Expertenrat
für Klimafragen

# Biennial Expertise 2024

**Expertise on the development of greenhouse gas emissions to date, trends in annual emission budgets and the effectiveness of measures (in accordance with Section 12 (4) Federal Climate Action Act)**

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5. February 2025

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## Expertise on the development of greenhouse gas emissions to date, trends in annual emission budgets and the effectiveness of measures (in accordance with Section 12 (4) Federal Climate Action Act)

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Imprint

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As a means of linguistic representation of all social genders and gender identities, this report uses gender neutral terms or the gender asterisk (e.g., Wissenschaftler*innen) for all references to people.

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# Summary

The Council of Experts on Climate Change provides its **biennial expertise** in accordance with the statutory mandate pursuant to Section 12 (4) of the Federal Climate Action Act. In the report, the Expert Council examines the development of greenhouse gas emissions (GHG emissions) to date, trends regarding total annual emission budgets and sectoral annual emission budgets, the effectiveness of measures regarding target achievement, as well as their social distributive effects and economic viability. The focus of the analyses is on developments since 2021. Additionally, the report presents and contextualises estimates from scientific studies on the scale of financial investment volumes for Germany's transformation towards greenhouse gas neutrality. Finally, the Expert Council provides an assessment on the direction of Germany's future climate action policy and formulates requirements for future climate action programmes.

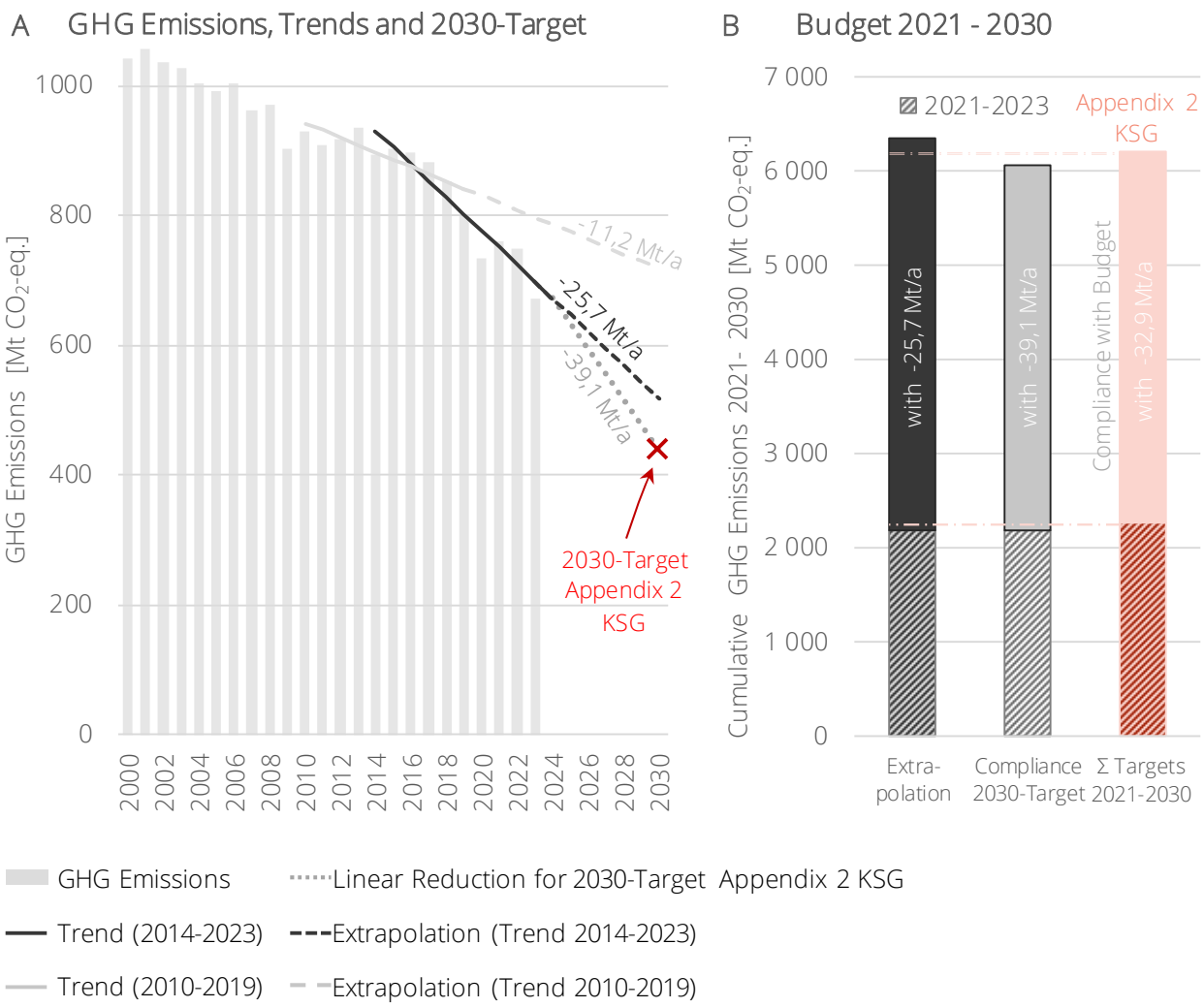
**Past developments and trends regarding annual emission budgets**

**Cross-sectoral GHG emissions** (excluding LULUCF) have decreased significantly since 2021, with all sectors except transport registering declines. The pace of GHG emission reductions varies considerably among sectors. Significant reductions were particularly observed in the energy sector. In the industrial sector, notable reductions also occurred in 2022 and 2023. In the sectors buildings, agriculture, and waste management, GHG emissions have decreased slightly, whereas in the transport sector GHG emissions have increased slightly since 2021.

For the years 2021 to 2023, the observed declines in GHG emissions were sufficient to meet **the annual total emission budgets (excluding LULUCF) specified in the Federal Climate Action Act**. At the sectoral level, however, a mixed picture emerges regarding target achievement: While the sectors energy, industry, agriculture, and waste management met their sectoral targets, GHG emissions in the buildings sector (temperature-adjusted) were slightly above the target values. GHG emissions in the transport sector significantly exceeded the annual total emission budgets specified in the Federal Climate Action Act.

The pace of GHG emission reductions observed in recent years would not be sufficient to achieve the legally set climate target for the year 2030. The **trend** in GHG emission reductions from 2014 to 2023 has accelerated compared to the ten-year span from 2010 to 2019. If the target stipulated in the Federal Climate Action Act—reducing GHG emissions in 2030 by 65 % compared to the 1990 reference value—is to be achieved, the average annual reduction rate from 2024 onward would have to increase by more than 50 % (see Figure 1, Field A). Similarly, to comply with the cumulative total annual emissions budgets implied in Annex 2 of the Federal Climate Action Act for the period from 2021 to 2030, the pace of GHG emission reduction would have to increase significantly (see Figure 1, Field B).

Figure 1: Cross-sectoral GHG emissions – developments, trends and targets




Source: own visualization based on GHG emissions data from UBA (2025).[1]

[1] The figure shows the cross-sectoral GHG emissions excluding the LULUCF sector. The KSG targets for the cross-sectoral analysis are taken from Annex 2 KSG. Panel A shows the trends (solid line) and trend extrapolations (dashed line) with the corresponding slope (calculation via linear regression over the respective 10-year period). For the average reduction rate required from 2024 to achieve the 2030 target (dotted line), it was initially assumed that a return to the trend would take place in 2024. Subsequently, a reduction rate was determined that ensures the target is achieved in 2030. Panel B shows cumulative GHG emissions for the period 2021 to 2030: On the one hand, hypothetical values resulting from the considerations in field A via the trend extrapolation (left bar) and the achievement of the 2030 target in accordance with Annex 2 (middle bar); on the other hand, the GHG budget defined in Annex 2 KSG over the period 2021 to 2030 (right bar, cumulative annual emission totals). The bars show the assumed linear reduction rates required to achieve the target. The lower dashed horizontal line in field B marks the GHG budget from 2021 to 2023 in accordance with Annex 2 KSG, as a comparison to the budget actually consumed in 2021-2023 (shaded area in the left and middle bar). The dashed horizontal line on the top allows for a comparison with the cross-sectoral GHG budget according to Annex 2 KSG.

More than two-thirds of the observed average annual reduction rate from 2014 to 2023 was attributable to the energy sector, with the remainder distributed among the other sectors (excluding LULUCF). If the average annual reduction trend from 2014 to 2023 were to continue, the energy, agriculture, and waste management sectors could both fall below their target values for 2030 and meet the cumulative GHG budgets up to 2030. In contrast, for the industry, transport, and buildings sectors, target shortfalls would occur and the cumulative GHG budgets would not be met. This is consistent with the assessment of the Expert Council in its special report on the review of the projection data for 2024. There, it concluded that the GHG emissions projected for 2030 in all sectors—apart from the agriculture and waste management sectors—are likely to be underestimated.

For the analysis and assessment of GHG emission developments, the Expert Council employs a concept developed in its biennial expertise 2022, which illustrates the various fields of action and options for reducing GHG emissions. The decline in GHG emissions in the years 2022 to 2024 is partly attributable to a reduction in activities. The term "activities" refers to human actions that generate GHG emissions via the fossil capital stock. For example, between 2021 and 2023, electricity consumption decreased significantly. In the industrial sector, the declines in GHG emissions were primarily due to higher energy prices compared to the pre-crisis year 2019, as well as cyclical and structural declines in demand—particularly in the sectors covered by the European Union Emissions Trading System (EU-ETS 1). The reduction in activities was partly influenced by crisis events. Whether this crisis-induced share is of a permanent nature remains uncertain. For instance, the sharp increase in gas prices as a result of the Russian invasion of Ukraine led to a significant decline in gas consumption in households, commerce, and industry. However, in 2024, gas consumption increased again. Similarly, passenger transport increased after a significant decline during the COVID-19 pandemic.

The phase-out of fossil or emissions-intensive capital stock is still too slow to meet the sectoral emissions targets. In the buildings sector, the replacement rates for gas and oil heating systems are low, and sales of new fossil heating systems remain high. In the transport sector, a high number of cars with combustion engines continue to be newly registered, and it is expected that, without countermeasures, they will remain in use for a long time. As a result, high GHG emissions are still anticipated in both the buildings and transport sectors in 2030, making it unlikely that the statutory targets in these two sectors will be met.

The build-up of new non-fossil or low-emission capital stock is also progressing too slowly overall to achieve politically defined targets for indicators that are relevant for the development of GHG emissions. Assuming a linear extrapolation of the build-up observed during 2022 to 2024, none of these indicators would increase sufficiently to achieve the political goals or the corresponding benchmarks in the climate neutrality scenarios. Only in the energy sector has the significant decline in GHG emissions been accompanied by an extensive build-up of new capital stock. In particular, the momentum in the expansion of photovoltaics and the approvals for onshore wind energy installations have increased markedly, thereby making the politically targeted build-up goals for 2030 for both photovoltaics and onshore wind increasingly attainable. In all other areas, actual developments are lagging behind the trajectory pursued by the federal government or are even regressing. For instance, in the buildings sector, sales of heat pumps experienced a significant slump in 2024, and the annual renovation rate of buildings remains below 1 %. In the transport sector, the share of battery-electric vehicles among new registrations has decreased once again after the subsidy provided by the environmental bonus was terminated. Likewise, in the industrial sector, there have been only marginal advances in the electrification of processes that have so far relied on fossil energy carriers.

In the **LULUCF sector**, the data situation changed drastically with the publication of the latest National Forest Inventory: instead of a cumulative net source of +11 Mt $CO_2$-eq. for the years 2018 to 2022, around +371 Mt $CO_2$-eq. are now estimated—roughly 34 times more than previously assumed. In 2023, the GHG emissions of the LULUCF sector thus amounted to approximately 10 % of Germany's total annual GHG emissions. The LULUCF sector has been a constant net source since 2014 and would significantly miss the statutory target of a net sink of -25 Mt $CO_2$-eq. by 2030, unless there is a rapid reversal of the observed trend.

### Considerations on the effectiveness of climate action measures

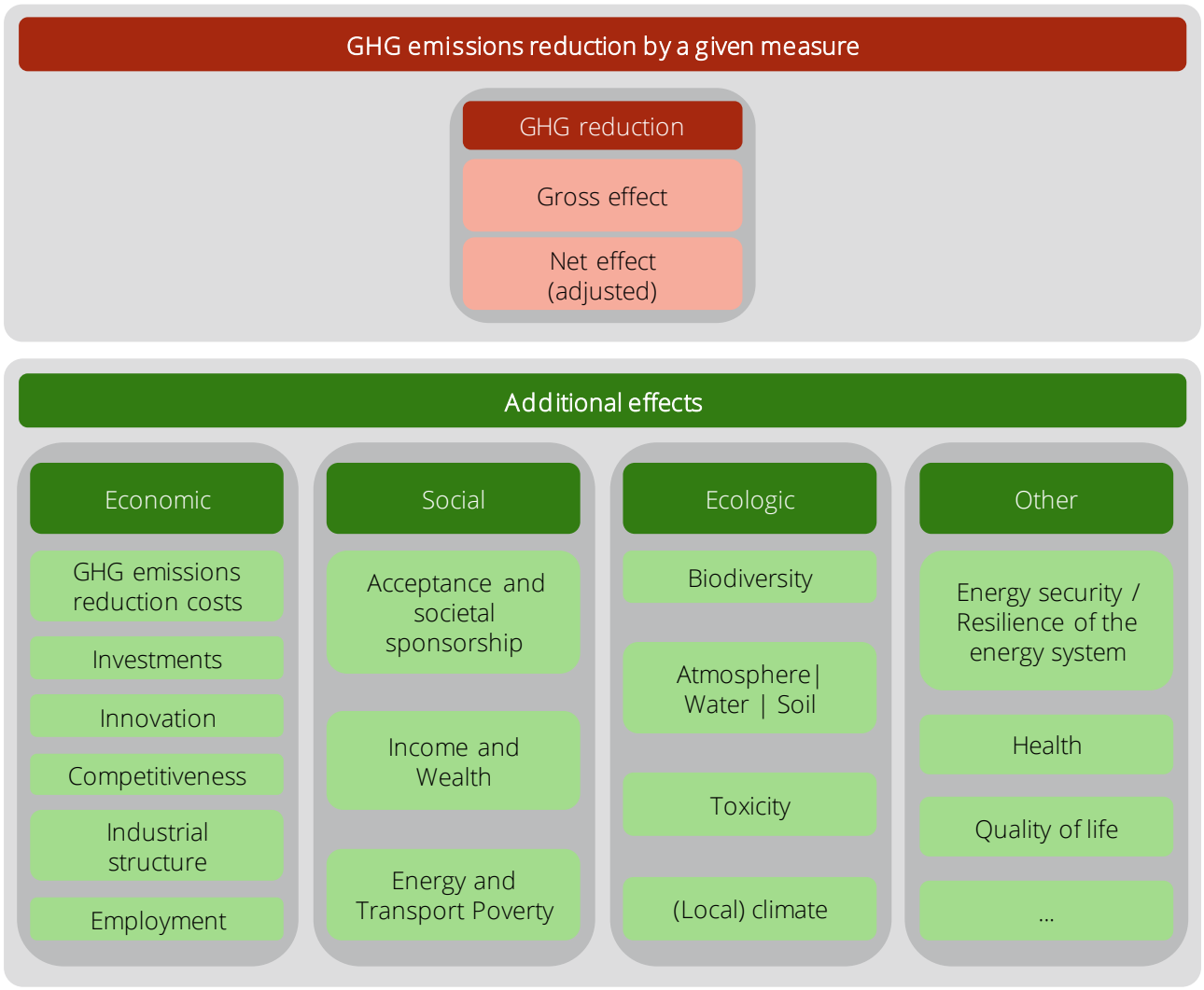
Over the past two years, **a number of measures to reduce GHG emissions have been substantially amended or newly introduced**. In addition, several programmes and strategies have been adopted that are directly or indirectly relevant for achieving the targets set out in the Federal Climate Action Act. At the level of measures, these include, for example, regulatory changes to accelerate approval procedures in the energy sector, the introduction of climate protection agreements in industry, the amendment of the Federal Funding for Efficient Buildings (BEG) and the Building Energy Act (GEG), as well as the implementation of the Heat Planning Act (WPG) in the buildings sector and, in the transport sector, the Deutschlandticket.

The Expert Council thus notes that overall **efforts to reduce GHG emissions were intensified** in the years 2022 to 2024. However, a review of the underlying instrument mix reveals that there has been little change in the structure of the measures. The focus remained on the amendment or new introduction of fiscal as well as regulatory instruments—the latter primarily shaped by the implementation of EU directives amended under the "Fit for 55" package. The new measures are aimed primarily at replacing the existing fossil capital stock with non-fossil alternatives and thereby preserving existing industrial structures, for example by supporting the switch to $CO_2$-free or low-$CO_2$ technologies in the steel or automotive industries. In this context, both climate policy considerations and the economic significance of these sectors play a role.

In this biennial expertise, the **effectiveness of measures** is also evaluated based on scientific literature with regard to their GHG emissions reduction and costs, as well as their economic, social, and other effects (see Figure 2). The analysis shows that the measures assessed in the report have made a noticeable overall contribution to reducing GHG emissions. In particular, significant reductions for GHG emissions covered by EU-ETS 1 can be attributed to the instrument itself, in addition to market- and crisis-related changes in fuel prices. With the Federal Emissions Trading Act (BEHG) and, prospectively, its transfer into EU-ETS 2, a comprehensive coverage of GHG emissions has been achieved in Germany since 2021 through a market-based instrument in the sectors buildings and transport, which are critical for meeting overall decarbonisation targets. However, compliance with the national GHG reduction targets under the EU Effort-Sharing Regulation will not be ensured by this instrument alone. Therefore, additional measures will likely be necessary to ensure that these targets are met, and to avoid the purchase of allowances from other countries. In the buildings sector, the BEG has had a significant impact on reducing emissions. Prospectively, reductions could be further increased by combining financial support (BEG) with regulation (GEG and WPG). In the transport sector, the environmental bonus helped boost the sales of battery-electric vehicles and thereby reduce GHG emissions. However, significant free-rider and pull-forward effects were observed. In the first funding periods plug-in hybrids were also subsidized, for which the GHG emissions reduction compared to similar vehicles with internal combustion engines is much lower. So far, the GHG emissions reduction effect of the Deutschlandticket remains uncertain due to the lack of comprehensive ex-post evaluations. In the medium to long term, however, it could strengthen the use of public transport (ÖPNV) and thereby promote a reduction in activities that contribute to emissions, provided that public transport is

further bolstered through additional measures and becomes attractive to a broader segment of the population. For the industrial sector, the Federal Funding for Energy and Resource Efficiency in the Economy (EEW) is a central funding measure that makes a noticeable contribution to reducing GHG emissions due to its substantial funding volume and its partly technology-neutral and competition-oriented design. Future evaluations will show the extent to which the newly introduced climate protection agreements can actually deliver the expected contribution to the transformation of the energy-intensive industry.

Figure 2: Overview of impacts from climate action measures




Source: own visualization. Selected impacts based on work from Heyen (2021); Weidner (1992); Kellner et al. (2023); Steuwer et al. (2024); Bull and Eadson (2023); DellaValle and Czako (2022); Hagemeyer et al. (2024); Repenning et al. (2018); Lehr et al. (2020); UBA (2020) and Zimmermann (2018).

Regarding economic effects, the analysis shows that funding programmes with expenditures in the double-digit billion range often exhibit moderate to very high GHG emissions reduction costs—depending on which sources are consulted—and, consequently, rather low cost-efficiency. This applies, for example, to the environmental bonus, which was prematurely discontinued at the end of 2023, or to the Deutschlandticket.

In the amendment of the BEG, this aspect was already taken into account, so that an increase in funding efficiency is now to be expected. It should also be noted that GHG-related funding efficiency should not be used as the sole criterion for assessing climate action measures. In addition to the goal of reducing GHG emissions, these measures frequently pursue complementary policy objectives. Such objectives include, for instance, preserving the energy-intensive industry through climate protection agreements or addressing social effects by providing financial relief to private households through the amended BEG or the Deutschlandticket.

Regarding **social effects**, some of the measures analysed in this report have a regressive distributional effect. For example, fiscal measures in the buildings and transport sectors—such as the environmental bonus or the BEG prior to its reform—primarily benefited high-income households. A more socially differentiated support scheme was initiated with the amendment of the BEG in 2023. However, energy poverty remains insufficiently addressed within Germany's climate policy toolkit. In addition, the burden of $CO_2$ pricing under the BEHG disproportionately falls on private households with low and middle incomes, which may be further exacerbated in the future with further increases in $CO_2$ prices or with the transition to EU-ETS 2. Therefore, accompanying political measures for EU-ETS 2 will be necessary to mitigate the social and financial consequences of high $CO_2$ and fuel prices. Moreover, specific obstacles—such as those related to infrastructure or the avoidance of lock-in effects—should be addressed. Various policy approaches are available to tackle the social effects of price- and quantity-based instruments for GHG reduction. These include the expansion of infrastructure and public services that are compatible with GHG reduction targets, the implementation of socially differentiated funding programmes, regulatory measures, and direct financial compensation. In combination, these measures could help ensure that in the transformation to a climate-neutral society, no segment of the population is burdened excessively or in a manner perceived as unjust.

### Investments for building a climate-neutral capital stock

High levels of **investment** are required to build up an efficient climate-neutral capital stock. The Expert Council analysed 13 studies that project (sectoral) investment volumes and the corresponding public sector financing volumes. The aim of the analysis is to compare the investment volumes shown in the studies up to the year 2030 and to discuss the possibilities of realizing these volumes in economic terms.

The **studies included differ in terms of their methodology and assumptions**, meaning that the reported investment volumes are not readily comparable. For example, the studies differ in the underlying scenario basis. The comparison of the results therefore primarily serves to illustrate the range of the reported investment volumes. On the one hand, ranges are shown for transformation investments, i.e. investments that are required as a result of the transformation towards climate neutrality. On the other hand, ranges are considered for extra investments, i.e. for the part of the transformation investments that go beyond replacement investments in climate-neutral technologies, i.e. for the part of the transformation investments into climate-neutral technologies that go beyond ongoing investments into replacements of existing capital stock. The investment volumes reported by the studies are classified as gross fixed capital formation. The effects of the corresponding investments on gross fixed capital formation (taking depreciation into account) and on capital productivity are therefore not taken into account.

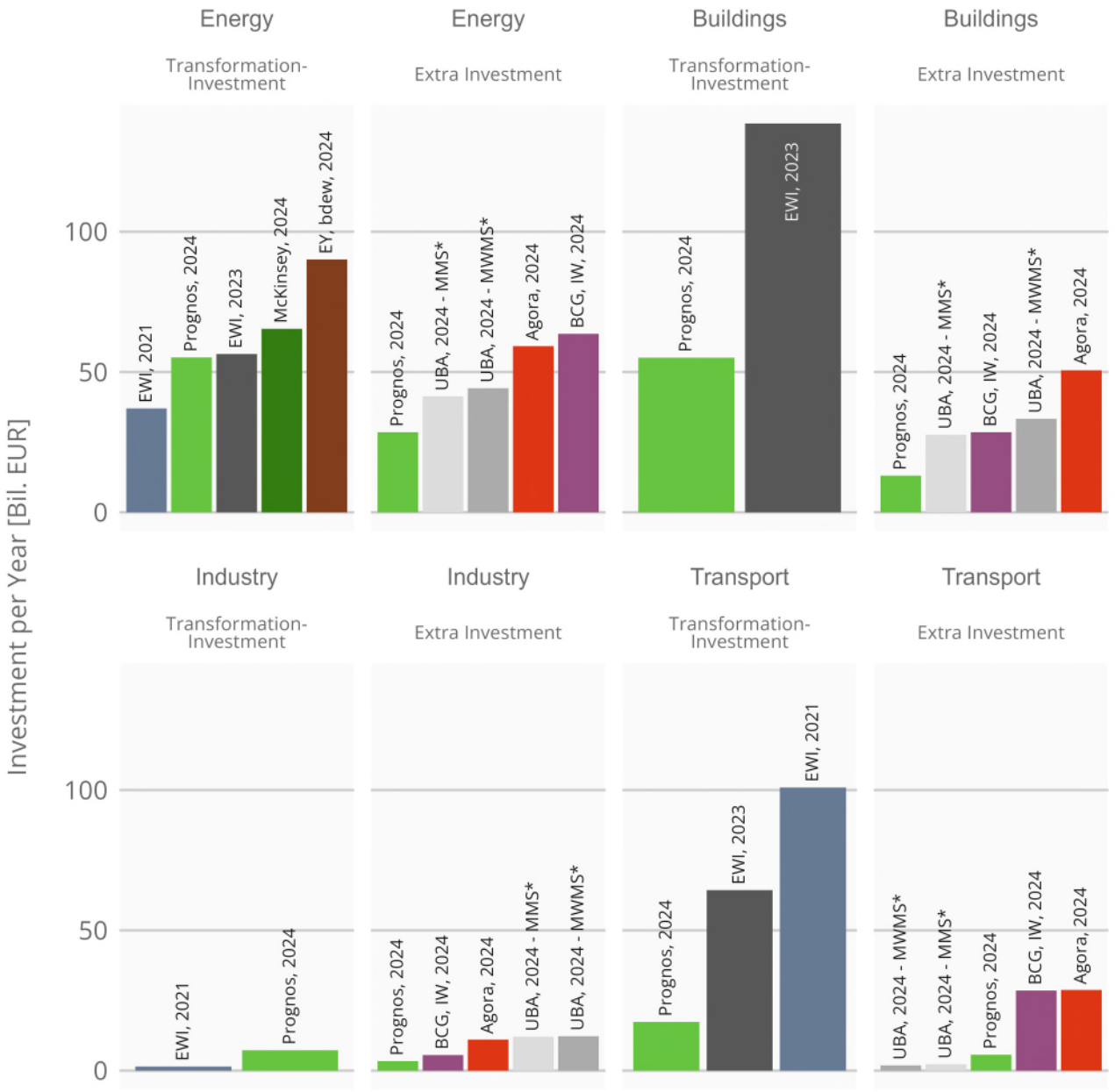
According to estimates, the **projected cross-sectoral transformation investments** range from around 135 to 255 billion euros per year. This corresponds to a range of 3.2 to 6 % of Germany's GDP in 2023, representing a relevant share of the country's expected economic output. Within the individual sectors, the estimated ranges vary considerably. In particular, the projected volumes of transformation investments are especially

high in the energy sector (37 to 90 billion euros per year), the buildings sector (55 to 139 billion euros per year), and the transport sector (17 to 101 billion euros per year) (see Figure 3).

Part of the transformation investments consists of extra **investments** that go beyond the investments made as part of the ongoing renewal of the capital stock. For extra investments, the studies indicate a range of 51 to 150 billion euros per year, which corresponds to 1.2 to 3.6 % of GDP in 2023. An analysis of these extra investments reveals clear differences between the individual sectors. In the energy sector, extra investments constitute a significant share of the transformation investments relative to the investments that would have been made anyway. Consequently, a large part of the projected investments can be attributed to the transformation. In contrast, in the buildings sector the studies indicate that a high proportion of the projected transformation investments would have occurred anyways, if new constructions are counted toward such types of investment.

The analysis of the studies indicates that the projected investment volumes are **economically significant**. The Expert Council therefore considers it important that the Federal Government actively addresses the financial challenges posed by future investment volumes while taking into account the financial requirements of all policy areas, in particular in its system development strategy. In order to conduct a well-founded assessment of the sustainability of the transformation process, the Federal Government should explicitly incorporate transformation investments into its multi-year financial and economic planning. Moreover, the growth potentials that could emerge for the German economy from these transformation investments should be explicitly considered in the Government's strategy development. In assessing the investment volumes for the transformation, the future macroeconomic follow-up costs expected as a result of climate change must also be taken into account. The extent of climate change—and thus the magnitude of associated costs—depends on global progress in limiting GHG emissions. However, apart from the avoided GHG emissions, making Germany achieve its climate targets through ambitious climate action policies would be important for the country's reliability. Only by meeting its own targets can Germany credibly advocate for ambitious climate action on the international stage.

Figure 3: Annually projected investment volumes until the year 2030 by investment aggregate and sector (in $EUR_{2023}$), based on data from different models and assumptions




Source: own visualization. Values are in prices of 2023 and are sourced from the displayed studies. * The scenarios of UBA (2024l) implement a set of climate action measures and do not assume that KSG targets are achieved; additionally, the scenarios do not consider investments for infrastructure.

The public sector is important for meeting projected investment volumes, both through its own investments and through the provision of investment incentives. Various studies estimate the public financing gap at a mid- to high double-digit billion-euro amount per year. The reserves of the Climate and Transformation Fund (KTF)—the main instrument for financing public transformation investments—have largely been depleted as a result of the Federal Constitutional Court's ruling in 2023. Accordingly, the revenues from $CO_2$ pricing will

primarily be available for financing in the future. This challenge is further compounded by extensive financial requirements in other policy areas that are expected in the coming years. These include, for example, investments for climate adaptation and negative GHG emissions, as well as anticipated higher financial needs for education, defence, and infrastructure renewal. The projected investment volumes to be undertaken by the state, coupled with the limited resources available, suggest that prioritising public spending across policy areas will be necessary for these extra investments. Furthermore, an increase in public financial resources could expand the scope for investments and mitigate potential cuts in competing expenditure areas.

Regarding the expected **private investment volumes**, the Expert Council considers it particularly important for the government to assess profitability considerations of private investors to ensure that they will provide adequate financing for extra investments. Finally, it should be analysed to what extent the German economy possesses the necessary **skilled workforce resources** to implement the transformation investments.

### Embedding climate action policy comprehensively

According to the Federal Climate Action Act, a new federal government must present a climate action programme within the first year of the legislative period. In light of the early federal election and based on the analyses in this report, the Expert Council provides an assessment on the direction of Germany's future climate action policy and formulates **requirements for future climate action programmes**.

The results of this report underscore the **high level of ambition of the political targets set out in the Federal Climate Action Act** and call into question whether these targets can be achieved without significant adjustments in the direction of climate action policy. In addition, key framework conditions have changed considerably in recent years. These include, for example, geopolitical and geo-economic developments as well as Germany's economic development. At the same time, six of the nine planetary boundaries for the extent of human activities on Earth have now been exceeded. The increasingly dramatic consequences and impacts of this—for example, due to extreme weather events—require political action, especially for climate change adaptation.

From the perspective of the Expert Council, this situation calls for a significantly stronger **integration of climate protection measures into a comprehensive and overarching political strategy** that covers all relevant policy areas. This strategy must be compatible with the strategy of the European Union and must specify the requirements thereof from a German perspective. Already in previous reports, the Expert Council has pointed out that climate action policy is closely interconnected with other policy areas, advising to develop a consistent overarching strategy for German climate action policy. According to the Expert Council, the urgency and relevance of these considerations have increased considerably due to the changes outlined and the new challenges facing Germany and the EU.

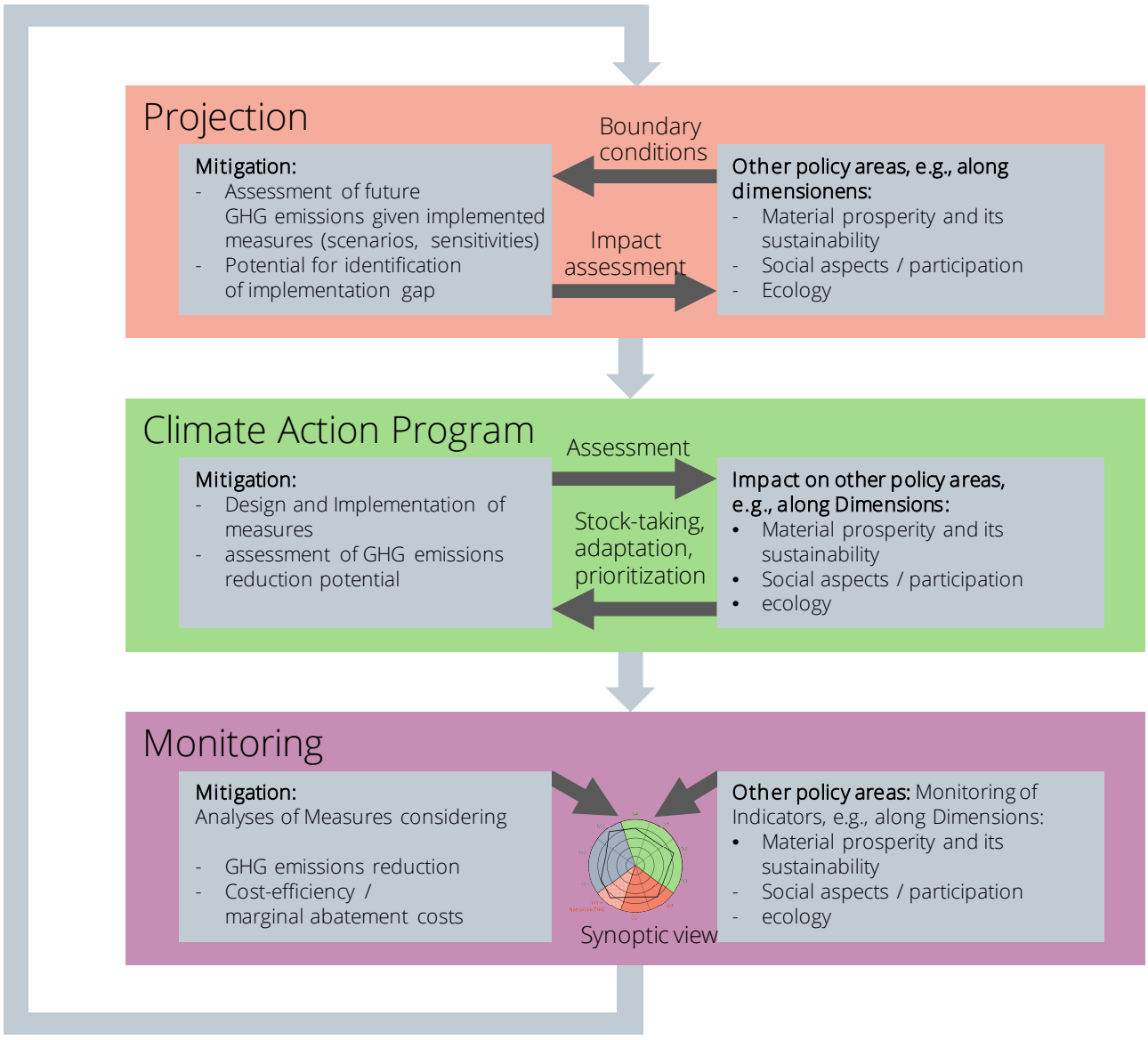
The comprehensive integration of climate action policy into the overall political context means, above all, that future **climate action programmes** and their measures must be designed with a much stronger consideration of their interplay with other policy areas. This can minimize unwanted or harmful impacts in other policy areas, maximize synergies and co-benefits, and ultimately ensure their implementation and acceptance within the broader context. Climate policy has numerous relationships with different policy areas, particularly economic policy, social policy, financial policy, labour market policy, environmental policy, and security policy. Moreover, the preparatory and follow-up process steps for the development of climate action programmes (ex-ante and ex-post target reviews; monitoring of measures and their effectiveness) must be designed and implemented in a correspondingly comprehensive manner (see Figure 4).

Implementing such comprehensively embedded climate action policy requires a **comprehensive target system** that includes the goals of all relevant policy areas, as well as appropriate indicators that capture this target system as completely as possible, while remaining manageable and allowing for the monitoring of target achievement.

In the event of **conflicting objectives,** a political negotiation process is required. The GHG emissions reduction targets established by the Federal Climate Action Act and the underlying decision of the Federal Constitutional Court in 2021—as well as European requirements—are firmly set. It follows that any compromise must initially emerge from and be achieved within the remaining policy areas. For this reason, the Expert Council considers particularly important the more comprehensive integration of climate action policy into the overall political context. According to the Expert Council, any potential conflicting objectives should be transparently identified, disclosed, and thereby brought into the societal-political discourse. Otherwise, the manifestation of these conflicting objectives could jeopardize the acceptance of the measures necessary to achieve the established climate protection targets, thus likely undermining the objectives of the Federal Climate Action Act.

The approach described—embedding climate action policy in an overarching strategy—places high demands on the governance of the process for the formulation, implementation, and monitoring of climate action measures. For the future **governance** of climate action policy, the Expert Council views the reintroduction of the Climate Cabinet, with a strong coordinating function within the Federal Chancellery, as a promising option. The starting point would be the assignment of responsibility for individual sub-targets in specific ministries to negotiate conflicting objectives within the Climate Cabinet. This would also reflect the overall responsibility of the Federal Government for implementation, which was particularly emphasized in connection with the amendment of the Federal Climate Action Act.

Figure 4: Implementation of future climate action policy with comprehensive embedding in an overall political strategy (using the dimensions from the report of the Enquete Commission "Growth, Prosperity, Quality of Life" as an example)




Source: own visualization based on dimensions from Enquete-Kommission (2013).

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