zero: The Applicability of Climate Neutrality Studies for Transitioning Firms in the German Building Sector and Energy-intensive Industry*

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Abstract

Various stakeholders are increasingly encouraging companies from the real economy to adopt measures facilitating their transition towards carbon neutrality. In this context, companies are expected to implement forward-looking strategies and climate-related reporting practices using scenario analysis aligned with scientific evidence and credible pathways to net zero carbon emissions. This paper examines the potential of scenario analysis as an element for transitioning to net zero. We review and compare eight existing economy and sector level climate neutrality studies for Germany that were published between 2019 and 2021, analysing their respective applicability as a science-based reference scenario for companies to strengthen strategy development and forward-looking reporting practices. Using the logical framework approach, we assess relevant transition indicators like technologies, energy and resource efficiency, carbon pricing, and other steering instruments for the building and energy-intensive industry sectors. These indicators measure progress towards climate neutrality and could be included as a crucial component in transition plans. We find that, although modelling approaches for the studies differ, they often converge on similar results that can partially be translated to indicators at the firm level and, thereby, may serve as reference scenarios for their transition planning.

Keywords: Climate Change, Scenario Analysis, Decarbonisation, Sustainability Reporting, Transition Plans, Sectoral Pathways, Building Sector, Energy-Intensive Industry Sector

JEL-Codes: G32, M41, M48, L52, L61, L85, Q51, Q58

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1 Introduction

The urgent challenges posed by climate change are recognised by an increasing number of companies from the real economy. Driven by regulatory pressure and investor demand, amongst others, more and more companies are eager to have their “net zero” pledges verified and validated. So far, several tools, methods, and initiatives exist to verify and validate emission reduction targets by complementing them with credible pathways or so-called “transition plans” (ICMA, 2022; OECD, 2022).[2]

One of the key challenges for corporate transition plans is ensuring credibility and comparability so that the information can be effectively assessed by regulators and financial institutions (Caldecott & Shrimali, 2023; CBI, 2023; Dikau et al., 2022; ECB, 2023; ICMA, 2022; OECD, 2022; TPT, 2022). One approach to developing a credible pathway for transition plans is the tool of scenario analysis (TCFD, 2020), which enables companies to adapt to changing circumstances (Gordon et al., 2020), especially in the context of sustainability (Villamil et al., 2022). Thereby, it may not only be beneficial for the companies but also for investors. First, scenario analysis can serve as an instrument of forward-looking firm-level management and strategy development (TCFD, 2020). Secondly, it can be employed for risk assessment by banks, investors, and financial market regulators to ensure financial stability through “scenario-informed” comparable and robust information (Baer et al., 2022; Dikau et al., 2022; ECB, 2023). Thirdly, it can be used as a communication tool between investors and companies as scenarios can serve as a benchmark to assess and manage the risk of individual borrowers and their portfolios (Huiskamp et al., 2022; Kempa et al., 2021). This represents an opportunity for carbon-intensive sectors that still heavily depend on emissions-intensive practices and, thereby, risk being divested by financial players that currently still rely on sector-level emission data (Baer et al., 2022; Neuhoff et al., 2021).

Some of the international initiatives, frameworks, and reporting standards, including the Task Force on Climate-related Financial Disclosures (TCFD) and the Carbon Disclosure Project (CPD), call for the inclusion of forward-looking elements in climate-related reporting standards, such as scenario analysis (CDP, 2023; TCFD, 2017, 2020, 2021).

To date, however, the European reporting landscape lacks a compelling requirement for companies to proactively disclose their decarbonisation targets and measures in a forward-looking manner, based on credible, science-based scenarios. In a most recently published delegated act, the European Commission adopted the first set of the European Sustainability Reporting Standards (ESRS) implementing the Corporate Sustainability Reporting Directive (CSRD) that foresees transition plans as an element to reform sustainability reporting (European Commission, 2023). The application is, however, subject to a materiality assessment and the concrete elements of transition plans remain rather vague.

[2] Further environmental and social aspects are important regarding the transitions but are not subject to this analysis.

A more concrete proposal for forward-looking reporting has been brought forward by the UK in 2022. It was the first country to launch a Transition Plan Taskforce (TPT), which developed a sector-neutral disclosure framework and implementation guidance after the UK government pledged at the UN COP26 climate summit that UK-listed businesses would have to publish decarbonisation plans by 2023 (TPT, 2022). The topic continues to gain momentum (TPT, 2023) and also other countries like Japan, Singapore, New Zealand, Hong Kong or Australia will soon implement or are in the process of developing forward-looking climate-related disclosures (Australian Treasury, 2023; Hong Kong Stock Exchange, 2023, 2023; Japan Financial Services Agency, 2022; Monetary Authority of Singapore, 2023).

While the idea to integrate transition plans and other forward-looking tools, such as scenario analysis in corporate reporting, has gained momentum, the challenge on how to ensure comparability and credibility remains (Caldecott & Shrimali, 2023; CBI, 2023; Dikau et al., 2022; ECB, 2023; Kreibich et al., 2021; OECD, 2022; Shrimali, 2023; TPT, 2022).

At the economic and sectoral levels, scientific studies can offer guidance on how climate neutrality can be achieved. After Germany anchored its path to net greenhouse gas (GHG)[3] neutrality by 2045 in the so-called "Klimaschutzgesetz" (English "Climate Protection Act", hereinafter referred to as KSG) in 2019, various climate neutrality studies have investigated how the objective of net zero can be achieved along sectoral decarbonisation pathways. These so-called "normative scenarios" (Borjeson et al., 2005) present a comprehensive breakdown of the various sectoral levers of transition, including, but not limited to, technologies, energy and resource efficiency, and policy instruments, and then outline their respective roles in achieving often sector-specific emission reductions. Using sectoral decarbonisation pathways for a specific country, such studies can play a crucial role for aligning a firm's strategy with a credible path to net zero as its successful implementation very much depends on geographical and national factors (Kampmann et al., 2023). Furthermore, the mere focus on global emissions pathways for setting science-based company targets may exceed carbon budgets (Bjørn et al., 2021). Sectoral decarbonisation pathways are more precise and take individual sectoral framework conditions into account (Caldecott & Shrimali, 2023; Schweitzer et al., 2023).

This paper aims to explore the applicability of such normative net zero scenarios[4] (NZS) as a reference in corporate climate transition plans and reporting for the case of Germany. Despite the growing importance of climate neutrality in corporate reporting, a significant gap remains in academic literature

[3] The EU and the United Nations Framework Convention on Climate Change (UNFCCC) use the terms climate neutral and greenhouse gas neutral as synonyms in their official communications. However, the Federal German Government distinguishes between the terms "greenhouse gas neutral" and "climate neutral" in the KSG. While greenhouse gas neutrality is understood as the final state for 2045 in the sense of the sum of a domestic measurement for Germany, "climate neutral" can also include the purchases of third countries. In the paper, we use the terminologies climate neutrality, greenhouse gas neutrality and net zero as synonymous and understand them to mean the "domestic" net greenhouse gas neutrality as defined in the KSG.

[4] In this paper, we understand climate neutrality studies to be a case of normative climate scenarios and, thus, use these terms as synonyms here to the greatest extent possible.

regarding the systematic assessment of existing NZS' applicability to a company's decarbonisation strategy. To fill this gap, this paper provides a systematic analysis of the transition levers for the building sector and energy-intensive industries (steel, cement, chemicals) identified in selected NZS for Germany. The building and industry sector alone accounted for about 40 percent of direct CO_2-emissions in Germany in 2022 (Umweltbundesamt, 2023) and, thus, are of utmost relevance for Germany's decarbonisation efforts. Employing the theoretical framework of the "LogFrame" model (Hale et al., 2021; Sartorius, 1991), we further contextualize our findings and derive implications for transitions indicators at firm-level that go beyond CO_2-emissions (Dikau et al., 2022; Kampmann et al., 2023) and also incorporate the idea of early indicators (Fietze et al., 2021; Lester & Neuhoff, 2009; Sartor, 2016). Thereby, our research can offer an academic and practical contribution to the ongoing efforts to improve corporate forward-looking climate-related reporting.

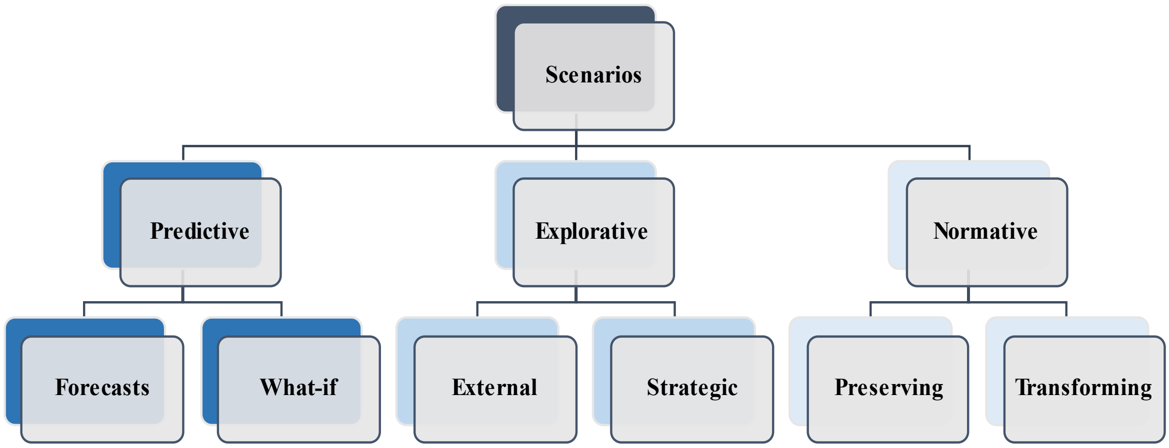
The paper is structured as follows. Section 2 sheds light on different types of scenarios and their application in the context of climate change and how scenario analysis applies at the company level. Our research design, data, and methods are described in section 3. In section 4, we systematically synthesize findings of selected NZS for Germany along the main identified transition levers. Based on these findings and the theoretical background, we derive implications for transition indicators that can be derived from the NZS for forward-looking strategy development and reporting as well as provide illustrative examples for the building sector. Section 5 concludes and gives a set of broader policy recommendations.

2 Background and theoretical framework

2.1 Different types of scenarios

To grasp the intricacies of scenarios, it is essential to differentiate between various types and levels of scenarios. Generally, scenarios serve to rigorously investigate how various future situations may unfold and how strategic interventions can be undertaken to attain desired outcomes while mitigating or avoiding undesirable ones. Borjeson et al. (2005) determine three different types of scenarios originating from different angles of questions (see also Figure 1). The first category relates to predictive scenarios that try to answer the question "What will happen?" such as forecasts or what-if scenarios. By contrast, so-called explorative scenarios are guided by the question "What can happen?" and, therefore, these scenarios are explorations of what might occur in the future, regardless of opinions about what is desirable or what is thought to be likely to occur. Finally, the last category of the typology comprises normative scenarios that try to answer how a specific target can be achieved, focusing on potential approaches. This category can be further differentiated between preserving and transforming scenarios. Consequently, these scenarios can be utilized for distinct purposes and contexts depending on the user's perspective and agenda.

Figure 1: Graphical visualization of different scenario types



Source: Authors' graph based on scenario typology by Borjeson et al. (2005).

2.2 Scenario analysis in the context of climate change

In the context of climate change research, scenarios are a long-standing key component for assessing the uncertainty of climate-related developments (Beck & Mahony, 2018).

In climate research, scenarios are used to determine the likely outcome of emission concentrations in our atmosphere on climate-related indicators like extreme weather events, temperature, or drought. Well-known climate research scenarios include, among others, the representative concentration pathways (RCPs), which the Intergovernmental Panel on Climate Change (IPCC) presented in its fifth assessment report. RCPs consider the growing GHG concentration and the additional radiation drive resulting from this as the basis for the simulations (Girod et al., 2009). The so-called shared socioeconomic pathways (SSPs) scenarios have supplied the economic and societal justification for the RCP scenarios in the latest sixth assessment report of the IPCC, concentrating on factors like demographics, health, education, economic growth, technological change, and policy orientations (Abram et al., 2019). While the RCP scenarios represent an example of predictive scenarios, the SSP rather represents a mix of predictive and explorative scenarios, as a wide range of plausible societal and climate futures from 1.5°C to over 3°C warming by 2100 is provided (Girod et al., 2009; Huiskamp et al., 2022).

As these predictive and explorative climate scenarios illustrate the drastic consequences of climate change, they have, in turn, informed and supported policy outcomes, such as the renowned Paris Agreement of 2015 (Beck & Mahony, 2018), in which the 21st Conference of the Parties (COP) to the UNFCCC agreed to limit global warming to well below two degrees, preferably to 1.5 degrees (United Nations, 2015). Subsequently, corresponding steps were also taken at the European level. The European Commission's proposal of a so-called "European Green Deal" (EGD) was explicitly aimed at strengthening 'the efforts of the EU and its industries to meet the global climate objectives of the Paris Agreement' (European Commission, 2019, p. 5). The EGD not only corroborates the Paris Agreement, but it also sets out the goal that Europe's economy and society are to become climate-neutral by 2050 which was written into law in the European Climate Law (European Union, 2021). Consequently, national governments introduced climate neutrality laws to contribute to this new agenda (Roelfsema et al., 2020), like in the case of Germany as elaborated earlier.

To deal with these new challenges, several scenarios and studies that examine on the one hand, how the set normative goals of GHG neutrality can be achieved and, on the other hand, what opportunities and risks arise from climate change and the transition to climate neutrality have been published.

As mentioned earlier, a couple of scientific NZS investigate how climate neutrality can be achieved for the case of Germany along different transition levers like technologies as well as resource and energy efficiency in specific sectors. In addition to national NZS for GHG neutrality, there are also international NZS that show different (sector) pathways for emission reductions. The NZS of the International Energy Agency (IEA), among others, are of utmost importance here (G7 Climate, Energy and Environment Ministers, 2022).

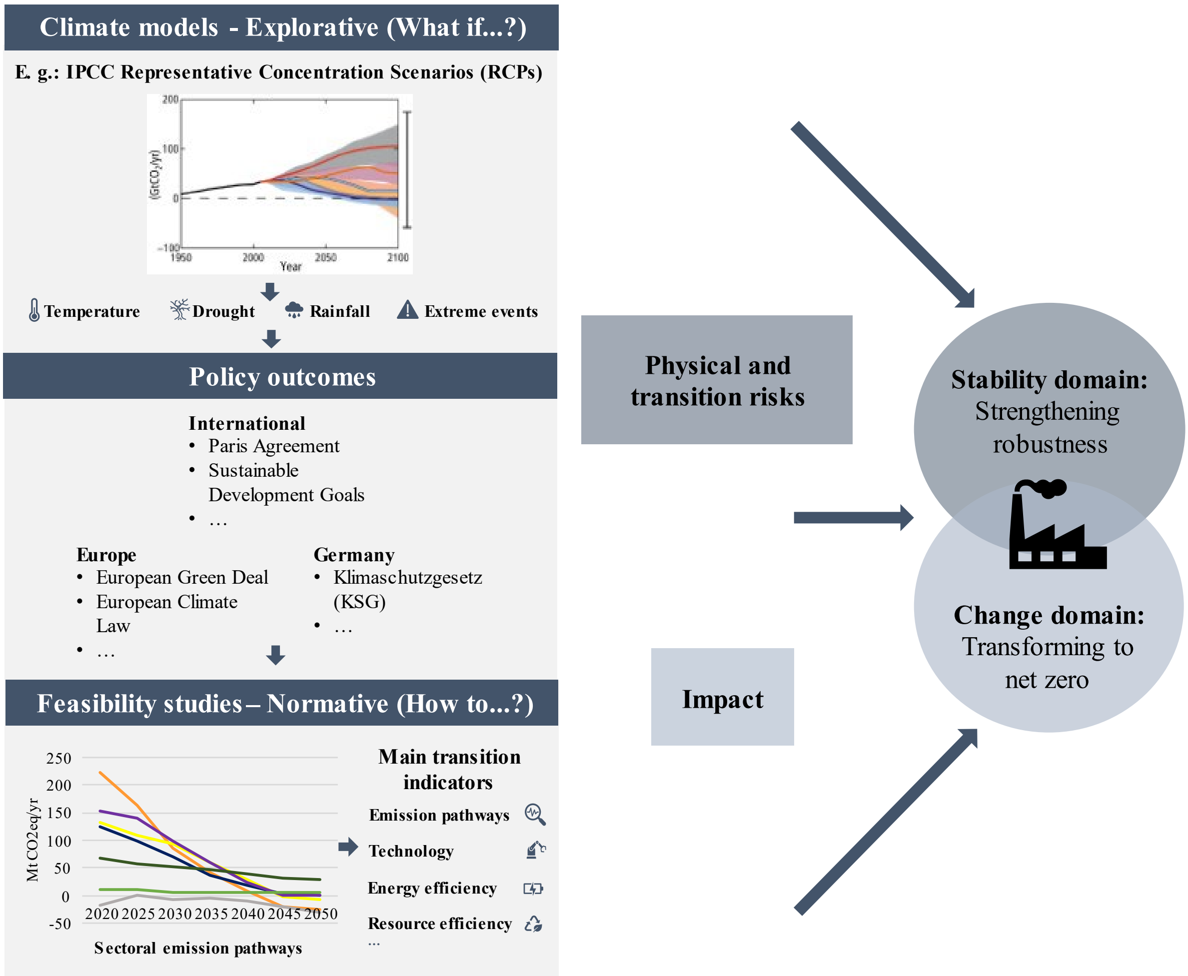
In addition to these normative NZS that examine the feasibility of achieving the goal of climate neutrality, exploratory climate-related scenarios attempt to illustrate this uncertainty along different pathways and make it more tangible for stakeholders from the business community. For example, the Network for Greening the Financial System (NGFS) provides a set of four hypothetical climate scenarios, offering a common and current point of reference for comprehending how developments in climate change (physical risk) and climate policy and technological trends (transition risk) can evolve in different ways (Bertram et al., 2020; NGFS, 2021). These scenarios are designed for financial institutions as a tool for stress testing and scenario analysis. They encompass a variety of potential future events in the climate, economy, and policy space (Bertram et al., 2020).

2.3 Use of scenarios at the company level

These various types of climate-related scenarios also have different areas of application at the company level. Generally, while the tool of scenario analysis has contributed to the ability of companies to adapt to changing circumstances over time (Gordon et al., 2020), methodological confusion persists (Balarezo & Nielsen, 2017).

In the context of using scenario analysis in order to build “climate resilience” at the firm level, Huiskamp et al. (2022) differentiate between the “stability domain” and the “change domain” of a firm, as illustrated in Figure 2.

Figure 2: Different application areas of climate-related scenarios at the company level



Source: Authors' graph. The stability and change domain is inspired by the work of Huiskamp et al. (2022).

The stability domain refers to ensuring a company's robustness towards different transition and physical risks by analysing "What-if-scenarios" and, thus, can be attributed to firm-level risk management. Here, two types of climate risks are important: transition risks and physical risks. Transition risks refer to the financial and economic impacts of the transition to a low-carbon economy, including policy and regulatory changes, but also technological disruption and shifting consumer preferences. By contrast, physical risks refer to the direct physical impacts of climate change, such as more frequent and intense natural disasters, sea-level rise, as well as changes in temperature and precipitation patterns. These risks can affect a company's physical infrastructure, supply chains, and operations, potentially leading to disruptions, damage, and losses (Clark, 2019). By understanding and managing these risks, companies can better position themselves to thrive in a rapidly changing global economy.

By contrast, the change domain refers to the transformation of a 'business model or value chain towards a net-zero economy' (Huiskamp et al., 2022, p. 1765) and, thus, to the strategy development of a firm. This requires a comprehensive approach that involves reducing GHG emissions across all aspects of a company's operations and value chain. In order to translate information from scenarios to the change domain – e. g. through setting specific targets –, different approaches can be distinguished (Bjørn et al., 2021; Faria & Labutong, 2020; Schweitzer et al., 2023). Two common approaches are the so-called Absolute Contraction Approach (ACA) (Faria & Labutong, 2020) and the Sectoral Decarbonization Approach (SDA) which are also used by the Science Based Targets-Initiative (SBTi, 2021). The ACA is the most straightforward; it calls for each company to reduce its emissions at the same annual rate necessary globally to achieve a set temperature goal (Bjørn et al., 2021). By contrast, the SDA builds on sectoral pathways to take into account emission intensities per tonne of product in a given sector (Griffin & Heede, 2017). The SDA approach is also used by the Transition Pathway Initiative to assess a company's preparedness for the transition to a low-carbon economy (Transition Pathway Initiative, 2022). These two approaches are however limited to emissions and could be complemented by other decarbonisation levers like technologies, energy efficiency or material efficiency.

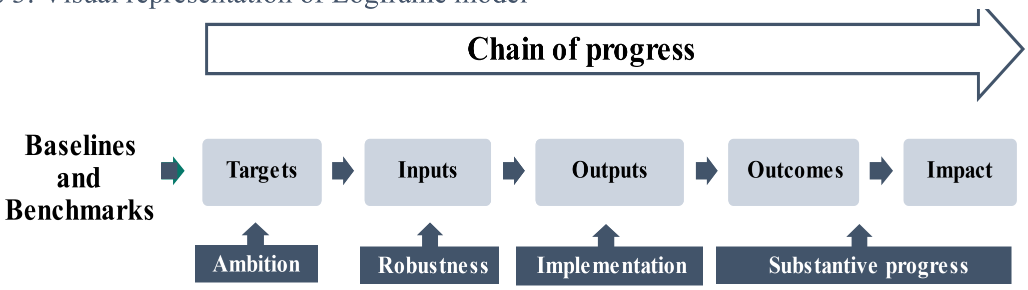
While scenario analysis has already proven its practical relevance in the context of climate-related risk analysis (stability domain) for companies (Hillmann & Guenther, 2021; Linnenluecke & Griffiths, 2012; TCFD, 2022; Weinhofer & Busch, 2013), it has not gained the same level of prevalence in corporate strategy development or in the change domain of a company so far. According to the TCFD recommendation, the impact of climate-related risks and opportunities on current operations, corporate strategy, and financial planning should be disclosed where possible, as well as how resilient the strategy is when incorporating different climate-related scenarios, including a "2 degrees or lower" scenario (TCFD, 2017). The TCFD has also published guidance on transition plans, which is recognized as part of a company's climate strategy that belongs to a company's business strategy, but clearly distinguishes it from a company's adaptation plan, which takes care of climate-related risks and opportunities (TCFD, 2021). However, until now only a few companies have released 'comprehensive dedicated transition plan reports' (TCFD, 2022, p. 71). For the largest 100 companies in Germany, there is no case where a company systematically assesses the resilience of its business strategy against a climate-related scenario (Loew et al., 2021).

3 Research design: data and methods

This paper analyses existing NZS that study how to achieve climate neutrality in Germany. We evaluate eight studies that were published between 2019 and 2021, inclusively, that show, both on a macro and sectoral level, how the German economy can decarbonise by 2045 or 2050 (see Table 1). The focus is exclusively on studies that adopt a macro approach, encompassing the entire economy, rather than being limited to a single sector. Since scientific databases such as Scopus or Web of Science cannot be accessed for studies of this kind, the documents were researched using the Google search engine.

In the first step, we analyse relevant NZS and synthesise key outcomes to identify the most relevant transition levers for companies in the building and energy-intensive industry sector. Some of the NZS also contain several models and scenarios which we do not discuss in detail but specify accordingly if a reference value only refers to a specific model or scenario of an NZS. Second, we align these different levers of indicators – late and early – using the so-called "Logical Framework" (LogFrame) (Sartorius, 1991). Building on the Sartorius model, Hale et al. (2021) apply the LogFrame model to the context of measuring the progress of climate policy, where it models the impact of climate action 'as a causal chain from the targets actors set (which may be quantitative or qualitative, and apply to mitigation, adaption, or other spheres) against relevant baselines and benchmarks), to the inputs they bring to bear, to the outputs they create, to the direct and indirect outcomes and impacts to which these outputs contribute' (Hale et al., 2021, p. 410). The relationship between these processes and elements is shown in Figure 3.

Figure 3: Visual representation of Logframe model



Source: Authors' graph based on LogFrame model after Hale et al. (2021).

In the context of climate action, the focus is often on CO_2 or GHG emissions, hence an outcome or impact indicator. However, this indicator of substantive progress only 'refers to the final parts of the causal chain' (Hale et al., 2021, p. 411). However, as suggested by several scholars, there should also be early indicators, arguing that change is signalled earlier by, for example, input and output indicators than by outcome indicators (Hsu & Mapes, 2021; Lester & Neuhoff, 2009; Sartor, 2016). Fietze et al. (2021) also highlight the importance of early indicators in the context of the German KSG. Thus, the LogFrame model for indicators will help to establish a basis for transition indicators that go beyond GHG emissions and that can be used at different stages of progress. Finally, we derive conclusions about the implementation of transition plans and their alignment with existing frameworks.

Table 1: Overview of analysed NZS

Title	Scope	Date	Involved institutions	As cited in text
Wege in eine ressourcenschonende Treibhausgasneutralität	Macro and sectoral level in Germany, GHG neutrality in 2050	June 2020	Federal Environment Agency (Umweltbundesamt)	UBA CN 2050
Langfristszenarien für die Transformation des Energiesystems in Deutschland 3	Macro and sectoral level in Germany, GHG neutrality in 2050	May 2021	Corsentec, Fraunhofer Institute for Systems and Innovation Research (Fhg-ISI), Institute for Energy and Environmental Research Heidelberg (ifeu), Technical University Berlin (TU), on behalf of Federal Ministry for Economic Affairs and Climate Action (BMWK)	BMWK CN 2050
Klimaneutrales Deutschland 2045	Macro and sectoral level in Germany, GHG neutrality in 2045	April 2021	Prognos, Öko-Institut, Wuppertal Institut, on behalf of Stiftung Klimaneutralität, Agora Energiewende, Agora Verkehrswende	Agora CN 2045
Net-Zero Deutschland. Chancen und Herausforderungen auf dem Weg zur Klimaneutralität bis 2045	Macro and sectoral level in Germany, GHG neutrality in 2045	Sept. 2021	McKinsey	McKinsey CN 2045
Klimapfade 2.0. Ein Wirtschaftsprogramm für Klima und Zukunft	Macro and sectoral level in Germany, GHG neutrality in 2045	Oct. 2021	Boston Consulting Group (BCG), on behalf of Federation of German Industries (BDI)	BDI Klimapfade 2.0
Dena Leitstudie. Aufbruch Klimaneutralität	Macro and sectoral level in Germany, GHG neutrality in 2045	Oct. 2021	Institute of Energy Economics at of the University of Cologne (EWI), Institute for Technical Building Equipment (ITG), Environmental Energy Law Foundation (SUER), Research Institute for Thermal Insulation (FIW), Jacobs University Bremen (JUB), Wuppertal Institute for Climate, Environment, Energy gGmbH (WI), on bedalf of Deutsche Energie-Agentur (dena)	dena CN 2045
Deutschland auf dem Weg zur Klimaneutralität 2045. Szenarien und Pfade im Modellvergleich	Macro and sectoral level in Germany, GHG neutrality in 2045	Oct. 2021	PIK, MCC, Paul Scherrer Institute (PSI),RWI, Fraunhofer Institute for Systems and Innovation Research (FhG-ISI), German Aerospace Center - Institute for Networked Energy Systems (DLR-VE), German Aerospace Center - Institute of Transport Research (DLR-VF), Institute of Energy Economics and Rational Energy Use (IER), German Aerospace Center - Institute of Vehicle Concepts (DLR-FK), Fraunhofer Institute of Energy Economics and Energy Systems Engineering (FhG-IEE), Helmholtz Centre Hereon, Fraunhofer Research Institution for Energy Infrastructures and Geothermal Energy (FhG-IEG), on behalf of Kopernikus-Projekt Ariadne	Ariadne CN 2045
Wege zu einem klimaneutralen Energiesystem. Die deutsche Energiewende im Kontext gesellschaftlicher Verhaltensweisen.	Macro and sectoral level in Germany, GHG neutrality in 2045	Nov. 2021	Fraunhofer Institute for Solar Energy Systems (FhG-ISE)	FhG-ISE CN 2045

4 Results

4.1 Findings of Net Zero Scenarios for Germany

Despite variations in modelling methodologies and granularity, the analysed NZS tend to converge on the implications for key transition elements, including technologies, energy efficiency, sufficiency, resource efficiency, regulatory instruments, and investment requirements. Therefore, to structure the analysis of the NZS, the following six elements are chronologically considered in this analysis:

- Emission pathways
- Technologies
- Energy efficiency
- Resource efficiency
- Carbon pricing
- Other policy instruments

Transition levers like sufficiency and investments needed are of equal importance in most of the studies but will be omitted from this analysis to reduce complexity. It is noteworthy that the synopsis presented below regarding the levers of transition does not entail a uniformity of values, but rather represents a spectrum derived from diverse suppositions and frameworks across various studies. Nor does it represent a complete assessment of the studies but emphasizes the essential commonalities, including their implications and limitations. We also do not compare assumptions like population growth, GDP growth, or other similar elements of the studies.

Emission pathways

Emission pathways are provided in most of the studies and give companies some initial guidance on the level of ambition they are pursuing in their decarbonisation efforts. It should however not be the sole focus of target-setting on company level in the sense of the ACA as introduced above.

Figure 4 illustrates the emission pathway for both the building and the energy-intensive industry sectors for the NZS of Agora CN 2045, Ariadne CN 2045, BDI Klimapfade 2.0 and dena CN 2045.[5] For the building sector, emissions for the different scenarios decrease rapidly from an average of about 123 megatons (Mt) CO_2-equivalents (CO_2eq) in the period from 2018 to 2020[6] to 71 Mt CO_2eq in 2030. By 2045, residual emissions of about 1 Mt CO_2eq remain on average. The scenario with the sharpest decrease is modelled by the lead model for this sector "REMod" of the Ariadne CN 2045 study, which

[5] The NZS from BMWK CN 2050 and UBA CN 2050 also provide emission pathways which however relate to the climate neutrality in the years 2050 and are therefore excluded for reasons of comparability in the graph. The NZS from FhG-ISE also provides an emission pathway, but only for energy-related emissions. The NZS from McKinsey does not provide an emission pathway.

[6] As the net zero studies considered in this study have different baseline years, we use a baseline period rather than a baseline year as basis for comparison.

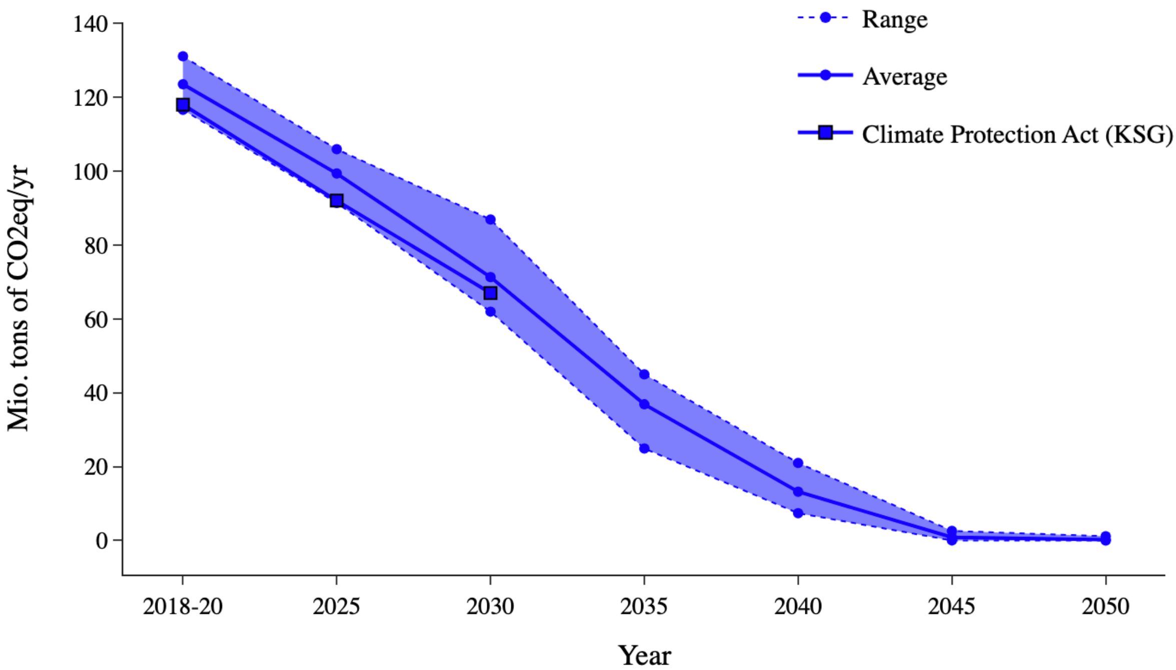
is characterised by ambitious assumptions for the use of heat pumps, connections to district heating, and a high renovation rate. Here, a reduction in emissions to around 62 Mt CO_2-equivalents is already assumed by 2030, which is represented by the lower bound of the range in Figure 4. Apart from that, the emission pathways all show a similar course and are approximately aligned with the KSG emission ceiling that lies within the range of the models.

For the industrial sector, emissions decrease rapidly from an average of about 153 MT CO_2eq in the period from 2018-2020 to 97 Mt CO_2eq in 2030. In 2045, on average about 5 Mt CO_2eq of negative emissions per year can be achieved through CO_2 capture and storage, Carbon Capture Utilisation (CCU) and Carbon Capture Storage (CCS), among others. Emissions in the lead model for this sector "FORECAST" of the Ariadne CN 2045 study already decrease drastically by 2030 to 72 Mt CO_2eq. This significant reduction is due to the fuel switch (for steam generation and furnaces) to electricity, hydrogen, and gas.

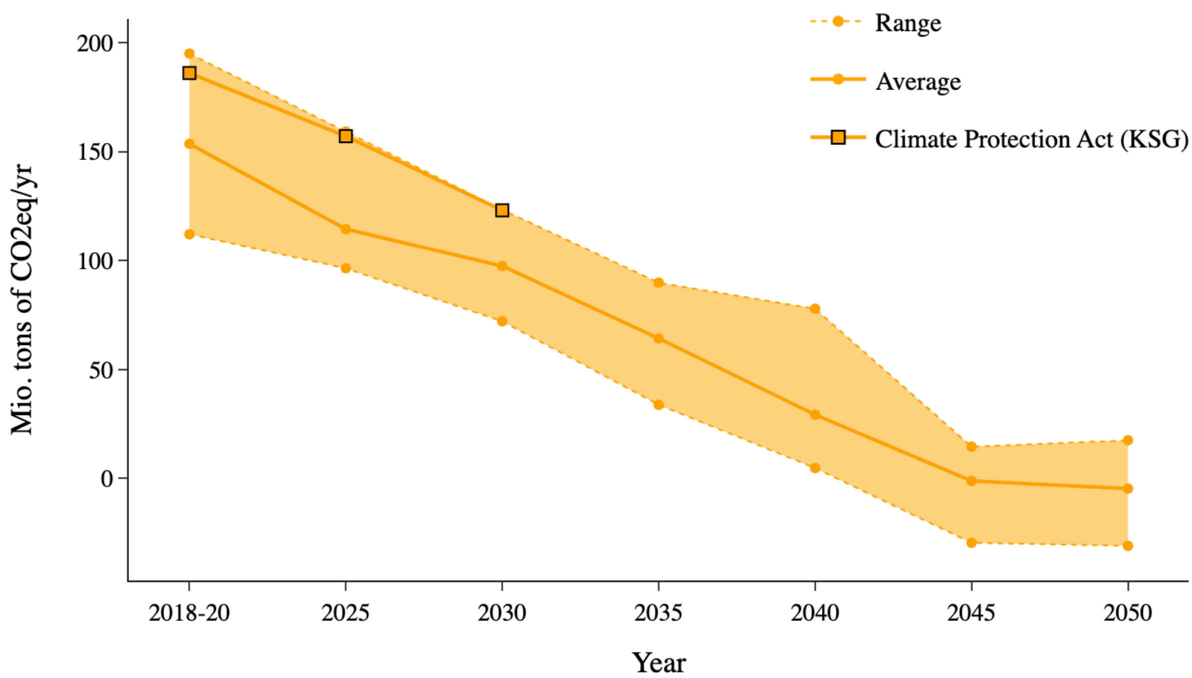
While this only represents the emissions development at sectoral level, companies may well use this as a reference for their own emissions reductions. As the pathways for both sectors illustrate, most emissions reductions will need to occur by 2030, which companies should also consider in their own decarbonisation strategy. As explained earlier, GHG emissions can serve as a target to set the ambition level but should not be the sole focus of decarbonisation efforts.

Figure 4: Development of emission paths for building and industry sector in selected NZS

a) Building sector Mt CO_2eq



b) Industry sector Mt CO_2eq

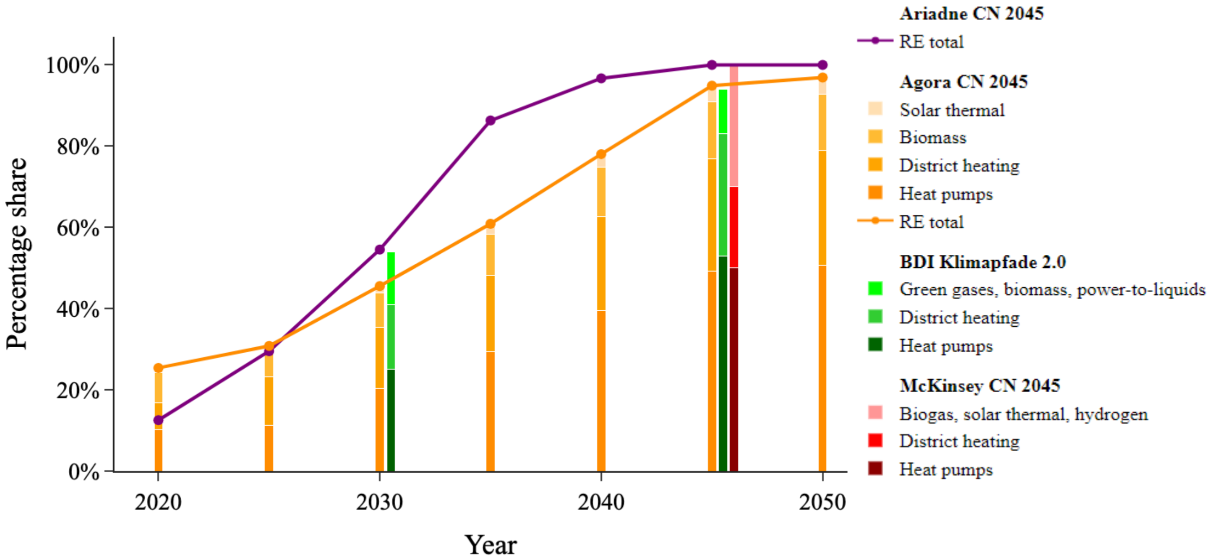


Source: Authors' graphs based on NZS from Agora CN 2045, Ariadne CN 2045 *[average across all models],* BDI Klimapfade 2.0 and dena CN 2045. Given the different baseline years of the studies, we summarized them for simplification reasons at one point of time.

Technologies

The use of climate-friendly technologies is of high importance in all scenarios and, therefore, can provide a good benchmark of technological feasibility for both companies and investors. For the building sector, all scenarios emphasize the outstanding importance of the implementation of renewable heat technologies, like heat pumps and heat grids. To achieve climate neutrality by 2045, about 4 to 9 million heat pumps need to be in use by 2030 and by 2045 to 2050 about 13 to 16 million heat pumps (Agora CN 2045, Ariadne CN 2045 [REMod], BDI Klimapfade 2.0, BMWK CN 2050 [TN-Strom], dena CN 2045). This requires the number of heat pumps to increase by about 400,000 - 500,000 units per year until 2030 (dena CN 2045, Ariadne CN 2045 [REMod]). The number of buildings connected to heating networks is expected to increase from 1.3 million in 2020 to about 1.75 million in 2045 (dena CN 2045) or to even 4.4 million buildings by 2050 (BMWK CN 2050 [TN-Strom]). Until 2030, 160,000 to 220,000 dwellings (Ariadne CN 2045 [REMod], Agora CN 2045) per year should be connected to district heating networks, and between 2030 and 2045, 340,000 per year (Agora CN 2045). While the absolute numbers of implemented renewable energy (RE) technologies may be less relevant for companies in practice, the relative numbers of implied technologies provide an indication for development until 2045, as shown in Figure 5. The figure shows the share of RE technologies used in the building and heating sector according to selected studies. As can be seen from the graph, by 2030, the share of RE technologies already reaches around 46 to 55 percent, increasing thereafter to around 94 to 100 percent in 2045, with heating pumps being the dominant technology, at around 50 percent.

Figure 5: Representation of the share of renewable energy in the building and heating sector (residential and commercial buildings)



Source: Authors' graph based on NZS of Agora CN 2045, Ariadne CN 2045, BDI Klimapfade 2.0 and McKinsey CN 2045. The share of RE technologies from the Ariadne CN study refers to the overall heating sector from the REMIND-EU model.

Furthermore, the studies assume a phase-out of certain technologies, such as the replacement of all fossil fuel technologies by 2045 or 2050 (Agora CN 2045, BMWK CN 2050 [TN-Strom]). Immediately (UBA CN 2050) or 2030 at the latest, no new oil or gas boilers will be installed, if possible, so that they are phased out by 2045 or 2050 (BDI Klimapfade 2.0, BMWK CN 2050 [TN-Strom], McKinsey 2045, Agora CN 2045).

In the industry sector, for the primary steel industry, the widespread introduction of the H_2 direct reduction installation (DRI) by 2030 is assumed in all studies. By using green hydrogen as well as renewable energies, primary steel production is assumed to be almost completely decarbonised. To achieve GHG neutrality in 2045, about 1.3 million tonnes per year of primary steel capacity will be replaced with DRI plants until 2030 and from 2030 onwards about 1.05 million tonnes per year (Agora CN 2045). That means that the share of steel produced via the DRI-route increases to a minimum of 20 percent by 2030 and to over 50 percent by 2045 (BDI Klimapfade 2.0, Agora CN 2045, Ariadne CN 2045 [FORECAST]).

Unlike in the steel industry, no fundamental replacement of existing technologies is necessary in the chemical industry; instead, it is mainly processing steps that need to be replaced. For example, the natural gas-based Haber-Bosch process used for the synthesis of ammonia is substituted by hydrogen-based ammonia (BDI Klimapfade 2.0, Ariadne CN 2045). In addition, all current fossil-fuelled heat generators for conversion processes in the chemical industry must be replaced in the future with renewable solutions, such as electricity, biomass, biogas, and hydrogen. For the remaining demand for hydrocarbons that cannot be covered by recycled material, it is possible to use synthetic or bio-based naphtha according to the Fischer-Tropsch process[7] or synthetic methanol, which can be produced from

[7] Fischer-Tropsch synthesis (FTS) is a catalytic process for converting synthesis gas (CO and H_2) into a petroleum-like product called Fischer-Tropsch crude oil, which can be easily upgraded to a wide range of transport-grade liquid hydrocarbons.

renewable electricity and CO_2 (BDI Klimapfade 2.0). Demand for sequestered carbon is expected to more than double by 2050 to about 1 billion tonnes per year (dena CN 2045). However, compared to the steel sector and given the heterogeneity of the chemical sector, the reference here remains rather broad.

The cement industry is modelled to rely on existing, albeit modernised, production processes as well as CCU and CCS processes to reduce unavoidable process emissions (Agora CN 2045, Ariadne CN 2045, BMWK CN 2050 [TN-PtG], dena CN 2045, FhG-ISE CN 2045, McKinsey CN 2045). The first CSS plants could be in use as early as 2030 (Agora CN 2045). To achieve GHG neutrality in 2045, about 1.4 million tonnes per year of cement must be produced in cement kilns with CCS (Agora CN 2045). This represents about 4% of the cement production capacity in Germany in 2020, which is about 35 million tonnes of cement (Verein Deutscher Zementwerke e.V., 2021). The studies here remain rather cautious when it comes to concrete reference values for the cement sector, mainly elaborating at the level of technology choice.

Energy efficiency

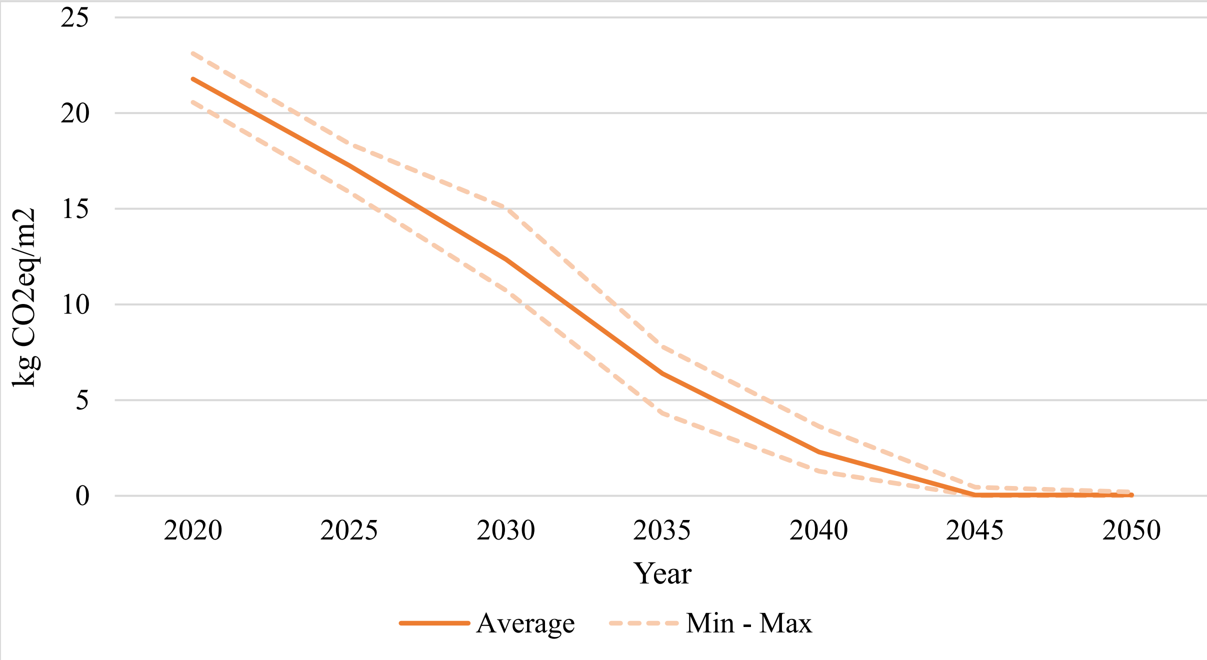
Energy efficiency is assumed in all NZS to reduce energy demand, especially in the building sector, while it plays only a minor role in the industrial sector.

In the building sector, the annual thermal renovation rate is an important target value in all studies. The renovation rate usually refers to the renovated building area and results from the ratio of the renovated buildings to the total building area in a given year (BDI Klimapfade 2.0; Singhal & Stede, 2019). According to the scenarios, the annual refurbishment rate should increase from the current level of approx. 1 percent to approximately 1.5 - 2 percent by 2045 (Agora CN 2045, Ariadne CN 2045, BDI Klimapfade 2.0, dena CN 2045). In some scenarios, the renovation rate even rises to over 2 percent (Ariadne CN 2045 [REMod – H2 scenarios], McKinsey CN 2045, UBA CN 2050). However, one problem is that, in some cases, the definition of the renovation rate is unclear. There is also no clear definition from the Federal German Government, which should provide clarity.

Some NZS also model an increase in the depth of renovation. Depending on the type of dwelling, the depth of refurbishment corresponds approximately to the KfW-70 to KfW-55 efficiency house standard (Agora CN 2045, Ariadne CN 2045, BDI Klimapfade 2.0, FhG-ISE CN 2045). In fully renovated buildings, this leads to a significant reduction in total energy demand that drops to an average of 60 kilowatt hours (kWh) per square metre (m^2) in existing single-family houses and to about 40 to 45 kWh/m^2 in multi-family apartment buildings (Agora CN 2045).

The reduced energy demand will accordingly be reflected in reduced GHG emissions. Figure 6 illustrates how the average of emissions per sqm (kg CO_2eq/m^2) for private and commercial buildings for selected climate neutrality studies will develop.

Figure 6: Average sectoral emissions in the building sector in kg per sqm in selected NZS (private households and tertiary sector)



Source: Authors' graph based on NZS of Ariadne CN 2045 [space area: average across all scenarios and models; GHG emissions for private households' average across all scenarios for TIMES PanEU model] and Agora CN 2045.

Interestingly, although energy efficiency plays a prominent role in the industrial sector, only little concrete guiding reference can be derived from the NZS. In most of the NZS, it is explicitly assumed that energy efficiency increases significantly using the best available technologies (Ariadne CN 2045, BDI Klimapfade 2.0, BMWK CN 2050, dena CN 2045, FhG-ISE 2045, McKinsey, CN 2045, UBA CN 2050). The industry sector can reduce its energy demand by 21 percent by 2030 through efficiency gains and process changes (dena CN 2045).

Resource efficiency

Resource efficiency is another important transition lever that is highlighted in all studies, especially for the industry sector.

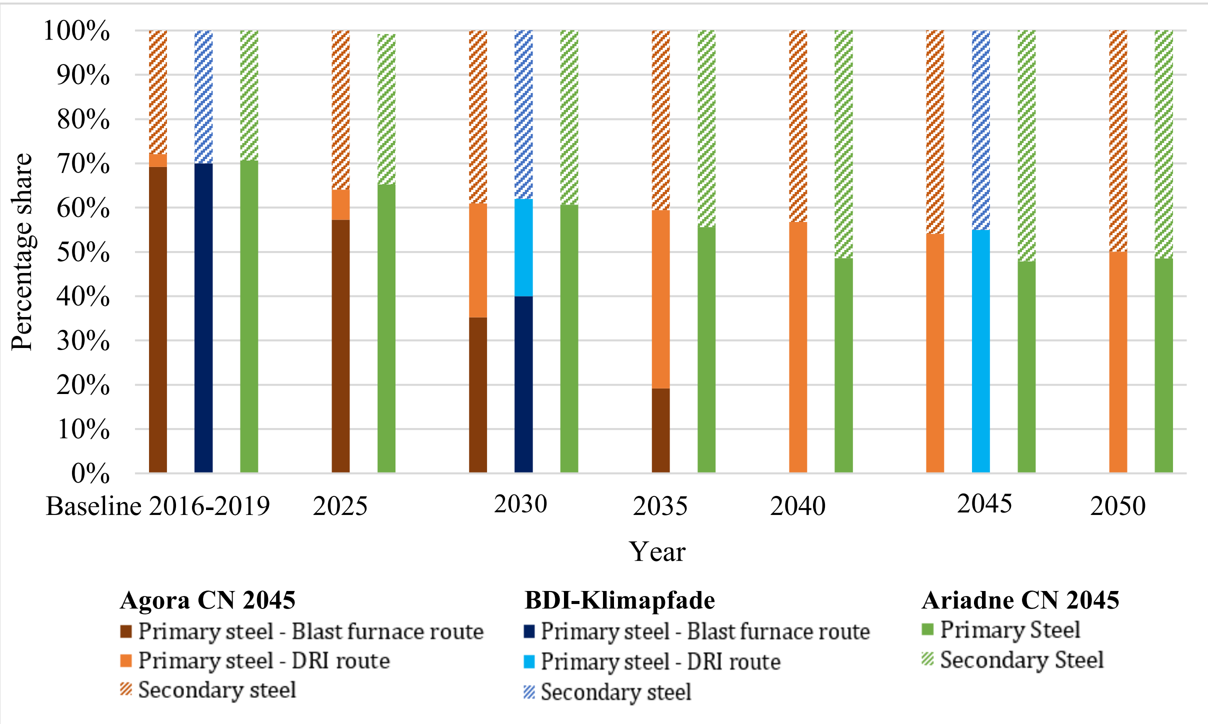
In the building sector, resource-efficient materials are considered in the NZS to be used in renovations as well as in new buildings (Agora CN 2045, Ariadne CN 2045, BDI Klimapfade 2.0, dena CN 2045, McKinsey CN 2045, UBA CN 2050). In the construction industry, for example, the material-saving use of concrete or innovative construction methods could avoid around 0.5 Mt CO_2eq by 2030 (BDI Klimapfade 2.0). However, apart from the use of materials in construction and possibly insulation, resource efficiency in the building sector plays only a minor role and study results remain rather broad. In the energy-intensive industries, in the steel industry, the use of steel scrap is expanded in all studies. For example, as illustrated in Figure 7, the share of the secondary route from recycled steel in crude steel production increases from currently around 30 percent to around 40 percent in 2030 and to close to or over 50 percent in 2045 (Ariadne CN 2045, Agora CN 2045, BDI Klimapfade 2.0) which saves about 12.5 TWh of energy, roughly equivalent to a GHG emission reduction of about 4 Mt (Ariadne CN

2045).

In the chemical industry, material defossilisation is of outstanding importance to achieve climate neutrality. This means that the procurement of raw materials should be secured primarily by recycled and renewable hydrocarbons, which can be obtained by means of mechanical and increasing chemical recycling. It is assumed that the material recycling rate of plastic waste will increase from 30 percent in 2019 to about 55 percent by 2030 (Ariadne CN 2045, Agora CN 2045, BDI Klimapfade 2.0).

In the cement industry, energy and emissions can mainly be saved using resource-efficient concretes (such as CEM II/C and CEM VI) and alternative binders as a substitute for clinker (Agora CN 2045, Ariadne CN 2045, BMWK CN 2050, BDI Klimapfade 2.0, dena CN 2045, McKinsey CN 2045, UBA CN 2050). Although it can also be assumed that the production of cement and cement clinker decreases due to the declining number of new buildings in the building sector, a stronger decrease can be expected from the use of alternative binders. As such, the proportion of clinker in cement can be reduced from currently over 70 percent (McKinsey CN 2045, BDI Klimapfade 2.0) to 63 percent by 2030 (BDI Klimapfade 2.0) and to below 60 percent in a net zero scenario (McKinsey CN 2045). A further decrease in energy consumption and GHG emissions in this sector is expected due to material-saving construction methods (Agora CN 2045, dena CN 2045, UBA CN 2050). Thus, domestic cement production is expected to fall by around 14 percent by 2045 due to these effects (dena CN 2045). Therefore, for the industry sector, resource efficiency is an important lever that can be used as a reference for measuring progress towards climate neutrality. In particular, the share of recycled materials as a proportion of production can be obtained from the scenarios as a benchmark.

Figure 7: Development of share of primary and secondary steel production route in selected NZS



Source: Authors' graph based on NZS of Agora CN 2045, BDI Klimapfade 2.0 and Ariadne CN 2045.

Carbon pricing

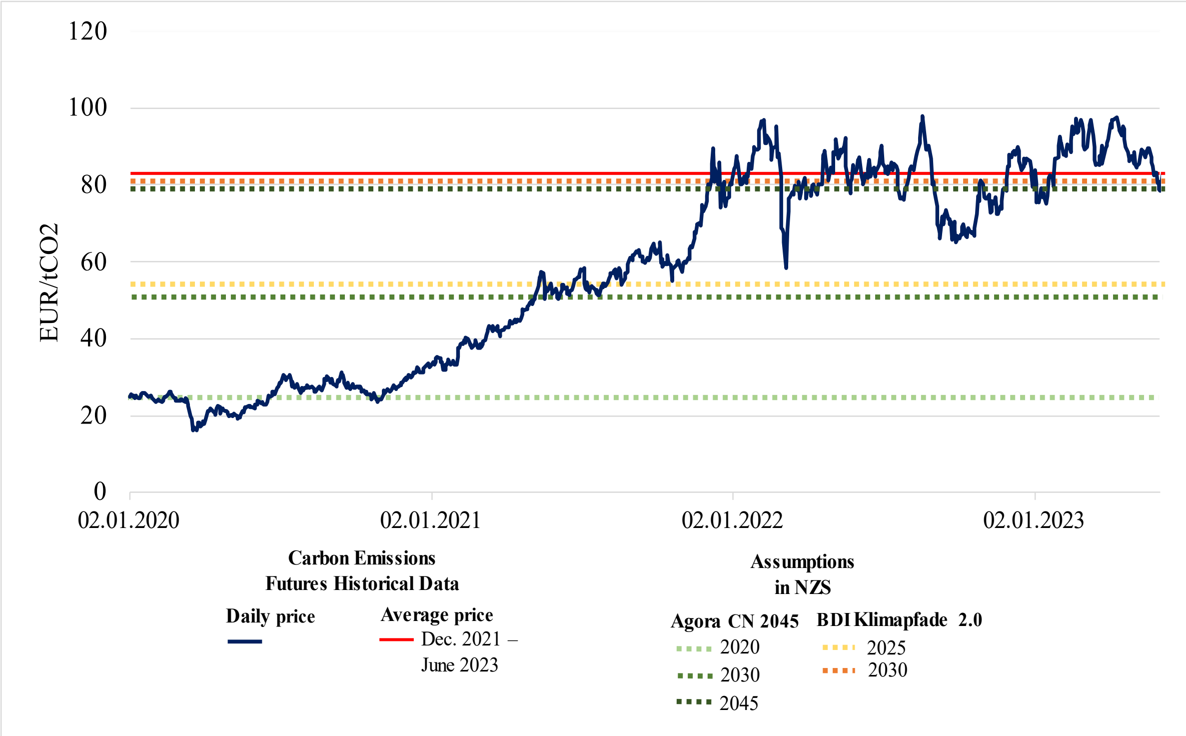
A reliable CO_2 price is emphasised as a central policy instrument in all NZS.

For the building sector in Germany, the Fuel Emissions Trading Act (BEHG) is of central importance. It covers the sectors of decentralised heat generation, road transport, and shipping. The nominal price paths are prescribed by law until 2025. The annually fixed price is to increase from 25 euros per tonne of CO_2 at the beginning of 2021 to 55 euros per tonne of CO_2 in 2025. From 2026 onwards, the certificates are to be auctioned such that the price is subsequently determined by the market. For 2026, however, a price corridor of at least 55 to a maximum of 65 euros per tonne of CO_2 is set. The NZS "BDI Klimapfade 2.0" assumes a linear increase in the price to 80 euros per tonne of CO_2 in 2030. In the other NZS, a price path for the decarbonisation of the building sector is not modelled. The Ariadne CN 2045 study advocates for a significant increase in the price from 2025 on and the dena CN 2045 study recommends an extension of the EU ETS to the sectors covered by the BEHG to ensure harmonisation with national emissions trading systems.[8]

CO_2 pricing also plays a central overarching role as an instrument for the industrial sector. For the industry sector, the CO_2 prices of the EU ETS apply. The studies show a relatively wide range for the nominal price development. For example, in some NZS, the price is expected to rise to 80 euros per tonne of CO_2 in 2030 (BDI Klimapfade 2.0), while other studies assume that it does not reach 80 euros per tonne of CO_2 until 2045 (Agora CN 2045). As shown in Figure 8, the actual development of the CO_2 price under EU-ETS deviates strongly from the price assumptions of the studies. The EU-ETS price already exceeded the 80 EUR/tCO_2 level at the beginning of December 2021. Recent forecasts by Refinitiv also predict an average CO_2 price of more than EUR 100/tCO_2 in 2025 (Onstad, 2022). Thus, the effect of CO_2 pricing assumed in the studies is likely to have a stronger impact earlier.

[8] On the European level, an extension of the EU ETS (ETS II) to the transport and buildings sectors is foreseen from 2027 onwards.

Figure 8: Assumptions of CO_2 price development under EU-ETS I in NZS vs. actual CO_2 price data



Source: Authors' graph based on historical price data of Carbon Emission Futures (at opening of trading). Data available at: https://www.investing.com/commodities/carbon-emissions-historical-data.

Other political steering instruments

In addition to CO_2 pricing, other instruments are important, and we discuss some examples here. In the building sector, local action planning and funding instruments also play an important role in driving future decarbonisation. Here, the NZS emphasise the role of municipalities. For example, municipal heat and infrastructure planning is called for, which makes it possible to discuss current heating types, consumption, C02 emissions, and potential for improvement at the regional level. In this context, the obligation of renovation plans could also be considered (BDI Klimapfade 2.0, dena CN 2045). Policy recommendations also include local energy renovation subsidy programmes (dena CN 2045). A key lever on the part of the government is also the anchoring of climate neutrality and environmental friendliness in public procurement; this also applies to buildings owned by the public sector (dena CN 2045). For example, the government could commit to using low-CO_2 steel and cement in the construction of buildings and infrastructure. Quotas for climate-friendly materials are also highlighted (BCG, 2021). With an annual procurement volume of about 300 billion euros, the state can contribute to strengthening the demand for climate-friendly products (dena CN 2045). In addition, some studies emphasise the need to address the distributional effects of the heat transition. Among other things, there is a need for an effective distribution of CO_2 costs between tenants and landlords (dena CN 2045). Redistribution mechanisms to consumers, such as per capita repayments, could also be considered (Ariadne CN 2045).

In the industry sector, the volatility of CO_2 pricing and the uncertainty about future price developments represent a significant obstacle to investments in climate-friendly technologies and production processes. Therefore, some studies emphasize the relevance of so-called carbon contracts for difference (CCfDs) (Agora CN 2045, Ariadne CN 2045, BDI Klimapfade 2.0, dena CN 2045). CCfDs guarantee a minimum price for CO_2 certificates for selected projects and, thus, can increase investment security and willingness[9]. The instrument's relevance is highlighted by various authors (Chiappinelli & Neuhoff, 2020; Richstein & Neuhoff, 2022). Another overarching instrument is the expansion of H_2 and CO_2 transport infrastructures (BDI Klimapfade 2.0). Furthermore, regarding the implementation of energy efficiency, long amortisation periods are a central challenge and should be supported by public support programs (dena CN 2045).

Although the steering instruments are not directly relevant to the measures within the company, they provide a possible corridor of supporting instruments for the company, which, depending on their form, could contribute to achieving their emission reduction objectives.

4.2 Implications for forward-looking strategy development and reporting

Bringing together the macro-level of NZS with the micro-level of companies, a clear picture emerges of what climate neutrality studies can and cannot do in this context. As we show, the analysed NZS offer the possibility as a reference scenario along the different transition levers that are of central importance for reaching climate neutrality. Despite variations in modelling methodologies and granularity, these studies tend to converge on the implications for key transition elements, including technologies, energy efficiency, resource efficiency, as well as regulatory and other policy instruments.

Connecting the identified levers to the theoretical LogFrame model, we identify a set of indicators that can inform the business strategies of companies and that can be reported along the framework to provide alignment along a decarbonisation target, such as climate neutrality in 2045, which is illustrated for the building sector in Figure 9.

The starting point for the scenario analysis is the *benchmark*. In the case of Germany, the overarching policy goal set by the KSG is reaching net zero in 2045. Companies can align with this target at the sectoral level or even set a more ambitious target as a benchmark, which can then be a company-specific scenario, as seen on the right-hand side of Figure 9. In a second step, the baseline is determined, for example, the starting year from which the company wants to measure its progress. After that, the NZS analysed here can serve as a reference scenario. Regardless of whether the company has a more ambitious target or 2045 as its goal, the studies can serve as reference values. In the case of more ambitious targets, the change processes aimed at by the company should consequently be implemented earlier, thus reflecting its intermediate emission reduction goals accordingly.

To measure the robustness of self-set emission targets, companies can, for example, report at the level of *input* indicators how many RE technologies, for example as share of heatable housing units, will be

[9] With CCfDs, the state guarantees the other party, i.e., the investor, a specific minimum price for a CO_2 allowance in the ETS for a selected project during the entire term of the contract. If the future market price is below the agreed minimum price, the state reimburses the investor for the difference. If the market price exceeds the minimum price, the investor must pay the difference to the state.

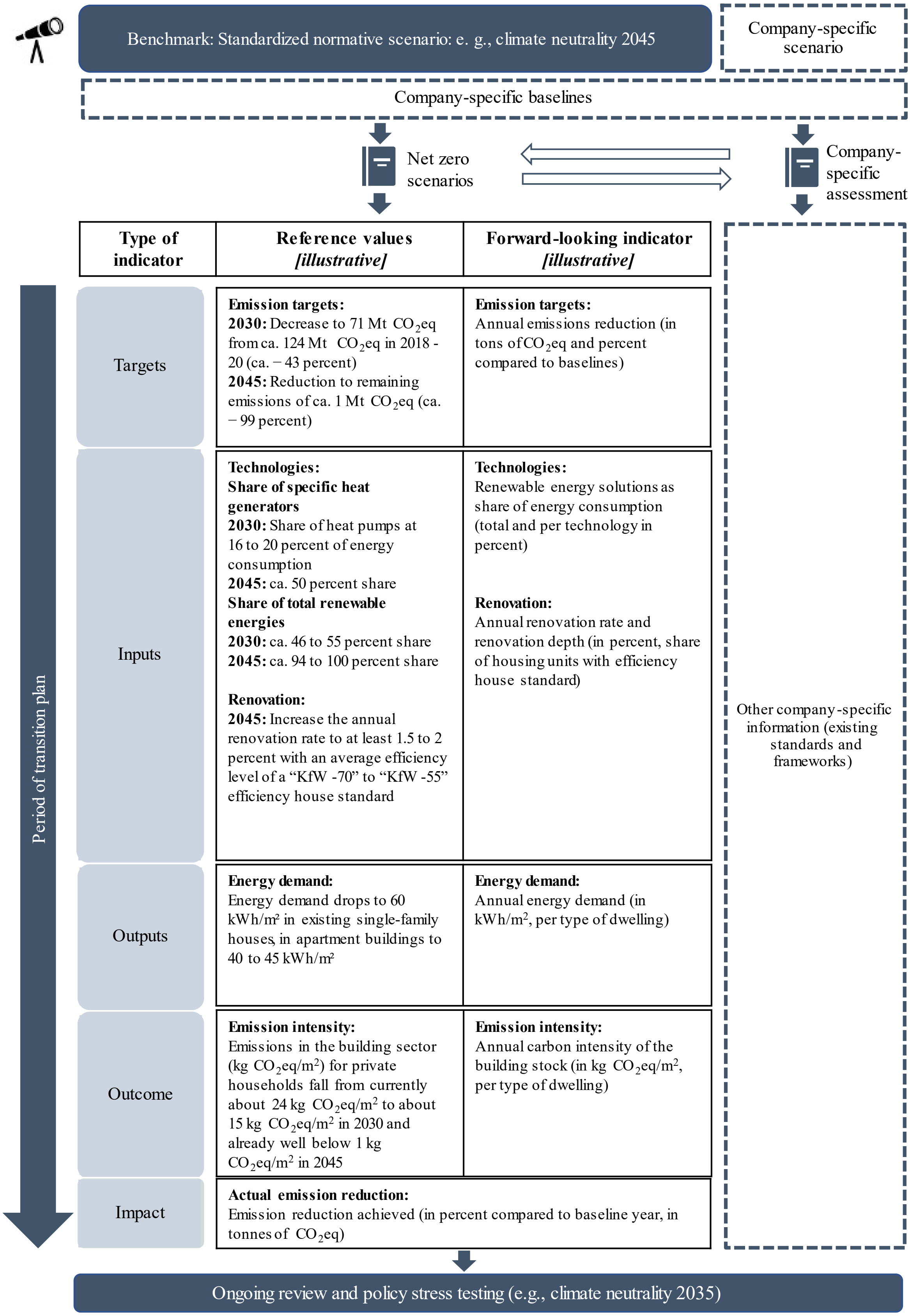
implemented, which all studies identify as a central transition lever. As we show, almost all studies emphasize the outstanding importance of RE technologies, like heat pumps and district heating networks. Another input factor can also be refurbishments. For example, the studies indicate an average renovation rate of at least 1.5-2 percent or more than 2 percent for the building sector with an efficiency level of the KfW-70 or KfW-55 standard. Accordingly, companies could report in a forward-looking manner their annual refurbishment rate and depth, in percentages as well as the share of housing units with certain efficiency levels. At the sectoral level, similar indicators are proposed to measure progress towards climate neutrality (Duwe, 2021; Fietze et al., 2021).

At the *output* level, this should be reflected accordingly at the level of energy consumption, which falls to 60 kWh/m^2 in existing single-family houses and to 40-45 kWh/m^2 in multi-family houses in the scenarios. Thus, companies could report their target energy consumption per square meter as well as per building type.

At the *outcome* level, this should then be reflected at the level of CO_2 intensity, which in the scenarios falls from around 22 kg/m^2 in 2020 to 12 kg/m^2 in 2030 and to well below 1kg/m^2 in 2045 for residential and commercial buildings in the NZS.

However, these indicators are only indicative and are only meant to illustrate by way of example that such scientific macro and sector studies can serve as a reference work to decarbonise one's own portfolio, while companies should be ensured flexibility to achieve their goals. As Figure 9 shows, companies should continue to report company-specific data in addition to the referential values from the studies and ensure an alignment with existing standards and frameworks. The challenge is to relate these to reference values and to be able to justify deviations accordingly. While aligning with the values of the NZS may not be the sole focus, it is important to contextualize one's own transition strategies to enhance comparability and minimize transition costs for investors or, in general, users of such transition plans. Lastly, forward-looking strategies and resulting indicators should be subject to ongoing review. As demonstrated, the policy context and supporting instruments surrounding net zero are highly dynamic, thus challenging the sensitivity of a firm's transition plan. Therefore, in addition to a main reference scenario of net zero, another stress scenario should be used to test the achievability of the plan in the event of policy tightening (German Sustainable Finance Advisory Committee, 2021; Marchewitz et al., 2022).

Figure 9: Illustrative indicator framework for transition plans



Source: Graph based on Ballesteros, Hüttel, Neuhoff & Marchewitz (2023), modified.

5 Conclusion and policy recommendations

Focussing on the building sector and energy-intensive industries in Germany, our analysis shows that normative net zero scenarios can provide a science-based and forward-looking reference for companies that need to strategically plan and report their decarbonisation efforts and progress. By aligning or relating company strategies or production processes with selected transition levers from NZS and reporting these in a forward-looking perspective, companies can be better compared, especially in homogeneous sectors. The companies can report along a NZS pathway, for example, via transition plans.

As demonstrated through the LogFrame model for the building sector, the scenarios with sectoral breakdowns offer a comprehensive view beyond just GHG emissions, encompassing input, output, and outcome indicators that can reveal progress, even early on. Ensuring comparability in more heterogeneous sectors, such as the chemical sector, is so far more challenging as the analysed studies often lacked concrete quantifiable indicators as, for example, provided regarding buildings or steel. Nevertheless, more abstract indicators, such as the material recycling rate, can be used as a benchmark. In such cases, the potential for more granular sector-specific pathways should be further explored (Caldecott & Shrimali, 2023; Shrimali, 2023), which may provide more granular pathways for heterogeneous sectors.

Therefore, our findings suggest that incorporating normative NZS in corporate strategy planning and reporting offers an opportunity to enhance transparency, credibility, and comparability of climate-related information disclosed by companies. This can not only facilitate the assessment of companies' decarbonisation progress but also enable stakeholders to make informed decisions regarding the allocation of capital and investments. Further, the assessment of companies' contributions to the transition to a low-carbon economy and its associated transition risks will be enhanced. Banks for example would benefit from increasingly relying on forward-looking firm-level data to identify transition risks from the economic activities and counterparties within sectors they are exposed to (Dikau et al., 2022). Hence, our research has the potential to inform policy discussions and contribute to the development of more effective forward-looking climate-related reporting frameworks.

However, the explored NZS have limitations. First, the political agenda surrounding these scenarios is subject to change, as evident in the case of Germany in the ongoing discussion around the Climate Protection Act or the CO_2 price projections. Thus, a regular review of the transition scenarios and adjustments is necessary. In this context, companies should subject their transition strategy to a sensitivity analysis in the event of a policy change. Second, although our study provides valuable insights with regard to aligning the macro level of net zero to the micro level at the company level, neither current corporate practices nor company-specific strategies and objectives are considered in the NZS. For example, many companies already set their own climate neutrality targets before 2045. Some German companies already claim to be climate neutral or that they will achieve it before 2045 (Union

Investment, 2022). Third, the system boundaries of emission reductions here are clearly defined by the source principle and omit the fact that companies also consider scope 3 emissions for their decarbonisation strategies. Moreover, some companies may still rely on “offsetting” as a decarbonisation strategy. Recent evidence shows that many companies rely on emissions offsetting to achieve their climate neutrality targets (Machnik et al., 2020; New Climate Institute et al., 2022). However, the studies do not take this type of emission avoidance into account.

One of the central limitations of our study is that we do not compare the model mechanisms and scenario assumptions provided in the NZS in detail. For future research, it might be helpful to analyse these facets in more detail. As the example of carbon prices illustrates, some of the assumptions behind the NZS may not hold anymore due to political, economic, or societal developments. Furthermore, we only provide insights that can help to strengthen the credibility against which benchmarks companies disclose their transition, but we do not provide guidance for how the credibility of companies’ activities can be assessed irrespective of what a company discloses, such as assessing the net zero alignment of a firm’s CAPEX (Kampmann et al., 2023). Future research could further investigate how the various transition indicators can be complemented by relevant financial or organizational information related to concrete activities by a company.

While this paper did not aim to compare existing regulations or frameworks in detail, it becomes obvious that there is a need for standardised forward-looking reporting in the context of net zero. For successful and comparable reporting, comparable transition indicators and scenarios are needed, which can help to assess whether a company is achieving its targets, even beyond looking at only GHG emissions. This requires at least a reference scenario, such as climate neutrality 2045, and also a stress scenario, such as climate neutrality 2035, to test the plan's sensitivity toward policy change (German Sustainable Finance Advisory Committee, 2021; Marchewitz et al., 2022). As stress testing is a key element of risk management for financial institutions, forward-looking firm-level data can improve data quality and prevent firms from being assessed and rated based on average sector data. Existing initiatives and frameworks can be helpful for companies in individual cases; however, it does not solve the problem of comparability, which is especially important for emission-intensive industry sectors. Frameworks such as TCFD and the UK's TPT frameworks are already laying the groundwork for a common reporting standard.

Finally, the challenge for regulators lies in striking a balance between standardization and flexibility. Finding this equilibrium is crucial for guiding the transition towards a sustainable future. However, this will also require clear rules on how to include offsetting and the scope of emission coverage. Regulatory efforts should also build on, and align with, existing processes and frameworks, such as the TCFD, CSRD, and the ISSB, to avoid fuelling a fragmentation of standards.

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