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Financing the transition to greenhouse gas neutrality: Is the German banking system prepared?

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Non-technical summary

Research Question

The transition to a greenhouse gas-neutral economy entails a broad-based structural transformation. Achieving Germany's goal of greenhouse gas neutrality by 2045 requires a shift to non-fossil energy sources and low-carbon production and consumption patterns, necessitating substantial investments. Against this backdrop, we address two key questions: first, what level of investment and financing is required to achieve the goal of greenhouse gas neutrality in Germany? Second, we ask if the German banking system has sufficient capacity to finance the investment needs that go beyond replacement investments. Finally, we draw on surveys conducted by the Bundesbank to assess which investments firms and households actually plan to undertake in the coming years to reduce their own CO_2 emissions.

Contribution

Our study contributes to the current discussion on the financial feasibility of Germany's transformation toward greenhouse gas neutrality. Following an overview of selected recent studies estimating the investment needs for this transformation, we convert conservative estimates of investment requirements into the investment and financing needs of individual sectors within the national accounts framework. Based on this, we conduct simulation calculations using the capital endowment of the German banking system. This provides important insights into the investment volumes that could be financed through the banking system.

Findings

The annual additional funding requirement for Germany beyond replacement investments is estimated in various studies to be between 2% and 4% of GDP, compared to realised additional investments of 1.6% of GDP per year during the period from 2015 to 2020. Our study concludes that the German banking sector, in terms of its capital resources, is capable of financing these additional investments even under conservative assumptions. However, the positive finding that no barriers to bank financing are expected – given solid excess capital and assuming frictionless credit allocation between banks – should not obscure the fact that insufficient incentives and other factors have so far hindered the willingness to invest and finance decarbonisation measures in key sectors. This is also suggested by the results of surveys conducted by the Bundesbank.

Nichttechnische Zusammenfassung

Fragestellung

Der Übergang zu einer treibhausgasneutralen Wirtschaft bedeutet einen Strukturwandel auf breiter Front. Die für das Erreichen des Ziels der Treibhausgasneutralität Deutschlands bis 2045 notwendige Umstellung auf nicht-fossile Energien sowie kohlenstoffarme Produktion und Verbrauchsmuster erfordert dabei umfangreiche Investitionen. Vor diesem Hintergrund widmen wir uns zum einen der Frage, welcher Investitions- und Finanzierungsbedarf entsteht, wenn das Ziel der Treibhausgasneutralität in Deutschland erreicht werden soll. Zum anderen betrachten wir in Frage kommende Finanzierungsinstrumente und untersuchen insbesondere, ob das deutsche Bankensystem ausreichend Kapazitäten aufweist, den über Ersatzinvestitionen hinausgehenden Investitionsbedarf zu finanzieren. Schließlich ziehen wir bundesbankeigene Umfragen heran, um einzuschätzen, welche Investitionen Unternehmen und Haushalte in den kommenden Jahren tatsächlich vornehmen wollen, um eigene CO_2-Emissionen zu reduzieren.

Beitrag

Unsere Studie leistet einen Beitrag zur aktuellen Diskussion um die Finanzierbarkeit der Transformation Deutschlands hin zu Treibhausgasneutralität. Im Anschluss an einen Überblick zu ausgewählten aktuellen Studien, in denen der Investitionsbedarf für die Transformation geschätzt wird, werden konservative Schätzwerte für den Investitionsbedarf umgerechnet auf den Investitions- und Finanzierungsbedarf der einzelnen Sektoren der volkswirtschaftlichen Gesamtrechnung (VGR). Auf dieser Grundlage werden unter Rückgriff auf die Kapitalausstattung des deutschen Bankensystems Simulationsrechnungen durchgeführt. Damit erhalten wir wichtige Hinweise, welche Investitionssummen über das Bankensystem finanziert werden könnten.

Ergebnisse

Der über Ersatzinvestitionen hinausgehende jährliche Mittelbedarf Deutschlands wird in unterschiedlichen Studien auf 2% bis 4% des BIP geschätzt, verglichen mit realisierten Mehrinvestitionen in Höhe von 1,6% des BIP p.a. im Zeitraum 2015 bis 2020. Unsere Studie kommt zu dem Ergebnis, dass der deutsche Bankensektor mit Blick auf die Kapitalausstattung selbst unter konservativen Annahmen in der Lage ist, diese zusätzlichen Investitionen zu finanzieren. Der positive Befund, dass unter Rückgriff auf solide Überschusskapitalpolster und bei friktionsfreier Kreditallokation zwischen den Banken keine Barrieren für Bankfinanzierungen zu erwarten sind, darf gleichwohl nicht darüber hinwegtäuschen, dass unzureichende Anreize und andere Faktoren die Investitions- und Finanzierungsbereitschaft für Dekarbonisierungsmaßnahmen in wichtigen Sektoren bislang hemmen. Darauf deuten auch die Ergebnisse von Bundesbank-Umfragen hin.

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June 1, 2026

Abstract

Achieving Germany's goal of greenhouse gas neutrality by 2045 requires a shift to non-fossil energy sources and low-carbon production and consumption patterns. This transformation necessitates substantial investments. According to existing evidence, estimates of additional investment needs – beyond replacement investments – range between 2% and 4% of GDP per annum. This study explores the capacities of the German banking system to finance these additional investment requirements. We conclude that the German banking sector's, given solid excess capital and assuming frictionless credit allocation between banks, is capable of financing these additional investments even under conservative assumptions. However, the results of firm and household surveys conducted by the Bundesbank show that in both groups, a majority is reluctant to decarbonize and undertake the necessary investments in the coming years.

Keywords: Banks, Capital regulation, Climate investment, Net-zero emission pathways
JEL-Classification: G21, G28, G31, Q43, Q54

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1. Introduction

Paving the way for the transition to a greenhouse gas-neutral economy ranks among the biggest challenges of this decade and beyond. The Federal Government's Federal Climate Action Act (*Bundes-Klimaschutzgesetz*) enshrined the objective of achieving greenhouse gas neutrality (net zero emissions) in Germany by 2045. That legislation requires greenhouse gas emissions to be reduced, relative to 1990 levels, by 65% by 2030, by 88% by 2040, and to net zero by 2045. Up to 2025, a reduction of 48% has been achieved. Pursuing the goal of greenhouse gas neutrality will call for large-scale investment. Energy systems (generation, transport and consumption points), transportation, industry and the existing building stock will need to be fundamentally overhauled (transformed). At the same time, the latest expertise of the German Council of Experts on Climate Change (2025) finds that current policy in Germany is not yet sufficient to achieve the necessary transformation path after 2030.[1] Moreover, the war in Iran and the resulting drastic increase in oil and gas prices underline that a transformation of the energy systems could increase the resilience of the German economy to price fluctuations.

In a first step, this technical paper summarises a selection of recent studies that estimate the additional investment needs required to keep the Paris Agreement goals of greenhouse gas neutrality within reach. We also present survey results of actual decarbonisation investment plans of German firms and households. We then allocate the additional investment needs for climate protection purposes to the institutional sectors and calculate the needs for different means of finance. This step shows that the banking sector is likely to play an important role in funding the transformation. In a second step, we explore whether the German banking system is capable of financing these investment needs. Using a simulation analysis based on the assumption that implementing the necessary investments will lead to additional demand for bank finance, we find that regulatory capital requirements are unlikely to be a bottleneck. Lastly, we briefly look at transformation financing from a capital market perspective.

2. Estimates of investment needs in Germany

2.1 Important definitions

We will use the term "transformation financing" to mean financing the transition to greenhouse gas neutrality. Following the wording used in Prognos (2024), we make a distinction between two different investment aggregates. We will use the notion of "climate protection investments" only when referring to investments that go beyond replacement investments as part of a

[1] The Council of Experts on Climate Change (2025) bases this finding on key assumptions it considers necessary for achieving the desired reductions in greenhouse gas emissions. These include high ETS CO_2 prices in particular, but also assumptions concerning government incentives to boost the uptake of e-mobility, for example. According to 2025 projection data, the Council confirmed compliance with the emission budget set out in the Climate Protection Act for 2021 to 2030, but expects significant shortfalls after 2030. See Expertenrat für Klimafragen (2025).

climate-friendly renewal of the capital stock.[2] That not only concerns uses of funds that would be wholly or partially absent in a world without climate protection (e.g. uses to generate green hydrogen), but also increases in funds (e.g. the additional cost of electric vehicles over those powered by internal combustion engines). The “extra investments” defined in this manner are identical to those given the same name in the Council of Climate Experts’ aforementioned biennial expertise.

By contrast, total climate protection-related investments, as defined in the aforementioned study of Prognos, comprise not only climate protection investments but also necessary climate-friendly replacement investments. This category includes both expenditure on climate-friendly technologies and spending on a bedrock of fossil technologies that are indispensable during the transition period. The focus of this analysis for the German banking sector will be on the climate protection investments because these comprise the entire additional investment and financing needs that go beyond the reinvestments to preserve existing operations and thus represent an additional financial burden.

To complement the analyses for Germany, which are the focus of this technical paper, Annex A.1 summarises the key findings from selected studies on global and European investment needs. These international and European studies do not examine the investments that go beyond replacement investments. Rather, they assess the sum of all total climate protection-related investments by comparing and contrasting needs estimates with the calculated investments. For example, the International Energy Agency (IEA, 2024), the Climate Policy Initiative (Buchner et al., 2023) and the European Commission (2023) compare the current level of investments globally and in Europe, respectively, with the investments needed to achieve a net zero path up to 2050, identifying investment gaps in each case.

2.2 Estimates for Germany

Transforming the German economy to achieve greenhouse gas neutrality by 2045 will call for considerable investments each year. Estimates by Prognos (2024), shown here in 2023 prices, indicate that transforming the German economy to full greenhouse gas neutrality by 2045 will require, on aggregate, total climate protection-related investments of €10.8 trillion$_{2023}$ overall between 2021 and 2045. Between 2021 and 2030 alone, investments of €4.4 trillion$_{2023}$ will be needed, a figure that equates to around 10.4% of projected GDP for this period.[3] Of that figure,

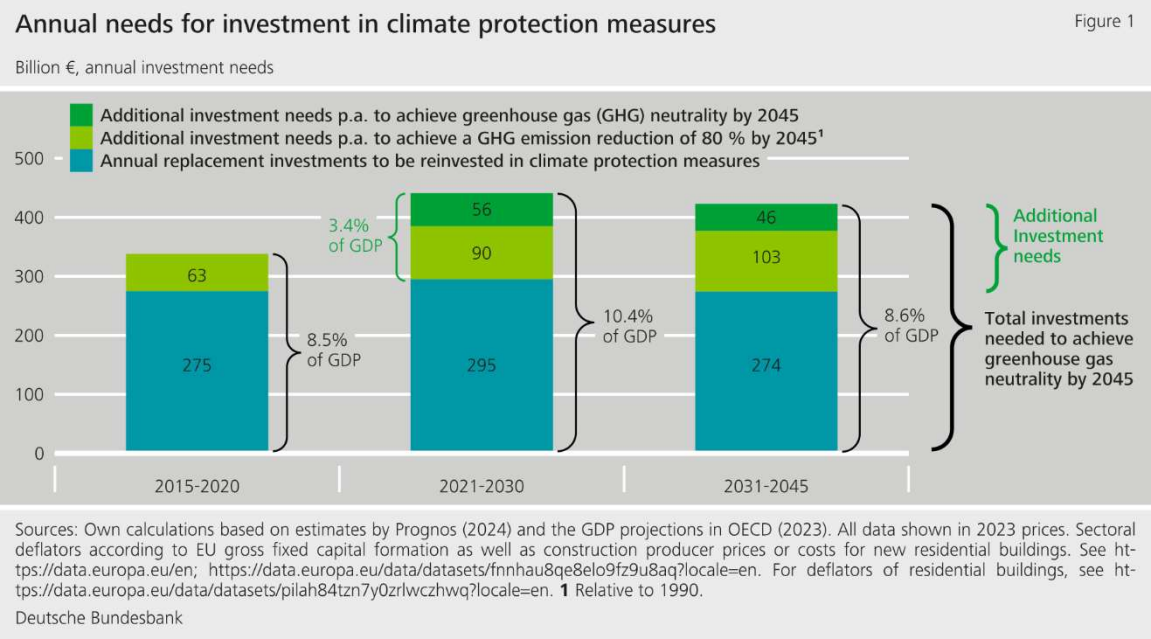
[2] Replacement investments as part of a climate-friendly renewal of the capital stock represent a key component of total climate protection-related investments. However, they are not examined in any greater detail below because funding for them is already in place, and this funding is assumed to continue in the future. Such replacement investments are assumed to also comprise the depreciation of a fossil capital stock and reinvestment of funds, as they are released, in climate-friendly business areas and technologies.

[3] By comparison, gross investments in the aggregate economy in 2023 amounted to around €907 billion$_{2023}$ – that is to say, 21.6% of GDP in 2023

around 7% of GDP relates to climate-friendly replacement investments (see blue parts of the bars in Figure 1).[4]

To achieve greenhouse gas neutrality, additional investments averaging 3.4% of GDP will be needed over and above these climate-friendly replacement investments.[5] Following the terminology used in Prognos (2024), we will refer to these additional necessary investments as "climate protection investments" throughout this paper.[6] In this study, we rely on the estimates of Prognos (2024) for three reasons. First, they are more conservative than the estimates of the latter two institutions (see Figure 2). Second, the Prognos study provides sectoral estimates on the basis of which it was possible to ascribe investment needs to institutional sectors as defined in the national accounts.[7] Third, the Prognos study explicitly quantifies replacement investments.

Figure 1



Sources: Own calculations based on estimates by Prognos (2024) and the GDP projections in OECD (2023). All data shown in 2023 prices. Sectoral deflators according to EU gross fixed capital formation as well as construction producer prices or costs for new residential buildings. See https://data.europa.eu/en; https://data.europa.eu/data/datasets/fnnhau8qe8elo9fz9u8aq?locale=en. For deflators of residential buildings, see https://data.europa.eu/data/datasets/pilah84tzn7y0zrlwczhwq?locale=en. **1** Relative to 1990.

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According to Prognos, the need for additional investments, i.e. climate protection investments, will amount to €1.46 trillion$_{2023}$, or €146 billion$_{2023}$ each year up to 2030 (see the two green layers of the middle bar in Figure 1. The light green layer refers to climate protection investments that will be needed to achieve an 80% reduction in greenhouse gas emissions (€90 billion$_{2023}$ per year based on the Prognos estimate for 2021-30). Furthermore, the dark

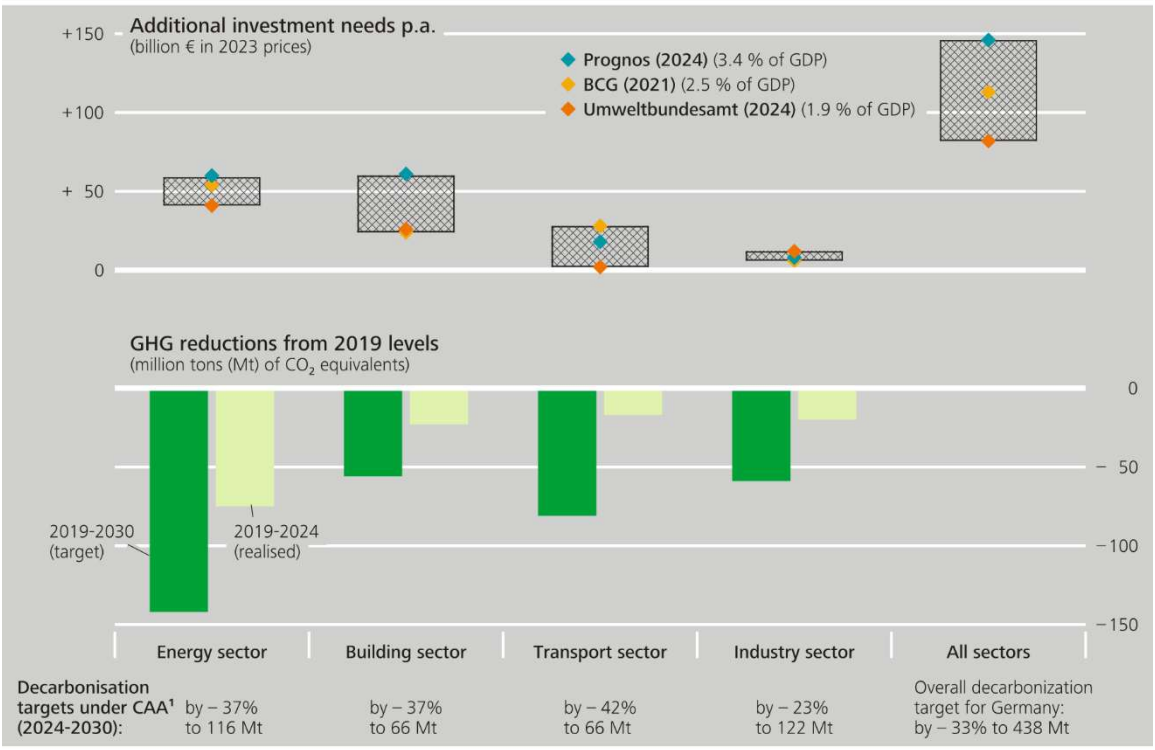
4 A more detailed version of this study uses data from various studies to compare the sectoral needs for climate protection investments.
5 Based on estimations from Prognos (2024) and GDP projections of the OECD (2023).
6 The studies of the Federal Environment Agency (Umweltbundesamt, 2024) and Boston Consulting Group (BCG, 2021) call these extra needs "additional investments".
7 The transformation pathway outlined in the study of Prognos (2024) was based on the sectoral targets for 2030 established in 2021.

green parts of the bars indicate the additional need for additional investments to achieve greenhouse gas (GHG) neutrality (€56 billion$_{2023}$ per year based on the Prognos estimate).

Figure 2

Range* of estimated needs for sectoral climate protection investments until 2030 and sectoral decarbonization targets by 2030

Figure 2



Source: Agora Energiewende (2025) for emissions data in CO_2 equivalents (CO_2e). Own calculations based on estimates by Prognos (2024) for climate protection investments in 2021-30 (base year: 2020), Boston Consulting Group (2021) for 2021-30 (base year: 2019), and the Federal Environment Agency (Umweltbundesamt, 2024) for 2023-30 (base year: 2022). Investment data expressed in 2023 prices and as a percentage of projected GDP (Source: OECD, 2023). * Range of the average annual need for climate protection investments (beyond the volume of replacement investments) estimated in various studies (additional investments) for the buildings, energy, transport and industry sectors. Replacement investments are not shown here – that is to say, the reallocation of replacement investments that will be needed in any case into climate protection-related areas is taken as given. **1** Denotes the greenhouse gas emissions reduction targets under the German Federal Climate Action Act.

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If we furthermore add necessary replacement investments to this number as well, significantly more funds will need to be (re)invested in a climate-friendly manner overall. Following the terminology used in Prognos (2024), this sum represents “total climate protection-related investments”, and is the sum of the blue and green parts of the bars in Figure 1. Using the Prognos figures, these total climate protection-related investments will have to grow from 8.5% of GDP (average for 2015-20) to 10.4% of GDP (average for 2021-30).[8] Agora Energiewende,

[8] This percentage-of-GDP estimate by Prognos of the need for total climate protection-related investments is significantly higher than the percentage of GDP that can be calculated from the IEA’s estimates. This would suggest that Prognos records the individual sectoral investment needs differently from the IEA. Meanwhile, the Climate Policy Initiative’s aggregated global estimates in Buchner et al. (2023) are fairly close to the estimates of Prognos.

too, identifies investment needs of a similar magnitude over the next ten years (11% of GDP) to make Germany competitive and greenhouse gas-neutral.[9]

Estimates made in various studies of the needs for sectoral climate protection investments (i.e. additional investments) up to 2030 diverge the most for the buildings and transport sector, while being closer together for the energy sector and the industry sector. Figure 2 illustrates the range of sectoral needs estimates taken from the studies prepared by Prognos (2024), the Federal Environment Agency (2024) and Boston Consulting Group (BCG, 2021). This figure also shows the reductions in greenhouse gas emissions that have taken place since 2019 and those that are still required up to 2030 (source: Agora Energiewende, 2025). Estimates of investment needs diverge the most in the buildings sector.[10]

Prognos (2024) identifies the greatest investment needs for the buildings sector and the energy sector. Meanwhile, BCG (2021) sees the greatest investment needs in the transport sector, and the Federal Environment Agency (2024) in the industry sector. By aggregating these sectoral investment estimates, we see a range of additional investment needs of between 1.9% and 3.4% of projected GDP for the period 2021-30.

By aggregating the sectoral investment needs from the Prognos study, we can see a hump-shaped pattern of annual climate protection investments (see Annex A.3, Figure A3.1). Between 2021 and 2030, these rise from just over 2% to more than 4% of GDP before declining again. By comparison, realised climate protection investments between 2015 and 2020 came to an average of only 1.6% of GDP.

2.3 What plans do firms and households have?

The business and household surveys carried out by the Bundesbank in 2024 indicate that a significant proportion of the firms and households surveyed are not planning to invest in climate protection measures to the necessary extent (see Annexes A.4 and A.5). 54% of the firms surveyed indicated their intention to invest in decarbonisation measures.[11] One-third of firms plan to invest more than in the past five years. As a proportion of sales, too, a higher share is set to be put towards decarbonisation investments.[12] The waste management and recycling, transport and storage, mining and quarrying, and electricity and water supply sectors, in particular, have a higher percentage of firms that are planning to invest more heavily in decarbonisation than in the past five years. However, there are also firms in all sectors that plan to scale back on decarbonisation investments. In addition, only one in four firms intend to

9 See Agora Energiewende (2025). In addition to Prognos (2024), the authors of this paper also refer to the Öko-Institut, Wuppertal Institute and University of Kassel (2024).

10 Following the approach used in Prognos (2024), the buildings sector comprises households' residential buildings and non-residential buildings in the business, trade and services sectors, such as office buildings and hospitals.

11 The Kreditanstalt für Wiederaufbau (2024) comes to a similar finding: according to the *KfW climate barometer* (KfW-Klimabarometer 2024), just over one-half of the surveyed firms take climate action into account in their business strategy.

12 Notes on financing sources: Where surveyed firms and households reported that they are planning decarbonisation measures, they are intending to finance these primarily through recourse to retained earnings – around 60% in the case of firms and around 70% for households – and bank loans (including government-sponsored loans) – just over 30% for firms and just under 30% for households.

reduce their own carbon emissions by at least 10% by 2028, and only 6% of firms are planning to reduce emissions by at least 25%. The picture is similar in the five-year period up to 2033, with only 14% of firms intending to reduce their emissions by at least 25%. This falls short of what is needed to achieve the target set by the Federal Climate Action Act, which stakes out a 33% reduction in emissions between 2024 and 2030 (see Figure 2). Households, too, are planning to increase their investments in decarbonisation measures only moderately, especially in the buildings sector. To achieve the Paris climate targets, total climate protection-related investments would need to be increased by around 25% per year, but households are only planning an increase of slightly over 3% per year compared with the historical 20-year average. It is striking that, especially up to 2028, plans initially envision a reduction of around 5% per year but, following that, an increase of around 11% per year compared with past levels is planned. It is possible this has something to do with the still largely unclear climate policy framework (local heating plans must be drawn up by 2028).

Overall, a large number of firms and households do not anticipate making significant cuts to their carbon emissions in the coming years. The majority of firms are not striving to achieve any substantial (absolute) reduction in emissions. Households, as well, are anticipating only a negligible reduction. This does not align with Germany's 2030 decarbonisation objective:[13] measured by the 2024 figures for remaining greenhouse gas emissions, sectoral emission reductions ranging from 23% to 37% by 2030 are still needed, based on the figures in Agora Energiewende (2025) (see Figure 2). Aside from the positive developments seen in the energy sector, emissions – especially in the transport and buildings sectors – have recently remained at previous levels. While the energy sector and the industry sector overachieved on their indicative 2024 decarbonisation targets under the Federal Climate Action Act by -19% and -9%, respectively, the buildings and transport sector failed to meet their 2024 targets by 5% and 14%, respectively.[14]

As a result, the household survey and the firm survey indicate a reluctance to invest. Against this backdrop, there is reason to fear that a climate-friendly use of replacement investments and additional climate protection investments will both fall short of the levels required.

3. Financing needs at the instrument level

An assessment of needs thus reveals that, to achieve the objective of greenhouse gas neutrality, investment has to be stepped up even further, both in Germany and worldwide. The following discussion tackles the question of whether the German financial system could, in principle, fund the necessary investments in Germany. We make the implicit assumption that

13 Germany's Federal Climate Action Act stipulates that annual GHG emissions need to be cut by 65% by 2030 compared with their levels in 1990. That equates to a reduction of 820 million t CO_2e. According to Agora Energiewende, a reduction of 48%, or 606 million t CO_2e, was achieved in 2024 – albeit largely due to emissions reductions in the energy industry.

14 See Agora Energiewende (2025). For 2025, the corresponding deviations from the indicative sector targets amounted to -16% and -13% in the energy sector and the industry sector (overachievement), while the buildings and transport sector failed to meet their 2025 targets by 16% and 24%, respectively.

the investments would be economically profitable and would thus, indeed, go on to be implemented provided the corresponding financial resources were available. From an economic perspective, the most appropriate way of defining investment volumes for the purposes of this investigation is to apply the concept of climate protection investments as used in the Prognos (2024) study and outlined above. Climate protection investments measure the investment needs that go beyond replacement investments and would therefore have to be financed additionally. The investment needs as calculated in Prognos exceed those in comparable studies (see Figure 2) and are therefore suited to serving as a "stress test" with regard to financing needs. Investment needs can be financed using various instruments, such as bank loans, bonds or equity. Determining financing needs at an instrument-specific level involves a variety of calculation steps.

First, the different investment needs are ascribed to various institutional sectors: households, non-financial corporations and general government. Drawing on the works of Brand and Römer (2022) and Burret et al. (2021), the aggregate climate protection investments calculated in Prognos (2024) can be mapped to the institutional sectors "households", "non-financial corporations" and "general government" with the help of plausibility assumptions and existing estimates. As this involves linking various studies, it necessarily produces only a rough estimate. Annex 2 details the calculation steps required. According to the calculations, for the period from 2020 to 2045, climate protection investments work out at an average of €64 billion$_{2023}$ per year for non-financial corporations, €54 billion$_{2023}$ for households and €26 billion$_{2023}$ for general government.

The sectoral investment needs calculated in this manner can then, in turn, be employed to derive instrument-specific financing needs. Fundamentally speaking, these financing needs can be covered by either internal financing (savings) or external financing (for example bank loans or bonds). Net savings at the macroeconomic level correspond to gross domestic product (GDP) less government and private consumption expenditure and depreciation, and retained earnings for non-financial corporations. External financing needs are calculated as the difference between the additional financing needs and the available internal financing. External financing needs can be met with various different instruments, including bank loans, bonds and equity. The relative shares of internal and external financing as well as the individual external financing instruments are derived from historical averages. For detailed calculation steps, see Annex 2. For the purposes of estimating instrument-specific financing needs, a distinction is drawn between two scenarios.

- *Net savings:* There are net savings available that can be put towards the internal financing of climate protection investments. Further investment is covered by external financing. This is the baseline scenario.
- *Zero savings:* No savings are available. Climate protection investments are funded entirely through recourse to external financing. This scenario represents a de facto upper limit for external financing needs.

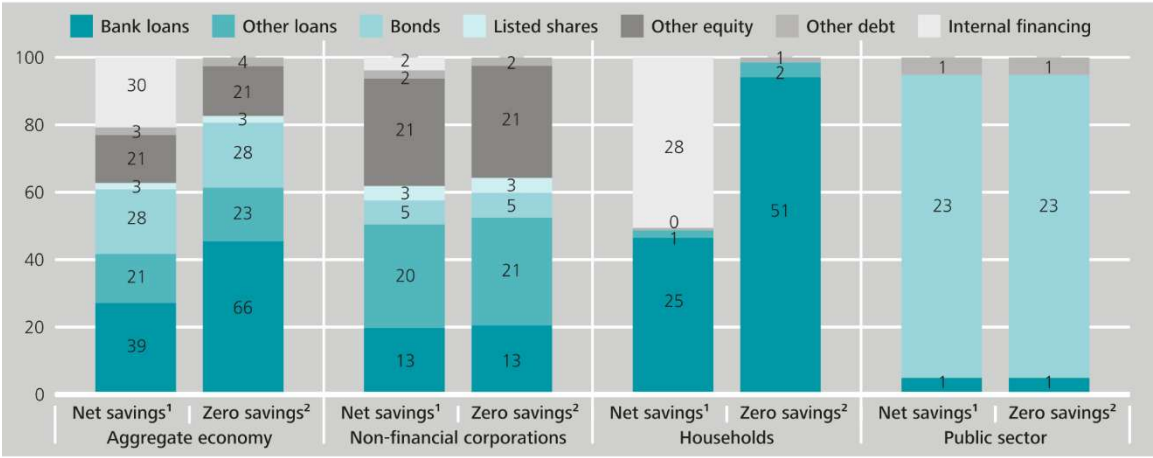
A large portion of investments is likely to have to be covered by external financing. In the “net savings” baseline scenario, internal financing covers around one-fifth (21%) of the additional financing needs for the economy as a whole, amounting to an absolute sum of €30 billion$_{2023}$ (see Figure 3 below). Alongside bank loans, bonds and other loans are important sources when it comes to external financing. The estimated need for financing in the form of bank loans amounts to €39 billion$_{2023}$ and equals €28 billion$_{2023}$ in the case of bonds and around €21 billion$_{2023}$ for other loans. This represents a relative share of total financing needs of 27%, 19% and 15%, respectively. Equity financing also has a significant part to play, working out at a volume of €24 billion$_{2023}$ (16%). Within the category of equity financing, other equity, such as shares in German limited liability companies (GmbH shares), plays a significantly larger role than listed shares, accounting for around 14% of total financing. There is considerable variation between the three sectors when it comes to the instrument-specific external financing needs yielded by the calculations. Households almost always use bank loans to meet their external financing needs. In addition, internal financing (savings) makes up more than half of their total financing. By contrast, general government draws its financing almost exclusively from bonds and accounts for the bulk of the financing needs via this instrument. Non-financial corporations are the only ones with a more varied financing mix.

Figure 3

Additional financing needs of the economy under different scenarios

Figure 3

%, real bn € in 2023 prices per year (absolute values in bars)



Sources: Brand and Römer (2022), Bundesbank, Burret et al. (2021), Prognos (2024), Federal Motor Transport Authority and own calculations. **1** Internal financing equals net savings. **2** No internal financing.

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In the case of non-financial corporations and households, it would also be possible to derive the expected financing needs at the instrument level from surveys. The business and household surveys carried out by the Bundesbank in 2024 and other surveys find that non-financial corporations and, above all, households in Germany intend to rely most heavily on

internal financing (retained earnings and savings) to finance their climate protection investments. The planned share of internal financing is around 60% for firms and around 70% for households, leaving the need for external financing much smaller than previously estimated. This sizeable discrepancy is mainly due to the fact that our own calculations presuppose a significantly lower availability of internal funding. That assumption is driven by the fact that the investment needs as calculated are significantly higher than the actual investments being planned by firms according to surveys. If climate protection investments were to be upped significantly compared with the present state of implementation and planning, there would likely need to be far greater recourse to external financing, since internal means of financing would no longer suffice. This fact notwithstanding, the figures derived from our own calculations tend towards overestimation of external financing needs rather than underestimation.

4. Analysis on the possibilities of transformation financing via external financing sources

4.1 Implications for the German banking system

This chapter shows whether the German banking system[15] is capable of meeting climate protection investment needs via additional lending (beyond regular lending activity). The starting points for the analysis are the results of Chapter 3, in which the climate protection investment needs in Germany to be met by bank loans were determined.[16] The annual demand for loans from institutions for climate protection investments are extrapolated into the future with an inflation factor of 2% and thus converted into a nominal variable. By contrast, common equity tier 1 (CET1) capital is already a nominal variable.[17]

To analyse whether climate protection investment needs can be financed by the German banking system, we focus on institutions' regulatory capital requirements and the resulting restrictions on further lending. This is because institutions in the German banking market are generally unable to grant loans without constraints, but rather are limited both by their liabilities side (refinancing of loans) and by regulatory requirements such as the aforementioned capital requirements. In the following model calculation, banks grant loans provided that they do not fall below regulatory thresholds regarding their (1) risk-based capital requirements[18], (2) their leverage ratio[19] and (3) their requirements from the framework of minimum requirements on eligible liabilities (MREL)[20], including a small management buffer for each of the constraints.

15 For the sake of this analysis the German banking market consists of institutions that fall under the German banking act (Kreditwesengesetz). This excludes the Kreditanstalt für Wiederaufbau, as it is taken out from the German banking act.
16 Additional information on the banking system's starting position can be found in the Annex under A3.1.
17 CET1 stands for common equity tier 1 capital. It mainly consists of paid-up capital, retained earnings and disclosed reserves.
18 Comprise the minimum requirements pursuant to Article 92 CRR, AT1/T2 gap, P2R, the combined capital requirements, and the target equity ratio or Pillar 2 guidance (P2G).
19 Comprises the minimum requirement of 3%, the G-SIB add-on, LR-P2R and LR-P2G.
20 Comprises MREL requirements, subordinated MREL requirements and internal MREL requirements.

Additionally, the analysis accounts for the upcoming changes in capital requirements due to the output floor requirement[21]. Over the next seven years, capital requirements of those banks that use internal models for calculating their capital requirements may increase due to the phase-in of the output floor. By the beginning of 2030, the output floor factor will will have increased to 72.5%, and all transitional provisions related to the output floor will be fully phased out by the start of 2033. The key control parameter in this model calculation is CET1 excess capital, i.e. CET1 capital held in excess of the aforementioned capital requirements by institutions.[22]

In addition, it is assumed that lending is distributed across the entire German banking sector according to the current market shares of individual banks. If a bank can no longer grant any further loans at a certain point in time, loan demand in this model is redistributed amongst all the remaining banks that still have capacity in a further iteration. The analysis therefore disregards possible regional and other frictions. The lending capacity of an individual institution is measured by the available CET1 excess capital above the thresholds mentioned in the previous paragraph. In extreme cases, these iterations can result in all of the banking system's free capacity being used up at one point in time. The target variable of the model is the minimum allocation to CET1 capital[23] at any point in time that is sufficient to service all climate protection investments plus regular demand for loans. Further details on the methodology of the analysis can be found in Annex A.3. As at the cut-off date of 30 September 2025, institutions in the German banking market had more than €5.6 trillion in loans on their balance sheets, of which around €4 trillion was vis-à-vis households and non-financial corporations. Climate protection investments are therefore relatively small compared with the current stocks of loans.

In the net savings and zero savings scenarios (Chapter 3), the annual average minimum allocation to CET1 capital for the 2045 target path is around 1.8% and 2.3%, respectively. If, as in the third scenario, all climate protection investments were to be borne by the German banking market, the minimum allocation to CET1 capital in this scenario would be around 2.8% (see Figure 4). With this minimum allocation to CET1 capital, the existing CET1 excess capital per institution would shrink over the analysis period down to the aforementioned thresholds. For instance, in the scenario where all climate protection investments are considered, the CET1 excess capital as a percentage of RWA would be around 1.4% by the end of the simulation. At the start of this analysis, this measure is significantly higher at 5.0%.

21 The output floor establishes a limit on the reduction of RWA that an institution can achieve through the use of internal models, in comparison to standardized approaches. Specifically, the RWA of an institution utilizing internal models cannot fall below the RWA calculated solely using standardised approaches, adjusted by an output floor factor. This output floor factor is subject to a phase-in-period that commenced in 2025, starting at 50%. By 2033, the output floor factor will reach its final level of 72.5%.

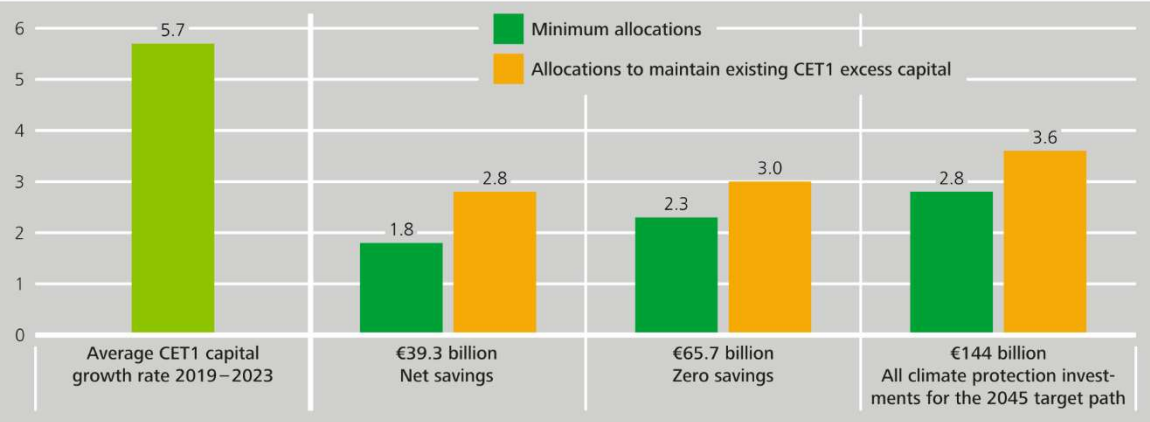
22 Institutions have excess capital for various reasons. Amongst other things, they provide themselves with space for the future so as not to run the risk of falling below the minimum capital requirements or the combined buffer requirements. Market expectations also play a role, especially in the case of publicly traded institutions.

23 Primarily in the form of retained profits for the financial year and transfers to the fund for general banking risks.

Figure 4

Average historical CET1 growth rate and annual average CET1 allocations to finance climate protection investments for the 2045 target path

Figure 4



Sources: Own calculations based on prudential reporting (COREP) and the requirements set out in Prognos (2024) as well as the transfer of which to institutional sectors.

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The German banking system would therefore be able to finance the climate protection investments while still functioning smoothly. However, CET1 excess capital might be reduced significantly and resilience to future crises might thus be weakened. By contrast, in order to maintain the current level of CET1 excess capital of around 5.0%,[24] larger allocations than the aforementioned minimum allocations are required for each scenario. In the net savings and zero savings scenarios, the annual CET1 allocation to preserve the current level of CET1 excess capital is around 2.8% and 3.0%, respectively. If all the climate protection investments had to be borne by the German banking market, the CET1 allocation to preserve the current level of CET1 excess capital would be around 3.6%. The figures are thus below the average annual growth of CET1 capital (5.7%) over the past five years (Q3 2020 to Q3 2025). In these years, that is, including the period of the coronavirus pandemic and the interest rate reversal, annual allocations to CET1 capital have always been above 4%. Even in the delayed transition scenario, the German banking system is capable of absorbing the necessary demand for loans related to climate protection investments. In this context, the volumes shift in such a way that fewer climate protection investments are made in the coming years, but these are then made up for at a later time, resulting in temporary peaks in investment needs due to this catch-up effect (see Figure 5). Compared with the 2045 target path, however, the required average minimum allocation to CET1 capital is only slightly higher in the case of the disruptive scenario, at around 3.2% per year. In order to maintain the current level of CET1 excess capital, an average CET1 capital growth of around 3.8% is required. However, due to temporary peaks in the climate protection investments CET1 excess capital shrinks to slightly above 3.8% in the

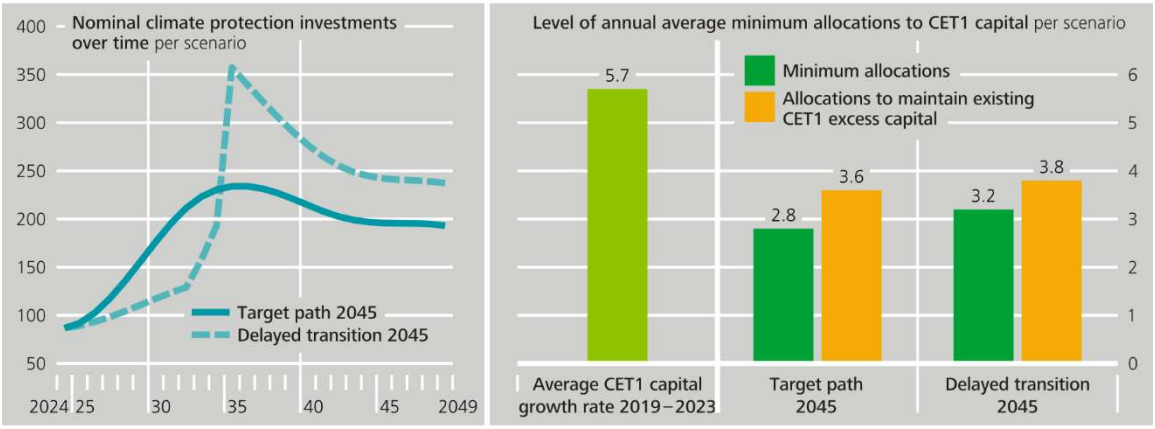
24 As at September 2025.

years where the volumes to be allocated are the highest, but afterwards it rises to the level of the starting point. Due to the conservative assumptions in the simulation (in particular, ignoring collateralisation by immovable property which reduces risk weights), it can be expected that the banking system will be able to make these allocations.

Figure 5

Nominal climate protection investments and annual average minimum allocations to CET1 capital

Figure 5



Sources: Own calculations based on prudential reporting (COREP) and the requirements set out in Prognos (2024) as well as the transfer of which to institutional sectors.

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However, the estimation made is subject to some uncertainties, especially given that various aspects have not been taken into consideration for the sake of simplicity. For instance a potential increase in the carbon price and the associated change in enterprises' creditworthiness may weigh on institutions' capital adequacy.[25] Projections of the future level of capital buffers, such as the countercyclical capital buffer and the systemic risk buffer, are also not included. Importantly, in order to account for these uncertainties, the analysis is deliberately based on conservative assumptions in some parts. Furthermore, hidden reserves pursuant to Section 340f of the Commercial Code were not considered in the case of all the institutions that prepare their financial statements according to the Commercial Code. Institutions would be able to release these reserves through profit or loss at any time and thus improve their capital adequacy.[26] Also excluded is collateralisation by immovable property which reduces the risk weight. Therefore, the average risk weights applied in the analysis might have been too high, since climate protection investments also includes investments for building

25 However, the Bundesbank's climate risk stress test shows that even the impact of a relatively abrupt spike in carbon prices should be manageable for the German banking system (see Gross et al., 2025).

26 As at 30 September 2025, the stock of hidden reserves pursuant to Section 340f of the Commercial Code held by institutions which prepare their financial statements according to the Commercial Code in the German banking market amounted to around €16.7 billion. A large share of this is attributable to savings banks and cooperative banks.

maintenance, where mortgages are used frequently. On the other hand, we assume in the simulation that investments related to climate protection do not default, but instead are paid off over time. Moreover, the securitisation of loans would have the potential to ease banks' equity situation and create scope for additional lending. Because of these conservative assumptions the lending capacity of the German banking market tends to be underestimated. Overall, the analyses suggest that the German banking sector should be able to meet the climate protection investment needs through additional lending, even under conservative modelling assumptions.

4.2 Transformation financing from a capital market perspective

The additional financing needs for bonds illustrated in Chapter 3 relate mainly to the public sector, which obtains funding almost exclusively via bonds. For the domestic corporate financing examined here, however, bond markets are less important, both in comparison with bank loans granted in Germany and in Europe. While the bond share of corporate liabilities in Germany was around 10% most recently, it was significantly higher for French enterprises (around 26%) and also for Dutch enterprises (around 15%).

The relatively cost-efficient access to bank loans is likely to be a key reason for their dominance, particularly if documentation and reporting requirements are taken into account. High fixed costs for corporate bonds, especially for the initial bond issuance, are often a considerable hurdle. In addition, private owners of enterprises are often reluctant to ensure the necessary transparency. Not least, an issuance of bonds generally requires a minimum volume in the range of several hundred million euro – more than most medium-sized enterprises require in a single refinancing operation. Even though higher issuance capacities appear possible in the German bond market from an international perspective, the conditions for bank loans generally seem to be more attractive for the enterprises requesting loans owing to their size and capital structure.

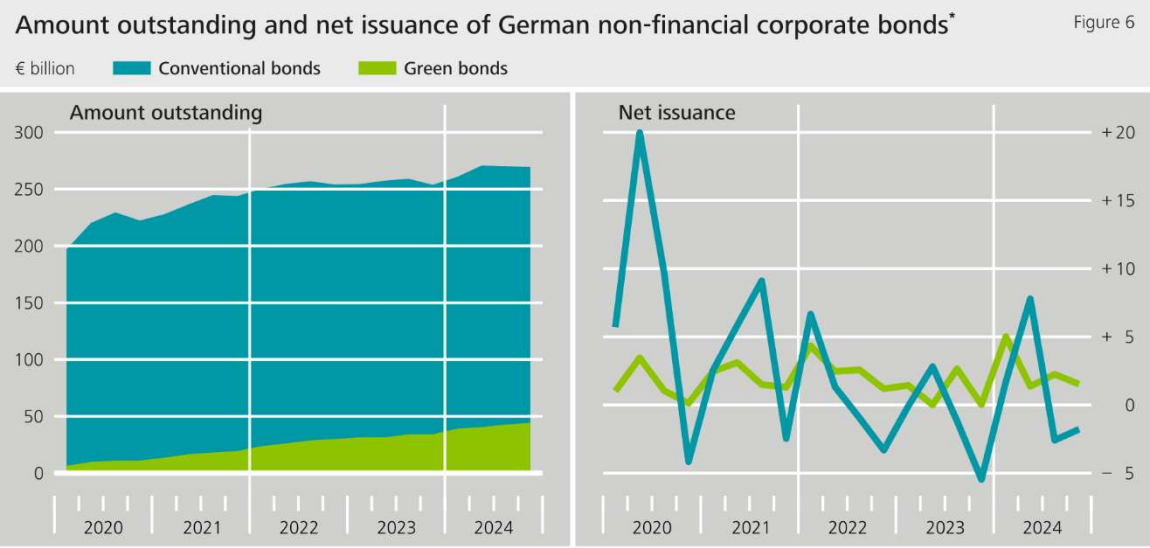
The total outstanding volume of domestic non-financial corporate bonds rose to around €270 billion at the end of 2024 (see Figure 6). This data does not include any bonds issued by banks or other financial issuers.[27] From a corporate perspective, the relatively young green market segment, in particular, would be suitable for funding the transformation in the capital market. For example, a possible green premium, known as a "greenium", could be used to provide somewhat cheaper funding. However, the premium fluctuates over time and across issuer sectors, meaning it cannot be the key factor influencing the profitability of an investment.[28] Measured in terms of the total outstanding volume of bonds issued by domestic non-financial corporations, green bonds accounted for a share of around 16% at the end of 2024. Even

[27] The data here therefore form a lower bound for non-financial corporations' capital market funding, as bonds issued by financial subsidiaries, for instance, are not taken into account.

[28] Public sector issuers generally have a higher greenium than non-financial corporations; see, for example, Deutsche Bundesbank, ESG Bond Monitor, February 2025.

though green bonds only covered a small sub-segment of the overall market, they have nevertheless grown strongly in recent years.

Figure 6



* Bonds issued by (foreign) financial subsidiaries are not included. Source: Own calculations based on the Centralised Securities Database of the Eurosystem.

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The growing importance of green bonds is reflected in net issuance, i.e. the share of newly issued bonds in net terms (gross issuance less redemption). In 2024, net issuance of green bonds amounted to €10.2 billion on balance, while net issuance of the other, conventional bonds totalled only €5.1 billion (see Figure 6). Looking ahead, investors' increased interest in green bonds could also be leveraged further to fund the transformation. In total, net issuance of green bonds covered less than 40% of the estimated need for external bonds financing for transforming the German economy to achieve greenhouse gas neutrality by 2045 (cf. Figure 3 in Chapter 3).

5. Summary

This study makes several contributions. First, it evaluates analyses that estimate the investment needs for Germany's transition to a greenhouse gas-neutral economy in the coming years. Second, it investigates the question of which financing sources could cover the necessary climate protection investments. Third, the study analyses whether the German banking system has sufficient capacity to finance these investment needs. Finally, the study draws on surveys conducted by the Bundesbank to assess which investments firms and households actually plan to undertake in the coming years to reduce their own CO_2 emissions.

The analysis yields the following findings and key takeaways:

1. Investment needs: For Germany, the annual climate protection investment needs (i.e. investments in addition to replacement investments that have to be undertaken anyway but are assumed to be used for climate-friendly purposes) amount to between 2.0% and 4.3% of annual economic output in the period from 2020 to 2045, assuming an orderly transformation. This is noticeably higher than the climate protection investments of 1.6% of GDP undertaken in the period from 2015 to 2020. Comparing the average of 3.4% of GDP required for climate protection investments by 2030 with this historical figure, the "gap" amounts to 1.8% of GDP. The greatest investment needs are in the buildings sector, followed by transport and energy. Based on the climate protection investments estimated in Prognos (2024), these are to be financed first and foremost by non-financial corporations (around 44%), followed by households (38%) and the public sector (18%).

2. Financing: Assuming that the financing behaviour observed over the past few years remains broadly unchanged, bank loans are likely to play a significant role in the baseline scenario, accounting for 27% of the additional financing needs of the economy as a whole. Other key sources of funding are likely to be retained earnings and savings (i.e. internal financing amounting to 21% of total financing) and bonds (19%). The capital market has so far not played a substantial role except for the public sector. In the corporate sector, its role has remained comparatively small.

3. Banking sector: The present analysis indicates that the German banking sector is well positioned to meet the necessary increase in loan demand for attaining greenhouse gas neutrality. Even in the most conservative scenario – i.e. German banks finance all climate protection investments in a delayed transition setting –, both the minimum CET1 allocations (3.2%) and the average CET1 allocations to preserve the current excess CET1 capital (3.8%) are below the historical growth rates for CET1 capital over the past few years.

4. Actual decarbonisation progress and planned investments according to own surveys: The simulation analyses for the German banking sector that are presented here are based on the assumption that the investments needed in order to achieve greenhouse gas neutrality are actually undertaken. How realistic this is can be assessed, first, on the basis of the sectors' decarbonisation progress in the past (a). Second, Bundesbank surveys conducted in 2024 indicate how the investment behaviour of households and firms may develop over the next few years (b). Third, firms and households surveyed suggest that expected financing volumes are likely to be significantly lower than the volumes assumed in our simulations for the banking sector (c).

    a) In terms of actual emissions reductions, the German energy sector has so far met and exceeded the decarbonisation targets set out in the Federal Climate Action Act. By contrast, the buildings sector and the transport sector are lagging behind the specified emissions targets. According to Agora Energiewende, these two sectors and the

industrial sector lack the necessary structural dynamism to achieve the climate targets.[29]

b) However, the decarbonisation efforts required to achieve the climate targets by 2030 (i.e. sectoral emissions reductions of between 23% and 37%) differ from the actual expectations of firms and households. The analysis of Bundesbank surveys points to a low overall propensity to invest among households and businesses. For example, a large proportion of firms are planning little to no investment in decarbonising their own business activities in the coming years. Among the firms that plan to reduce their CO_2 emissions, a large part wants to invest only a small portion of their expected sales in such efforts. While firms with high decarbonisation ambitions primarily plan to finance decarbonisation investments using bank loans, including government-sponsored loans, for firms as a whole retained earnings are the top source of such financing.

c) Households show a similar reluctance to invest: investment is initially expected to decline by around 5% in a historical comparison, especially over the next five years, while an increase of around 11% is expected in the subsequent five years. Compared with the necessary growth of around 25% in investment, this is not sufficient to achieve the sectoral climate targets. In particular, the vulnerable group encompassing the least wealthy 8% of households with the most energy-inefficient building stock has, in the past, invested around 30% less than the remainder of the sample. Although these households are planning similar investment volumes to the remainder of the sample, decarbonisation investments could be lower in this vulnerable group in particular.

d) Both firms and households are planning investments in climate protection that are only rising slightly over time. Moreover, the stated share of bank financing planned for decarbonisation investments is found to be lower than the share of own funds earmarked for this purpose. This suggests that the banking sector might not face significant additional demand for credit for climate protection measures over the next years.

The finding of a reluctance to invest among firms and households and of a “gap” between past investments and the current investment needs, amounting to 1.8% of GDP (based on Prognos, 2024), raises follow-up questions concerning how to deal with this discrepancy. Other factors that go beyond the analytical framework of this project are relevant here, for example the risk premia charged by investors – including banks – for financing climate-friendly technologies, or the future political framework (carbon pricing, subsidies, regulation).

[29] See Agora Energiewende (2025).

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Annex

A.1 Global and European investment needs

A1.1 Global investment needs

Global investments in climate protection are so far not high enough to carry out measures sufficient to limit global warming to 1.5°C above pre-industrial levels.[30] Studies by the International Energy Agency (IEA, 2024) and Climate Policy Initiative (see Buchner et al., 2023) suggest that the sum of total global climate protection-related investments does not yet match the level required to limit global warming to 1.5°C above pre-industrial levels. Although investment in renewables, grid expansion and storage has increased substantially in recent years, the IEA's NZE scenario (Net Zero Emissions by 2050) demands that the global capacity of these three components be tripled between 2023 and 2030. For that to happen, annual investments in these areas need to double over that period. As a proportion of current or (where applicable) projected global GDP, this corresponds to an increase from 1.2% to around 1.8% in 2030 (see Figure A1.1). In addition, investments in industry, and in particular in the buildings and transport sectors, need to be increased almost threefold and hit around 1.4% of global GDP in 2030 to double energy efficiency in these sectors.

Based on the IEA's estimates, total climate protection-related investments would have to rise from US$2.0 trillion$_{2023}$, or 1.8% of global GDP, in 2024 to US$4.2 trillion$_{2023}$, or 3.4% of (IMF) projected GDP, in 2030 (see Figure A1.1). At the same time, investment in fossil fuels would have to be halved to US$500 billion$_{2023}$, or cut from 1.0% of GDP to 0.3% of GDP. However, if investment in renewable energies sticks to its current trend, the IEA finds that only two-thirds of the investments needed to triple renewables capacity by 2030 would be achieved.

Buchner et al. (2023) places estimated annual global investment needs at as much as 7% to 8% of global GDP by 2030. The discrepancy between actual investments and estimated needs is even greater in Buchner et al. (2023) than in the IEA's calculations. According to the Buchner et al. (2023) figures, climate protection investments need to be four to eight times higher than the actual spend on total climate protection-related investments (US$1.4 trillion$_{2023}$, or 1.3% of global GDP in 2023) if the 1.5°C target is to be met.[31] Annual global investment needs presently amount to around US$8.4 trillion$_{2023}$ (8% of 2023 GDP) and are expected to increase to US$9 trillion by 2030 (7% of IMF-projected GDP for 2030).

[30] See IEA (2023b).

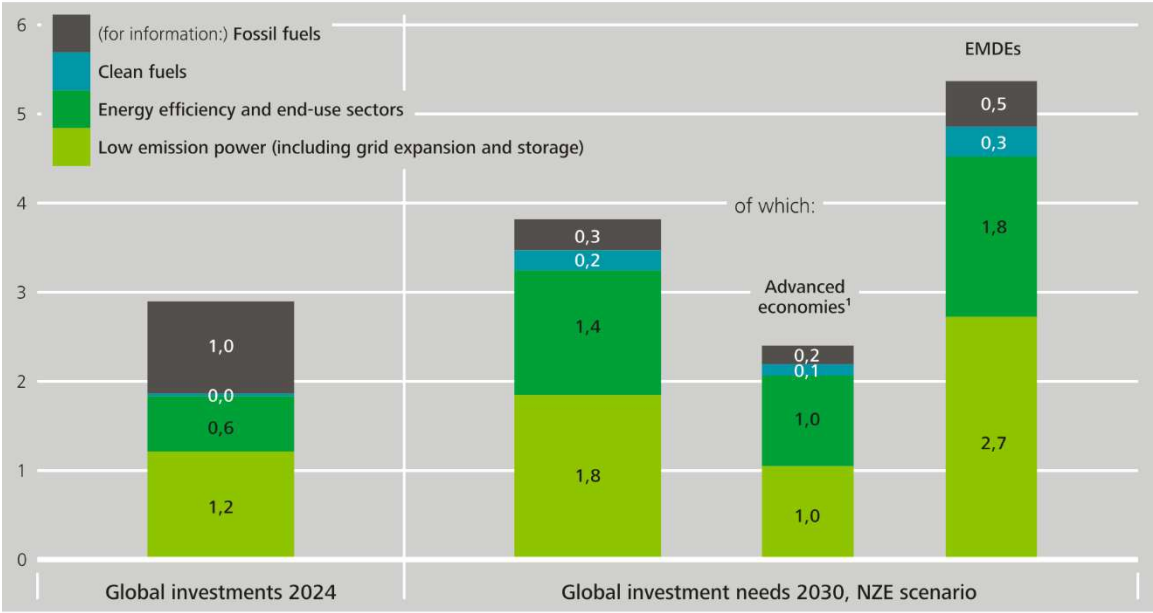
[31] See Buchner et al. (2023), Global Landscape of Climate Finance 2023. In that particular study, climate finance needs estimates for 2023-2050 include direct investments in climate-specific physical assets and exclude transition-related fossil fuel finance. The estimates are based on projections yielded from 15 sectoral scenarios (see Methodology document). Climate finance needs for 2023-2050 are expressed in real 2022 US$.

Alongside the increased need for investment in renewables, battery storage and grid expansion, the calculations of the IEA (2024) also identify a need for investments in energy efficiency. Specifically, energy efficiency at the global level needs to increase twice as quickly as it has so far.[32] While there is no need for a steep increase in investments in the industrial sector, investments in the buildings and transport sector have been far too low to date. Overall, investments towards upping efficiency in these three sectors need to roughly triple to US$1.9 trillion per year (dark green segments in Figure A1.1). This corresponds to an increase from 0.6% to 1.4% of the respective GDP.

Figure A1.1

Global investments related to climate protection:
2024 and estimated needs by 2030 in the IEA's Net Zero Emissions (NZE) scenario*

Figure A.1.1



Source: International Energy Agency (IEA, 2024), International Monetary Fund (2024) for GDP projections, own calculations. * The underlying investment estimates from IEA (2024) are based on US$ data at 2023 prices. In order to achieve the expansion in renewable power, grids and battery storage necessary to align with the 1.5°C target (IEA's Net Zero Emissions scenario), corresponding annual investments need to double. Furthermore, energy efficiency in the buildings, transport and industrial sectors (end-use sectors) has to double, and corresponding annual investments will need to increase threefold to fuel this. In addition, investments in fossil fuels need to be brought down to less than one-half. **1** Canada, EU countries, Japan, Korea, United Kingdom, USA.

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Investments in e-fuels are currently climbing rapidly, albeit from a very low level.[33] Adding in investments to the tune of around US$500 billion for the purpose of ensuring the supply of fossil fuels,[34] energy-related investments of US$4.7 trillion will be necessary in 2030 in the

[32] Whilst investment in electrification of the transport sector has so far been strong and has led to efficiency gains, investment in energy-efficient renovation of buildings is waning.

[33] Overall, the oil and gas industry invested around US$30 billion in 2023, less than 4% of its total investments in clean energy. Around half of this was attributable to mergers and acquisitions of firms in the clean energy sector.

[34] Here the IEA is assuming that investment in fossil fuels – which currently amounts to just under €1 trillion (2023) – will be halved. This minimum degree of fossil fuel investment – particularly spending to maintain infrastructure – will continue to be needed in the coming years, even under a Paris-aligned scenario.

IEA's Net Zero Emissions scenario. This corresponds to around 3.7% of global GDP projected for 2030.[35] In this scenario, transformative energy investments (i.e. investments in renewables, grid expansion, storage, energy efficiency improvements and e-fuels that are required to achieve net zero emissions by 2050) would have to more than double, corresponding to an increase from 1.9% to 3.5% of GDP.[36] Conversely, global investment in fossil fuels would need to drop from 1% of global GDP in 2024 to 0.3% of GDP in 2030. Figure A1.1 shows, furthermore, that investment needs relative to GDP are more than twice as high in emerging market and developing economies (EMDEs) as they are in advanced economies. This is mainly due to the fact that demand for energy is expected to rise sharply in the EMDEs and the need for additional energy supply will grow accordingly. These countries need to increase their investment in climate-friendly energy by around 160%, to around 4.8% of their projected GDP, by 2030.

A1.2 Estimation for the EU

The EU needs significantly higher investments in climate protection than have been made in the past, especially where transport, buildings and energy are concerned. The EU has set itself the targets of achieving greenhouse gas neutrality by 2050 and reducing emissions by 55% by 2030. Achieving these objectives requires a significant increase in annual total climate protection-related investments. According to the European Commission (2023), investment volumes in the period from 2021 to 2030 will need to top investments made in the previous decade (2011 to 2022: €764 billion$_{2022}$ per year) by around €500 billion$_{2022}$ per year (corresponding to 3.1% of EU GDP for the same period in 2022 prices). Taken together, annual total investment needs for climate-friendly investments in the period 2021 to 2030 amount to 7.8% of EU GDP in 2022 prices. The largest investment gaps are to be found in the energy sector, the transport sector and the buildings sector.

A.2 Deriving sectoral investment and financing needs

Investment needs at the institutional sectors level

To calculate the investment needs at the institutional sectors level as defined in the national accounts, it is necessary to link together various studies. The starting point for identifying the aggregate investment needs is the study by Prognos (2024). Relative shares of investment needs for households, non-financial corporations and the public sector, meanwhile, can be obtained using a variety of previous studies. This is done by allocating the investment needs in the "industry", "transport", "energy industry", "energy infrastructure", "households" and "accommodation and food service activities, trade and services" sectors to the institutional

35 expressed in 2022 prices. See IEA (2023c).
36 In other words, renewables, networks, battery storage and energy efficiency improvements.

sectors based on plausibility assumptions and existing estimates. One explicit assumption made in these calculations is that the relative shares of the institutional sectors have not changed significantly since the previous studies. Specifically, the study by Burret et al. (2021) subdivides the investment needs for the aggregate economy into the sectors “households”, “business, trade & services”, “industry”, “transport” and “energy”. The “energy” sector corresponds to the two sectors “energy industry” and “energy infrastructure” used in Prognos (2024). The other sectors are identical. Brand and Römer (2022) allocate some of the figures calculated in Burret et al. (2021) to the public sector. The difference between the figures for the aggregate economy according to Burret et al. (2021) and those for the public sector as per Brand and Römer (2022) is allocated as follows. Allocations to the households sector: the “households” sector less the small public sector share; 35.6% of the “passenger cars” sub-sector (average share of new passenger car registrations by households between 2018 and 2021) in the “transport” sector; and, in the “energy” sector, the “home storage” sub-sector. Allocations to the non-financial corporations sector: the “business, trade & services” sector less the public sector share; the whole “industry” sector; 64.5% of the “passenger cars” sub-sector (share of new passenger car registrations not done by households) in the “transport” sector; the remainder of the “transport” sector less the public sector share; the “energy” sector less the “home storage” sub-sector and less the public sector share. On aggregate, this yields data for the absolute financing needs of the three institutional sectors, households, non-financial corporations, and the public sector. It is possible to compute each sector’s relative share in relation to the aggregate investment needs according to Burret et al. (2021). These relative shares are then multiplied by the updated estimates of investment needs from Prognos (2024) to produce the absolute amounts for investment needs of the three institutional sectors presented in the main text.

Financing needs at the institutional sectors level

The financing structure at the institutional sectors level is calculated based on national accounts and financial accounts data. Intra-sectoral lending is excluded from the analysis, as are trade credits and advances. At the end of the day, these two financing instruments merely redistribute means of payment within the NFC sector, so they do not cover the financing needs that are of relevance here in the case of non-NFC investors. The relative share of internal financing and individual external financing instruments corresponds to the average of annual financing flows over the 2018-22 period. Not only does the average value reduce cyclical fluctuations, the period also straddles the relevant reference year (2020) for the calculated investment needs. The average includes the pandemic years of 2020 to 2022. The financial contribution of individual instruments fluctuated strongly during the pandemic period. However, if we widen the period of comparison to the years 2013-2022, the shares are almost identical to those for the 2018-2022 period. The pandemic years will therefore probably barely distort the relative shares. The use of historical data implies that the financing behaviour observed in recent years will continue in the future. However, it is certainly conceivable that the financial

structure will shift as a result of the transformation. This would also change the corresponding need for individual financing instruments.

A.3 Methodological notes on the analysis for the banking system

A3.1 Starting position

The need for climate protection investments identified in Chapters 2 and 3 should also be borne in part by the German banking market. As already outlined in Chapter 3, a financing mix is usually chosen. Depending on the sector in which investment needs arise, bank loans play a more or less significant role. The public sector, in particular, makes little use of bank loans. By contrast, these loans account for almost all external financing for households. They play also an important role for non-financial corporations, but not a major one.

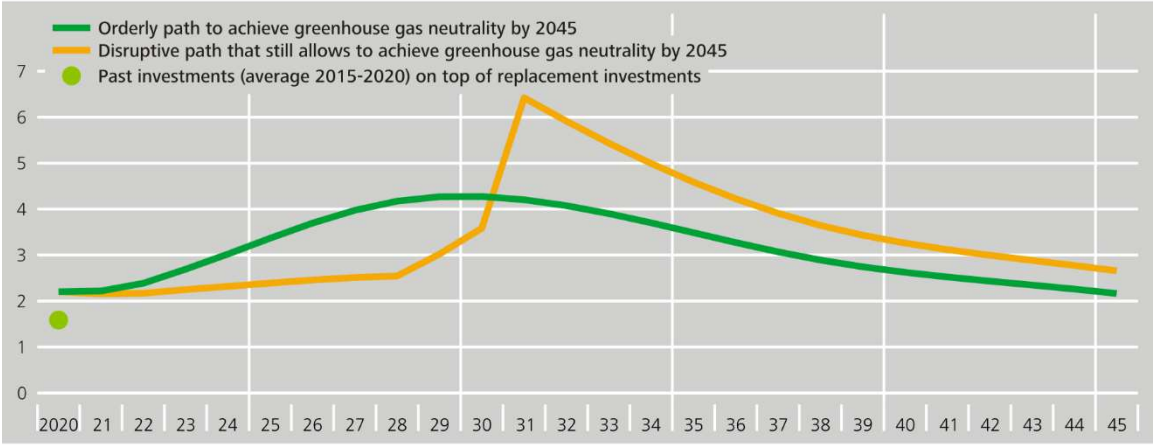
Against this backdrop, the model calculation initially assumes that only part of all of the previously estimated needs (bank loans from the net savings and zero savings scenarios) are met by German banks. In addition, however, a scenario is also considered in which institutions in the German banking market finances not only the volume estimated for bank loans, but all the external and internal financing needs. This scenario thus represents a maximum conservative scenario for the German banking market and is intended to assess its capacity.

Figure A3.1

Annual investment needs for climate protection* to achieve greenhouse gas neutrality by 2045

Figure A.3.1

% of GDP



Source: Prognos (2024), OECD (2023) for GDP projections, own calculations. * Investment needs on top of replacement investments.

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Since capital adequacy is one of the most important constraints on banks' lending capacity, the model calculations focus primarily on the following question: how high must the allocations to CET1 capital be on average per year in the German banking market to shoulder the climate protection investments arising each year? In an initial case, the analysis allows banks to use up their current excess capital, and, in a second case, the amount of capital allocations banks would need on average to maintain their current level of excess capital is analysed.

The time path of the arising investment needs for climate protection is not necessarily linear. Corresponding to Figure 5 in Chapter 4, Figure A3.1 shows an orderly path of climate protection investments (green path) as well as a disruptive path of delayed climate protection investments (yellow path). In the latter scenario, climate protection investments on top of replacement investments remain below 2.5% of GDP until 2028. This results in there being an even greater need for investment thereafter (up to 6.5% of GDP) in order to achieve the objective of GHG neutrality by 2045. It may be concluded from this that starting early with sufficiently large climate protection investments is crucial for an orderly trajectory. The more time that passes without these additional investments, the more disruptive achieving the decarbonization targets would be.

A3.2 Assumptions and methodology

Figure A3.2 is a schematic illustration of CET1 excess capital. It is derived by deducting the amount of CET1 capital, which is occupied by the binding constraint (leverage ratio requirement, risk-based capital requirement, or MREL requirement) from total CET1 capital. Figure A3.3 shows the evolution of CET1 excess capital in the German banking market.[37] As of the third quarter of 2025, the German banking market has CET1 excess capital of around 5.0% of risk-weighted assets (RWA). This is above average by historical standards over the past five years. Following the slump at the start of the coronavirus pandemic in March 2020, this figure recovered and even rose to 5.4% by the end of 2020. In the first quarter of 2023, two macroprudential capital buffers were activated in Germany and raised capital requirements in the German banking market, causing CET1 excess capital to fall from 5.1% to 4.5%. Since the activation came into effect, CET1 excess capital in the German banking market has almost always increased up until the beginning of 2025 when CRR III came into force and led to an increase in risk-based capital requirements for institutions using standardised approaches for credit risk. After the entry into force the numbers for CET1 excess capital relative to RWA has increased again to the level of the year-end in 2024.

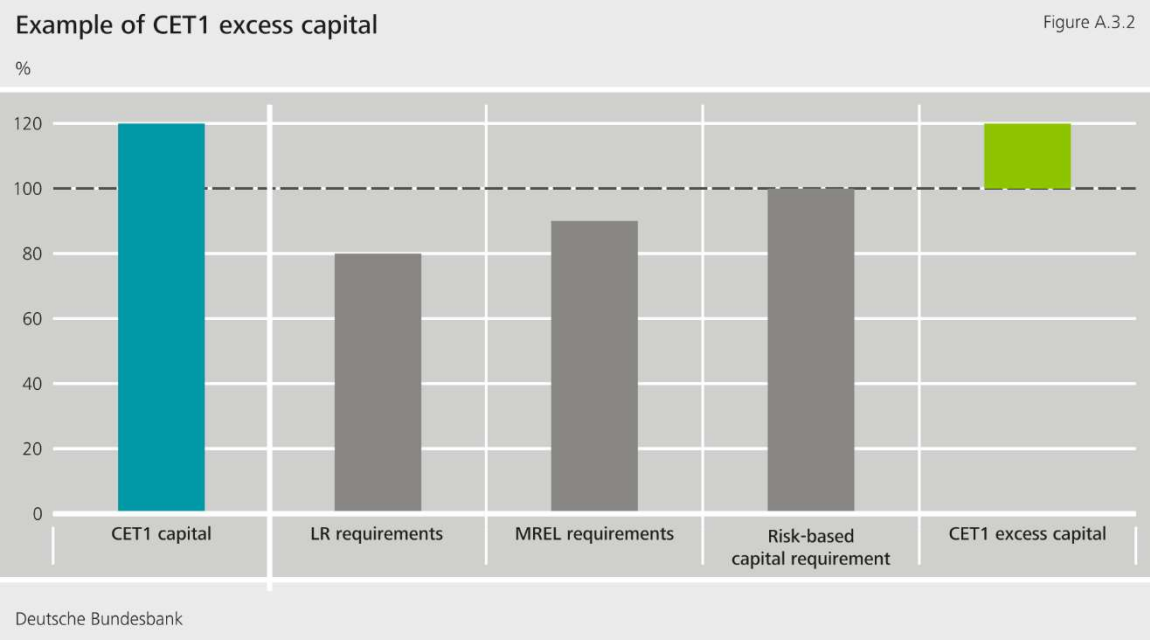
As long as institutions comply with supervisory requirements including having a small buffer, they continue to grant loans for climate protection investments in the model calculations. For the risk-based capital requirement, we apply a buffer here that is equal to the historical

[37] The German banking market consists of all institutions covered by the German Banking Act (i.e. excluding the Kreditanstalt für Wiederaufbau) excluding all branches of foreign banks in Germany.

minimum over the last five years[38] or 1% of RWA, whichever is lower. For the leverage ratio, the buffer stands at 0.5% of the leverage exposure. For the MREL requirements, the mentioned buffers for the risk-based capital and leverage ratio requirement apply as well.

The institution-specific loan amount that each institution is potentially able to grant is calculated on the basis of the market shares in lending at the reporting date analysed. In this context, the climate protection investment needs to be financed each year are broken down by individual institution.

Figure A3.2

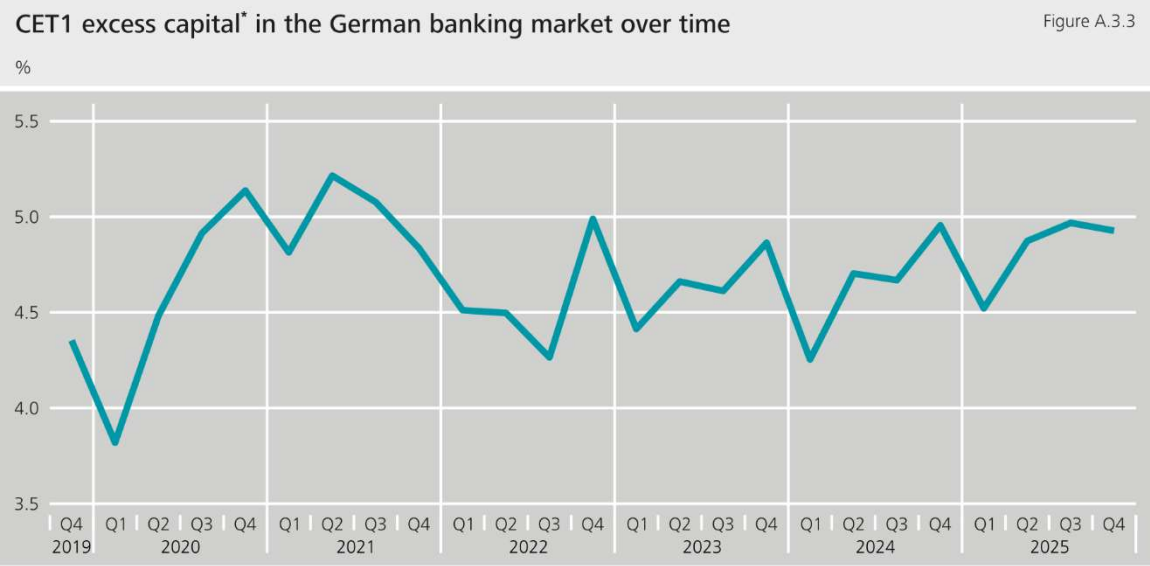


Based on the supervisory requirements, each institution calculates a risk weight for these loans that is measured by the current average risk weights used for German corporate exposures and retail exposures (not taking into account reductions in risk weights by real estate collateral) of the respective institution. Figure A3.4 illustrates this using the example of a stylised banking market consisting of three institutions. In this example, €50 billion in climate protection investments has to be financed by institutions in one year. The total amount is allocated to the three institutions based on the current market share. However, the institutions grant the allocated loan amount only if their exposure-at-default (EAD) capacity is greater than their allocated EAD. EAD capacity is determined by the scope that institutions have regarding their

[38] Using the minimum level over the last five years implies that the coronavirus pandemic, i.e. a real stress scenario, is taken into account. Although default numbers did not rise, thanks to various support measures and the suspension of the obligation to file for insolvency, counterparties' borrowing needs increased nonetheless. This was reflected in the granting of bridging loans, but also in higher drawdowns of credit lines.

supervisory requirements. For institution B, this scope is so small that the EAD allocated to it based on the market share exceeds its EAD capacity.

Figure A3.3



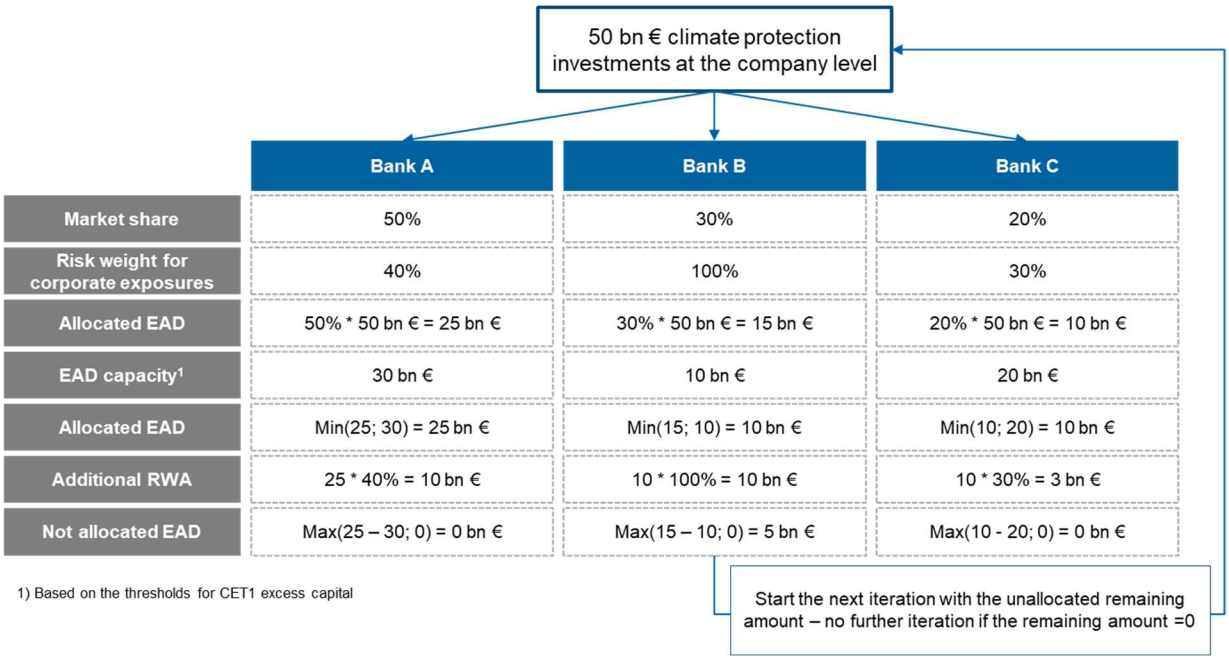
This bank is only able to finance €10 billion of the €15 billion allocated to it, as otherwise it would fall below at least one of the three thresholds (risk-based capital requirement, leverage ratio, or MREL requirement). In a second step, the remaining €5 billion is then allocated among the remaining institutions in the banking market. This allocation process continues until no euro is left to be allocated for climate protection investment needs or there is no longer any free EAD capacity. In the latter case, given the assumptions outlined above, the German banking market could no longer absorb the climate protection investments that arise.

Subsequently, the new period begins in which, in turn, climate protection investments must be financed by the German banking market. In the past financial year, institutions typically generated profit for the financial year, which they allocated (at least in part) to CET1 capital. In addition to retained earnings, this includes transfers to the fund for general banking risk, in particular. Allocations to CET1 capital increase institutions' EAD capacity as more excess CET1 capital is available given unchanged supervisory requirements. In addition, an inflation rate is assumed for lending which is not related to climate protection investments given unchanged risk weights and a static balance sheet structure[39]. The inflation rate translates into corresponding growth in RWA by multiplying it with the institution's specific risk density.[40] In

[39] The inflation rate for lending which is not related to climate protection investments is the average annual growth of the leverage exposure over the last five years (2.6%).
[40] Risk density is defined by RWA / leverage exposure.

addition, it is assumed that the loans granted in the context of climate protection investments will have a repayment factor of 4% and will therefore be repaid over a period of 25 years. This is a conservative assumption in view of typical maturities.[41]

Figure A3.4
Illustrative allocation of climate protection investments in a stylised banking market



Source: own figure.

Table A3.1:
Risk weights for corporate and retail exposures (German contractors, excluding exposures secured by immovable property) by approach and group of institutions (as of 30 September 2025, figures in percent)

	SA		IRB	
	Retail	Corporate	Retail	Corporate
O-SIIs	70	79	36	40
Other Sis	72	95	20	44
Savings banks	72	89	-	_
Cooperative banks	72	81	-	_
Other institutions	66	94	33	58
German banking market	**69**	**87**	**32**	**41**

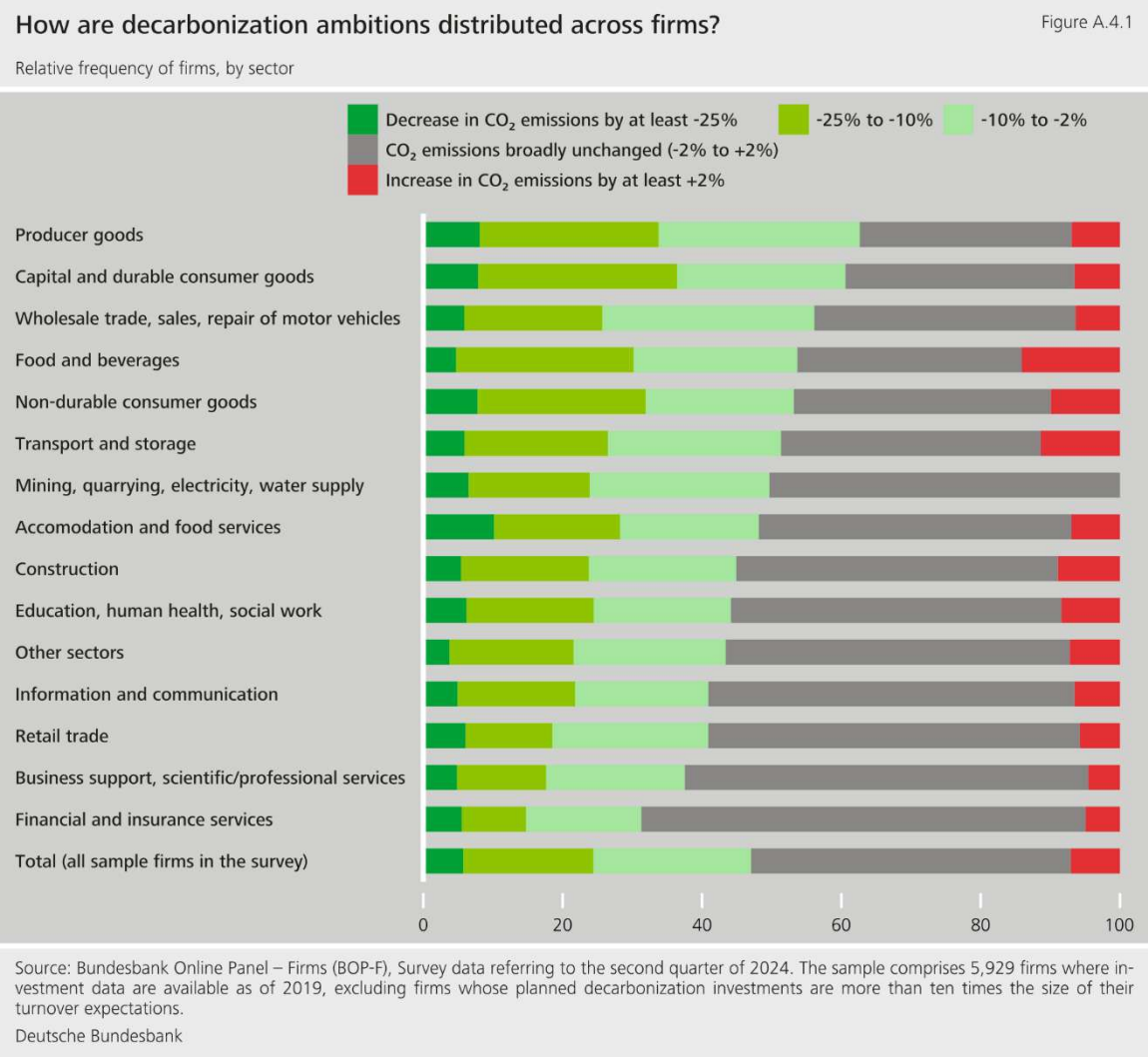
Source: own calculations based on prudential reporting (Common Reporting Framework, COREP/FINREP | Deutsche Bundesbank). SA means standardised approach, IRBA stands for internal ratings-based approach.

[41] The conclusions made based on the simulations are not sensitive with regard to the repayment factor. Even in a scenario with no repayments assumed, the needed CET1 allocations remain under the level of historic CET1 allocations.

For the purposes of the model calculation, the climate protection investment needs outlined in Chapter 2 are divided into two exposure classes. Households' climate protection investments are assigned to the retail exposure class, while enterprises' and the public sector's climate protection investments are assigned to the corporate exposure class and are given the corresponding average risk weight estimated by the individual institution. In both cases, potential collateral (real estate or financial collateral such as life insurance or securities) is not taken into account. This represents a conservative approach, as either the risk weight or the outstanding loan amount would decline if credit protection were considered. Table A3.1 shows the risk weights for the exposure classes in question. Average risk weights for corporate exposures are higher across the approaches than average risk weights for retail ones.

A.4 Bundesbank Online Panel – Firms (BOP-F) in the second quarter of 2024

Figure A4.1



Source: Bundesbank Online Panel – Firms (BOP-F), Survey data referring to the second quarter of 2024. The sample comprises 5,929 firms where investment data are available as of 2019, excluding firms whose planned decarbonization investments are more than ten times the size of their turnover expectations.

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Key takeaways

1. While some firms expect ambitious decarbonization, the overall picture suggests that firms expect only limited decarbonization in the coming years.

Only one in four firms intend to reduce their own carbon emissions by at least 10% in the coming years up to 2028, and only 6% of firms are planning to reduce emissions by at least 25%. The picture is similar in the five-year period after that (up to 2033), with only 14% of firms intending to reduce their emissions by at least 25%. Just under one in two firms are expecting emissions to remain broadly unchanged (changes of up to +/- 2%).

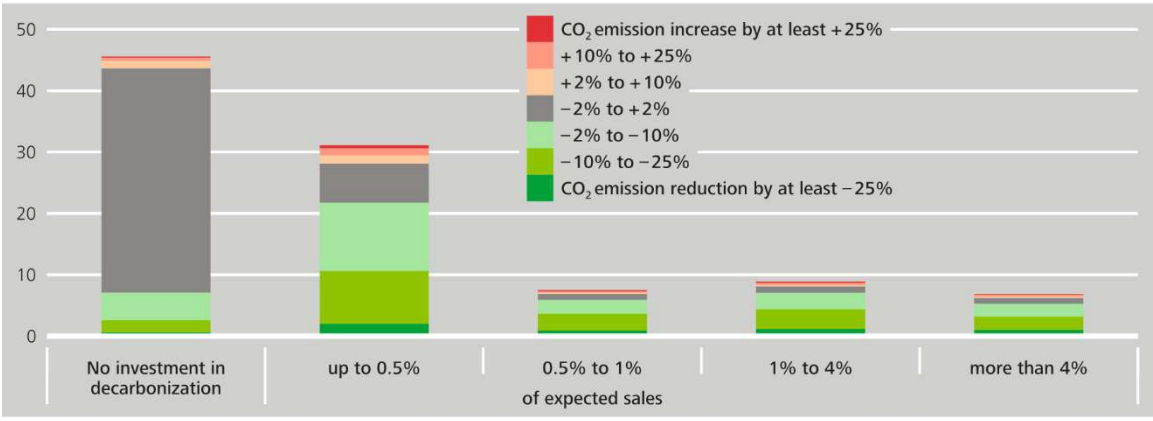
Figure A4.1 shows that the ambition to decarbonize differs across sectors, being highest in the "capital and durable consumer goods", "producer goods" and "wholesale trade, sales, repair of motor vehicles ..." sectors. This does not control, however, for the decarbonization efforts, if any, the firms in question have already made in the past.

2. While almost half of all firms have no plans to invest in decarbonization in the years up to 2028, the majority of the firms with investment plans intend to spend up to 0.5% of their expected sales for decarbonization measures.

Figure A4.2

Planned decarbonization investments in the period 2024 to 2028, by ambition level*) Figure A.4.2

Percentage of all surveyed firms



Source: Bundesbank Online Panel – Firms (BOP-F), Survey data referring to the second quarter of 2024. * The sample comprises 5,929 firms where investment data are available as of 2019, excluding firms whose planned decarbonization investments are more than ten times the size of their turnover expectations. For each surveyed firm in the sample, its planned decarbonisation investments in the period 2024 to 2028 are expressed a percentage of its sales expectations in this period.

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In the years up to 2028, 46% of all surveyed firms are planning not to invest in decarbonization. In the 2029-33 period, this is actually the case for more than one in two of all firms. Of the investing firms (i.e. excluding firms that plan no decarbonization investment), the majority intends to use up to 0.5% of their expected turnover for decarbonization measures in the period 2024 to 2028 (see Figure A4.2). Just under one in three of them want to invest between 0.5%

and 4% of their turnover in their decarbonization. 13% of firms with investment plans want to use as much as 4% or more of their turnover to reduce emissions.

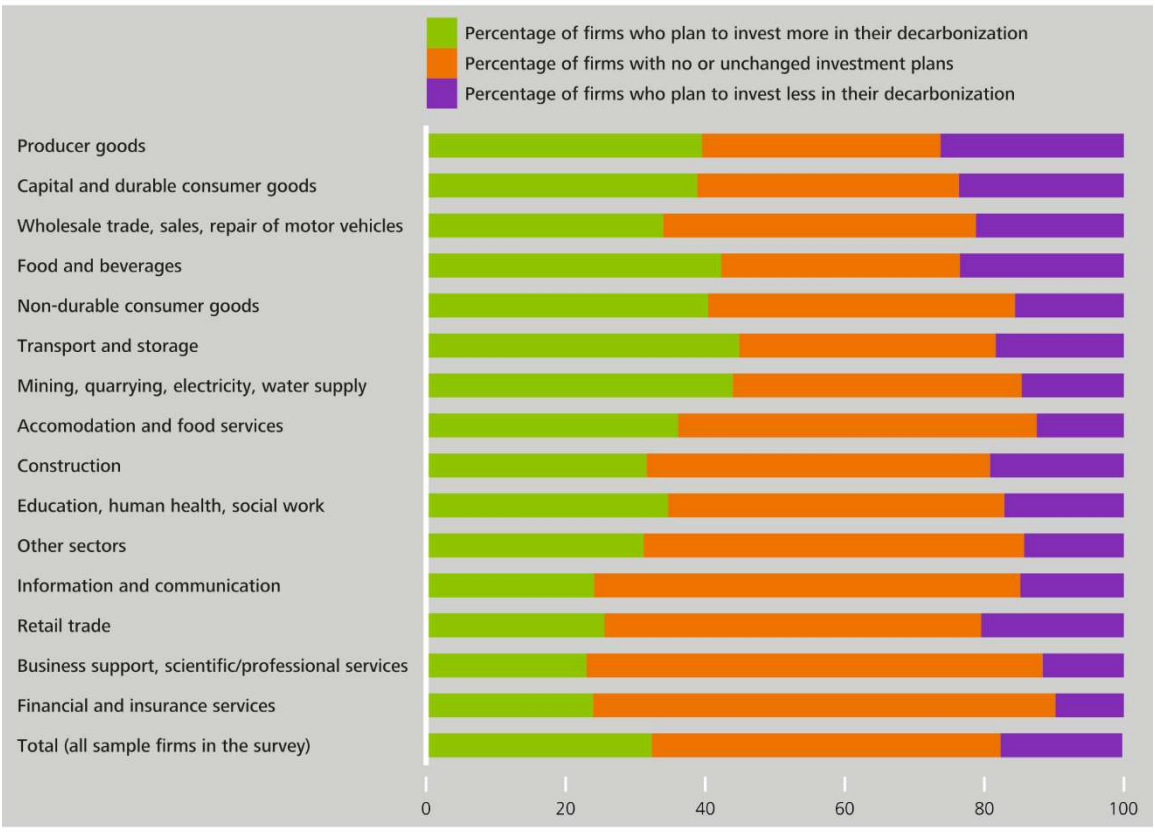
3. While firms with no or unchanged investments are dominant in many sectors, the number of firms who want to invest more in their decarbonization outweighs the number of firms who want to cut back their investment.

Figure A4.3

Do firms plan to invest more or less in their decarbonization than in the past? (plans for 2024 to 2028 compared with 2019 to 2023)

Figure A.4.3

Relative frequency of firms, by sector



Source: Bundesbank Online Panel – Firms (BOP-F), Survey data referring to the second quarter of 2024. The sample comprises 5,929 firms where investment data are available as of 2019, excluding firms whose planned decarbonization investments are more than ten times the size of their turnover expectations.

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Overall, 32% of the surveyed firms (roughly 1,900 out of 5,929 firms) plan to invest more than in the years 2019 to 2023, while 17% intend to reduce their decarbonization investments. Four in ten firms did not invest in the past and, as well, have no plans to do so in the future. One in ten firms do not want to change their (positive) investment. 1,917 of the 5,929 firms want to increase their decarbonization investments from 4% to 17% of their expected sales on average (after outlier adjustment: only firms whose investments are less than ten times the size of their sales), or from 3% to 9% of turnover (after outlier adjustment: only firms whose investments

are less than five times the size of their turnover). Remarkably, the sectors “Transport and storage” and “Mining, quarrying, electricity and water supply” exhibit comparatively large shares of firms with plans to invest more in decarbonization than in the years 2019 to 2023 (see Figure A4.3).

4. The expected funding structure depends on the level of ambition to decarbonize.

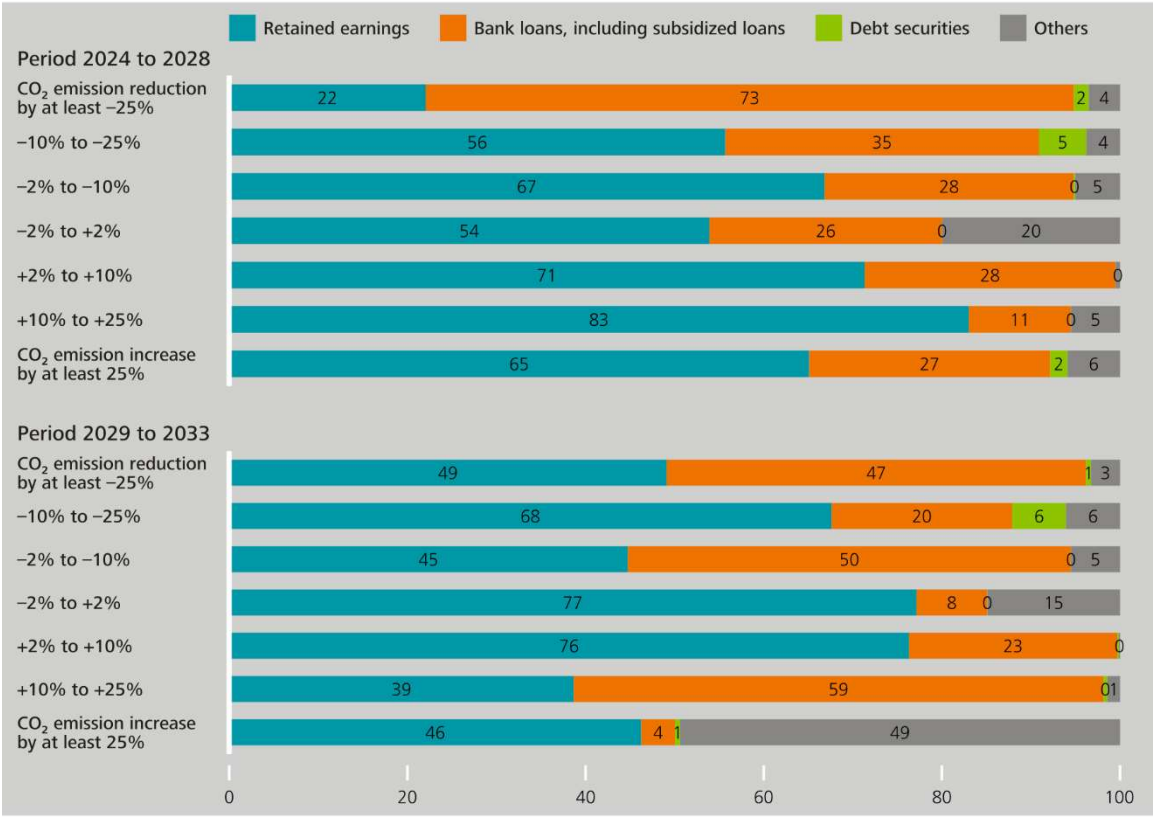
In order to finance their future decarbonization investments, firms mainly intend to use retained earnings and bank loans, including government-sponsored loans. Firms with ambitious plans to reduce their carbon emissions (more than 25%) by 2028 are mainly planning to use bank loans including government-sponsored loans (Figure A4.4) and to use retained earnings only as a secondary source of funding. For other firms that are expecting emissions reductions to be lower, decarbonization projects will mainly be financed out of retained earnings in the coming years.

Figure A4.4

Sources of financing for planned CO_2 emission reductions, by ambition level*

Figure A.4.4

Expected funding structure for decarbonization measures, all figures as a percentage



Source: Bundesbank Online Panel – Firms (BOP-F), Survey data referring to the second quarter of 2024. * The sample comprises 5,929 firms where investment data are available as of 2019, excluding firms whose planned decarbonization investments are more than ten times the size of their turnover expectations. The shares of financing forms shown here are calculated as the sum of the financing shares planned for the respective period, multiplied by the planned decarbonization investments. Because of this, the higher a firm's planned decarbonization investments, the stronger its weighting shown here.

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Taking together all surveyed firms with positive investments in decarbonization, the share to be financed via retained earnings is 60%, while bank loans including government-sponsored loans account for a share of 33%. This finding is robust if only non-financial corporations are considered firms, hence if firms the financial and insurance services sector are excluded from the sample.

A.5 Bundesbank Online Panel – Households (BOP-HH) in May 2024

Key takeaways

a) Investment

While households are planning to invest more than in the past (previous 20 years), the planned increase of around 3% on average over the next few years is much too small: in comparison, the above evaluation indicates the need for an increase of around 25% in the annual level. Over the next five years, in particular, average declines of around 5% are initially expected. This is probably due to the current political uncertainty.
In particular, less wealthy households with buildings in worse condition have invested around 30% less in the past than the residual group of households, but plan to invest similar absolute amounts per year over the next ten years.

b) Financing

Households mainly wish to use own funds (70%) to finance their future investments (ten years). In addition, they wish to use financing of around 16% from bank loans, 12% from government-sponsored loans and 2% from other financing sources. This is broadly in line with the results of the Bundesbank Online Panel – Firms regarding investment and financing plans.
In particular, less wealthy households with buildings in worse condition also rely to a lesser extent on own funds for their planned investments, and to a greater extent on bank loans and other financing sources.

Analysis

a) Investment

Households' planned investment volume is interesting with respect to two comparative variables: (1) the climate protection investments required in order to achieve the climate targets (see Chapter 3) and (2) historical investment activity. A comparison with the necessary climate protection investments shows whether households' plans are compatible with scenarios for the transition to greenhouse gas neutrality and there is thus a chance of meeting the climate targets. The comparison with historical investment activity shows whether households plan to adjust their historical investment volume or the climate protection investment volume.

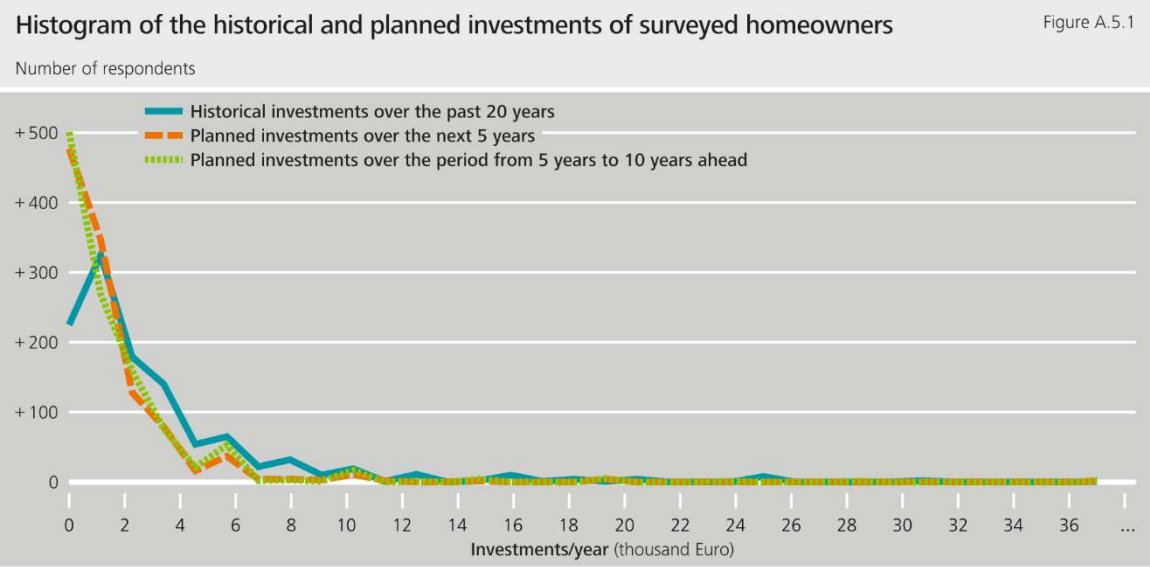
Table A5.1

Descriptive statistics on household investments per year

	hist. investments in Euro, -20-0 years	*plan. investments in Euro, 0-5 years*	*plan. investments in Euro, 5-10 years*
mean [Euro/year]	2,569	2,440	2,859
mean percent		-5.05%	11.27%
mean percent (0-10 years)		3.11%	
25% quantile [Euro/year]	250	0	0
median [Euro/year]	1,250	1,000	1,000
75% quantile [Euro/year]	3,000	3,000	4,000
max [Euro/year]	37,500	80,000	80,000

Notes: Data from the Bundesbank's Online Panel Households BOP-HH. A total of N=1,116 households are analysed.

Figure A5.1



Historical investments over the past 20 years amount to €2,569 in the sample (see Table A5.1). By contrast, planned investments will initially decline by around 5% compared with the historical rate, before increasing by around 11%. Averaged across the next ten years, this represents a rise of just over 3%. This is significantly smaller than the investment increase of around 25% necessary to achieve the climate targets. This is the result of households' average investments of around €183 billion per year over the past 20 years and the additional climate protection investments of around €46 billion per year shown above.

The descriptive statistics point to a significant reduction in planned investments in the lower (25% quantile) and medium (median) range of investment levels, while historically high-

investment households (75% quantile, maximum) continue to plan investments at similar and even somewhat higher levels.

The reduction in the lower and medium range of investments seen in the descriptive statistics is clearly visible in the histogram below. Just under half of respondents do not plan to make any investments over the next ten years, a figure almost two and a half times larger than in a historical comparison. Investment plans between around €2,500 and €10,000 show a substantial reduction.

Table A5.2
Regression of household investments per year (in the respective reference period) on risk group and residual group (constant)

	hist. investments in Euro, -20-0 years			
	Coefficient	Robust std.err.	t	P>|t|
risk group	-0.797	0.306	-2.60	0.01
const	2.632	0.130	20.29	0.00
	plan. investments in Euro, 0-5 years			
	Coefficient	Robust std.err.	t	P>|t|
risk group	0.069	0.461	0.15	0.88
const	2.434	0.173	14.06	0.00
	plan. investments in Euro, 5-10 years			
	Coefficient	Robust std.err.	t	P>|t|
risk group	-0.164	0.592	-0.28	0.78
const	2.872	0.196	14.68	0.00

Notes: Data from the Bundesbank's Online Panel Households BOP-HH. A total of N=1,116 households are analysed. The critical risk group is defined as the 8% of respondents with the weakest financial resources and buildings in the worst condition.

Households with relatively weak financial resources and properties in a worse condition are particularly interesting for further analysis. This group is defined by building condition (age and state of renovation) and financial resources (household income and wealth) in such a way that it includes just under 8% of households. From a financial perspective, the exact limits for belonging to this group are a maximum household net income of €5,999 per month and maximum household net wealth of €251,000. In terms of condition, the property must either be (1) in no higher than the bottom third with regard to renovation measures performed and must have a construction year of no later than 1979 or must be (2) in no higher than the middle third

with regard to renovation measures performed, but must then have a construction year of no later than 1949.
This results in a combination of the investment needs for the property and the owner's potential lack of financial capacity, which (1) necessitates government support, (2) jeopardises energy transition targets and (3) may lead to failures in the financial system.

Households with relatively weak financial resources and buildings with higher investment needs have invested significantly less in the past than the corresponding residual group of the sample. On average, this critical subgroup has invested around 30% less than the residual group over the past 20 years. At €1,835 per year, this group invested €797 per year less than the other households with comparatively high financial resources and buildings in relatively good condition, which invested €2,632 per year on average. On the other hand, the lower planned investments in the critical group are accompanied by far lower real estate values of €166,786 in the risk group, compared with €516,677 in the residual group (€492,060 on average). Based on these figures, it is therefore impossible to reach a conclusive assessment regarding appropriate investment levels in each group.
However, a comparison of the changes in planned investment levels between the two groups and a comparison with the respective historical 20-year average shows that, in absolute terms, too, the investment plans do not differ significantly between the two groups, from either an economic or a statistical point of view. As a result, real estate value appears to be of only secondary importance for the level of planned investments in both subgroups.

b) Financing

Table A5.3
Descriptive statistics on planned sources of financing for households

Financing via	mean	standard deviation	min	max
own funds/savings	69.9%	33.0%	0.0%	100.0%
bank loans	15.9%	25.5%	0.0%	100.0%
government-sponsored loans	12.1%	18.6%	0.0%	100.0%
other sources of financing (e.g. private credit)	2.1%	8.9%	0.0%	100.0%

Notes: Data from the Bundesbank's Online Panel Households BOP-HH. A total of N=1,116 households are analysed.

According to the survey, around 70% of households' planned climate-related investments over the next ten years are to be financed primarily from own funds. This is in line with the above-mentioned results of the Bundesbank Online Panel – Firms in the second quarter of 2024 on firms' investment and financing plans. This is followed by bank loans (around 16%) and

government-sponsored loans (12%). Other sources of financing play only a minor role, accounting for around 2%.

Figure A5.2

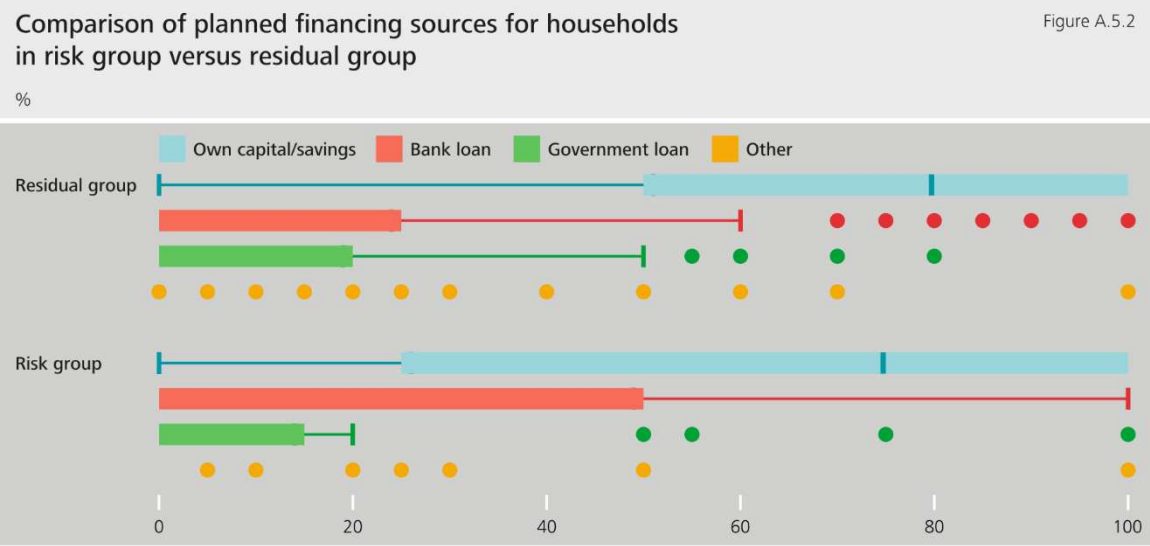


Table A5.4

Regression of source of financing shares for household investments per year on risk group and residual group (constant)

Financing via		Coefficient	Robust std.err.	t	P>|t|
own funds/savings	risk group	-9.844	4.984	-1.98	0.05
	const	70.717	1.240	57.02	0.00
bank loans	risk group	6.551	4.145	1.58	0.11
	const	15.353	0.950	16.16	0.00
government-sponsored loans	risk group	0.365	3.174	0.12	0.91
	const	12.095	0.688	17.59	0.00
other sources of financing (e.g. private credit)	risk group	2.928	1.940	1.51	0.13
	const	1.834	0.310	5.92	0.00

Notes: Data from the Bundesbank's Online Panel Households BOP-HH. A total of N=1,116 households are analysed. The critical risk group is defined as the 8% of respondents with the weakest financial resources and buildings in the worst condition.

Banks thus face an additional planned financing volume of around €0.91 billion per year. This is the result of the 3% increase in investment calculated above (around €5.7 billion per year) and the roughly 16% of planned financing via bank loans.

In particular, the households facing most difficulties, with buildings in the worst condition and the weakest financial situation, rely somewhat more heavily on bank loans and less on own funds. This effect is economically and statistically significant, as shown in Table A5.4 below. The planned use of own funds in the household risk group is around 10 percentage points lower than in the residual group (measured by a constant), while use of bank loans (around 6.5 percentage points) and other financing sources (around 3 percentage points), in particular, is higher. In the direct comparisons between the respective risk groups and residual groups, all t-tests for equality of coefficients also show statistically significant differences.