

Investing EUR 5 trillion to reach climate neutrality – a surmountable challenge

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Germany wants to be climate-neutral by mid-century. Technically, this goal is achievable but it requires significant transformations in all sectors. The study entitled 'The contribution of green finance to achieving climate neutrality in Germany' commissioned by KfW estimates that around EUR 5 trillion will need to be invested in climate action in Germany by the year 2050. But this high investment volume falls into perspective when we take into account that much of this involves investments that are necessary anyway and now need to move towards a sustainable path ('anyway investments'). The additional investment needs are expected to reach EUR 72 billion annually, taking into account Germany's recently adopted target of reaching climate neutrality already by 2045.

Both private and public capital will be needed to meet these investment requirements. The impetus provided by public investment funds will essentially depend on how targeted these will be and to what extent it will be possible to mobilise complementary private investment amounts. When we consider that Germany could cover an estimated two thirds of the necessary additional investment simply by eliminating subsidies that harm the climate, it becomes clear that reaching the goal in many cases does not really mean mobilising that much additional capital but rather systematically aligning political action and investment activity with the goal of climate neutrality.

While it is key to mobilising *additional* investment that existing investment barriers such as complex planning and approval procedures be removed in due course, *anyway* investments can be channelled into sustainable areas primarily by making specific adjustments to the enabling framework and enacting structural reforms. Different economic sectors have different investment needs. In the transport sector, around 60% of overall investment will have to be more closely directed towards climate neutrality. In industry, trade and services it is only 3%. Accordingly, the transformation will create mixed opportunities and risks. Policymakers will need to address them in a targeted manner so that Germany can emerge stronger from the transformation. It is even likely to generate positive impetus for economic growth – without even considering the avoided costs of escalating climate change.

Transitioning to climate neutrality will be no mean feat

Achieving climate neutrality calls for massive technological innovations in the use of renewable energy, typically in the

form of green electricity or green hydrogen. Thanks to extensive research and development processes, technical viability has now been confirmed.¹ While some innovations such as electric mobility or the generation of heat using electric heat pumps have almost reached the market maturity stage, other technologies are still being tested in pilot projects such as large-volume electrolysis of hydrogen or what is known as the hydrogen route for steelmaking. Broad market penetration requires a reliable framework and incentives for all actors. It also requires large additional quantities of electricity from renewables. Here, Germany needs to continue its expansion efforts and, at the same time, develop global supply chains to account for the limited land area available for expanding renewables domestically and the more favourable site conditions in other countries.

This requires extensive investment. Previous demand estimates have usually focused on additional investment required vis-a-vis a reference scenario based on the measures planned at the time the estimates were made. In the final analysis, they estimate climate-policy induced additional investment that goes beyond the investment undertaken anyway in the reference scenario. The reference scenario comprises both non-climate action related 'anyway investments' (e.g. the costs of an uninsulated facade) and certain climate action-related 'anyway investments' (e.g. the costs of the renewables expansion roadmap already decided). The figures determined this way quantify the additional investment required by tighter policies compared with the status quo.

All climate action investment is relevant

With a view to the upcoming financing requirements, it is clear that not only the additional investment for the transition needs to be financed but all climate action investment, that is, the additional investment plus the climate-action related 'anyway investment' already undertaken in the reference scenario. This climate action investment, in turn, must be considered in relation to the total investment to be expected in the relevant sectors up to 2045.

Against this background, KfW Research commissioned a study in order to quantify the three different investment concepts (additional investment, climate action investment and overall investment) for the various sectors and provide the first detailed and comprehensive figures on the various investment requirements (see box).

Study ‘Beitrag von Green Finance zum Erreichen von Klimaneutralität in Deutschland’ (Contribution of green finance to achieving climate neutrality in Germany)

On behalf of KfW Research, the authors of Prognos, Nextra Consulting and NKI (Institute for Responsible Investments) drew a broad and differentiated picture of the possible contribution of green finance to achieving climate neutrality in Germany.

In order to identify green finance requirements, the study began by comparing existing studies and then making a new calculation of the investment required to achieve climate neutrality. It employed a proprietary approach that deliberately mirrors the methodologies and conclusions of other relevant studies on the topic. Specifically, it quantified additional climate action investment and overall investment for a current scenario (climate action plan scenario, in short: CAP, Prognos et al., 2021), broken down by sectors and groups of actors, and added investments aimed at achieving climate neutrality that are not yet included in the CAP scenario. The result was a first comprehensive picture of the investment amounts required for all sectors on the way to climate neutrality. By analysing the investment logic pursued by the actors involved, the method also made it possible to identify the drivers and barriers of effective climate action and define the role which the capital market may play in financing the climate transition under the buzzword of green finance.

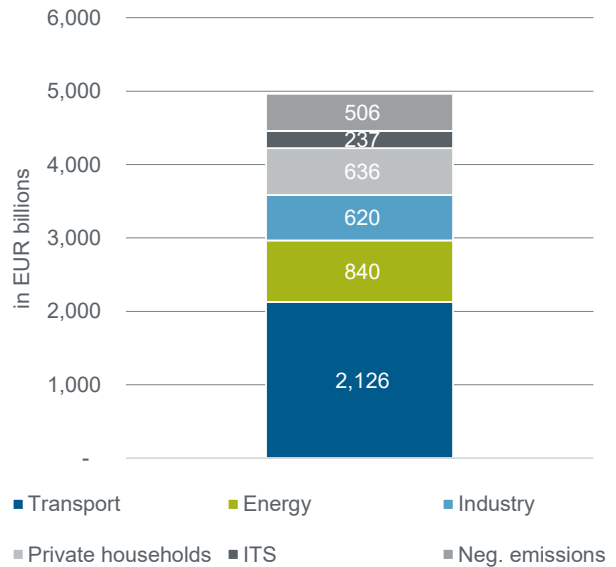
Link to the study: [Contribution of green finance to achieving climate neutrality in Germany](#) (in German)

Investment of EUR 5 trillion needs to be climate friendly

The study quantifies the necessary climate action investment needed to implement Germany’s climate action plan at around EUR 4.5 trillion as a starting point. In order to achieve the target of net-zero climate neutrality, a further EUR 0.5 trillion will be incurred, which will essentially be for negative technologies, so that the total climate action investment amounts to around EUR 5 trillion (Figure 1).² Of this sum, EUR 1.9 trillion is additional investment that goes beyond the policy reference already implemented.³

If the necessary climate action investment is spread out over the years remaining until 2045, Germany’s new target year for climate neutrality, EUR 191 billion or 5.2% of Germany’s GDP will need to be invested on average each year. The additional investment is EUR 72 billion per year, or 1.9% of GDP.⁴

Figure 1: Necessary climate action investment by economic sector



Source: Prognos / Nextra / NKI (2021).

If we take into account that the state, private sector and households spent only around 2.2% of gross domestic product on environmental protection in 2018,⁵ Germany faces a gigantic challenge. But these high amounts come into perspective if we consider that much of the quantified climate action investment comprises investment that needs to be undertaken in any case but must now be increasingly channelled to alternatives that contribute to climate neutrality. Furthermore, the quantified climate action investments are not just necessary to achieve the climate targets but help the German economy to tap into future growth markets.⁶

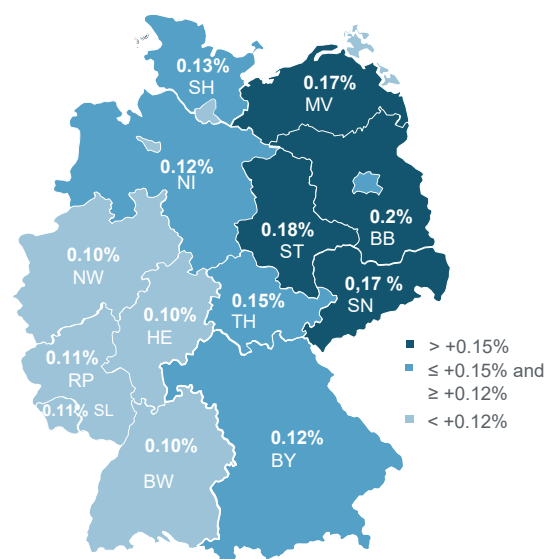
Climate action investment enables economic growth

The high climate action investment requirements provide significant economic opportunities. For example, making more efficient use of renewables directly reduces the import of fossil fuels. Furthermore, regions with high technological capacity – such as Germany and Europe – can benefit from the global transition by developing new technologies and providing key competences for the development of new value chains. This can strengthen Germany as an export-oriented economy in the long term.

The overall economic effects of the transition to climate neutrality can be quantified on the basis of different target scenarios. Although investments in the magnitude of several billion euros per year can also have reciprocal effects that may theoretically dampen economic activity (for example by crowding out investments that pursue other goals), the analysis of the scenarios shows that positive effects predominate. If the investments required to achieve climate neutrality are undertaken in the necessary volume, this is likely to trigger moderately positive effects on GDP and employment. The analysed scenarios imply that GDP will be between 0.9 and 1.4% higher in 2030 and between 0.4 and 0.9% higher in 2050 than in the absence of climate action investment. The workforce would be between 0.2 and 0.5%

higher in 2030 and between 0.1 and 0.2% higher in 2050 than in the reference scenario (Figure 2). This does not even take into account the economic costs of escalating climate change, for example due to increased extreme weather events. It has been found that every further year of inaction on climate change causes an additional USD 300–900 billion in annual damage around the globe.⁷

Figure 2: Employment effects of the transition by federal state



Variation in the workforce in 2050 on the 95%-path (Prognos and BCG, 2018) compared with the reference scenario.

Source: Prognos et al. / FES (2019).

The transition will have winners and losers

The truth is that the transition will generate both winners and losers. Even if a positive result can be achieved for society as a whole, there will be differences in both the burden of the investment requirements and the positive impetus on demand generated by the transition, for example between sectors and regions. Energy-intensive industries will generally be negatively affected, while the commercial sector is more likely to experience positive effects.⁸ However, the analysis shows that a 95% reduction pathway will lead to economic growth and positive employment effects by 2050 in all federal states. That means there is scope for supporting particularly affected regions in managing the transition until the positive investment effects materialise in all regions.

For the economy as a whole, the effects on GDP and employment are generally low but show that more climate action does not adversely impact on economic growth but actually provides positive impetus. This underscores the importance of the investments mentioned – and their timely implementation.

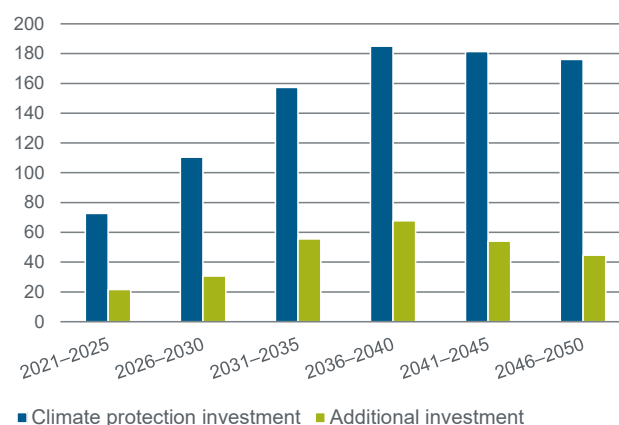
Investment requirements grow over time

Over time, the necessary transition investment will not be in the same volume every year. The investment requirements are comparatively low in the short term, mainly because measures will be implemented that are ready for the market already. Further along the transition path, however, more

demanding and cost-intensive measures such as carbon capture and storage (CCS) will have to be adopted to achieve the remaining greenhouse gas reductions, which is why growing investment requirements must be expected over time. The highest additional investment compared with the reference scenario is expected for the 2030s, while the current decade is still characterised by relatively low additional investment (Figure 3).

The profile also illustrates that failure to undertake necessary investments now would lead to even higher annual investment in future decades – which are potentially even more difficult to implement. It is therefore important to avoid investment backlogs. This applies all the more as businesses are positioning themselves today for their participation in the green markets of the future.

Figure 3: Development of investment requirements over time (EUR in billions p.a.)



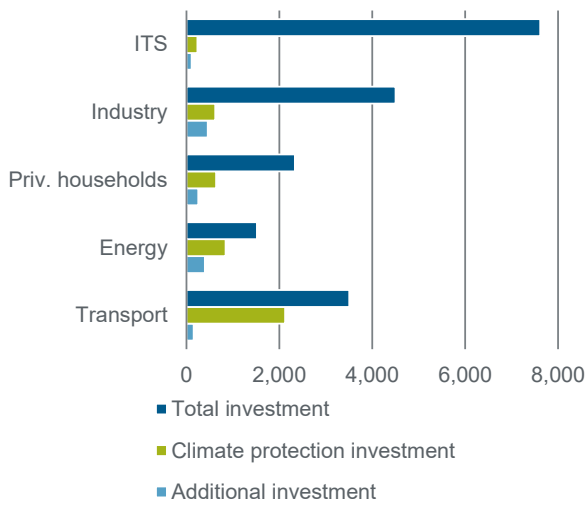
Source: Prognos / Nextra / NKI (2021).

Sectors have different investment requirements

The sectoral view shows different impacts as well (Figure 4). The ratio of climate action investments to overall investment provides insight into the share of upcoming investments required in the relevant sector to bring about climate neutrality.

The greater part of the necessary climate action investment – EUR 2.1 trillion – will be incurred in the transport sector. That is not only the highest volume by far in absolute terms but the highest share of total investment in the sector: Around 60% of upcoming investment will be climate action investment. This illustrates the large expected upheaval in the sector and its high energy intensity.⁹ But if we look at the additional investment, we see significantly lower figures of around EUR 153 billion, or around 7% of climate action investment (Figure 5). This is due to the high reinvestment regularly undertaken in the mobility sector and the generally lower additional investment in climate-neutral mobility (e.g. automobiles that run with zero-emission drivetrains) compared with the reference scenario.

Figure 4: Overview of investment requirements by economic sector (EUR in billions)



Source: Prognos / Nextra / NKI (2021).

Energy is the sector projected to have the second-highest volume of climate action investment. Part of the distance there has already been completed, not least by integrating the industrial and energy sector into the European Emissions Trading System (EU-ETS). Nevertheless, more than half of total investment here will still have to be used for a more systematic alignment with climate action – which demonstrates how closely the sector is tied to the issue of climate change. Grid infrastructure accounts for around one third of climate action investment. Unlike transport, the share of additional investment here is significantly larger, driven by an earlier and more comprehensive transition to decentralised generation from renewables than in the reference scenario. That will cause additional investment particularly in grid infrastructure, with almost half of all additional investment incurred in this area.

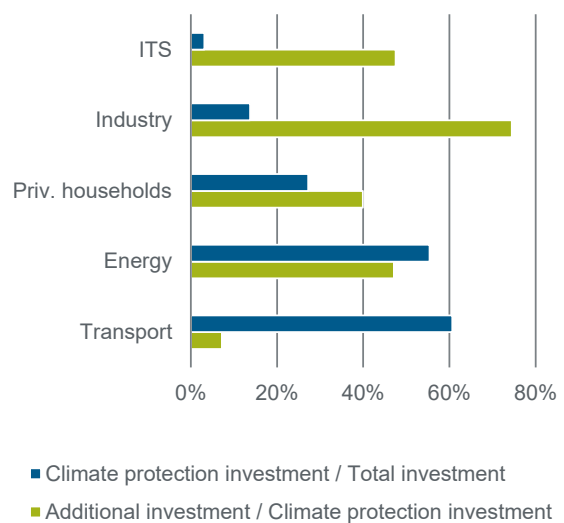
Private households (PHH) account for climate action investment worth EUR 636 billion. Most of this is investment in climate-neutral residential buildings. It is the third highest share of total investment. Here as well, many investments are heavily climate action-related. Around 40% are additional investments. This demonstrates that households, too, will definitely have to make substantial investments – against the background that the ability to invest depends strongly on the individual asset and income situation. Investment requirements are often highest particularly where the least financial resources are available.¹⁰

The industrial sector requires climate action investment in a similar volume. Although it makes up a significantly lower share of total investment, more than three quarters is additional investment. This illustrates the fact that energy-intensive industries need to mobilise a substantial additional investment volume because it takes great effort to make production processes climate-friendly. The share of additional investment here also varies between industries within the sector. It is particularly high in the energy-intensive basic industries (glass, steel, chemicals). It will not be possible to completely eliminate difficult-to-avoid emissions

such as industrial process emissions, so they will need to be neutralised by other means. This involves new and cost-intensive technologies for actively removing greenhouse gases from the atmosphere (especially CCS).

In the area of industry, trade and services (ITS), around half the climate action investment is composed of additional investments for measures such as energy-efficient process and building technology but their share in total investments is very low. Financing bottlenecks are therefore likely to be moderate. Rather, what is needed are explicit incentives to move the hitherto often neglected topic into the spotlight and stimulate necessary investments.

Figure 5: Shares in total investment and climate action investment (in per cent)



Source: Prognos / Nextra / NKI (2021).

Meeting the needs of the transition requires public and private investment ...

Although the technical prerequisites are fulfilled, mobilising the climate action investment needed to achieve climate neutrality is not a foregone conclusion. The financial sector will play an important role in financing the investment needs and directing capital flows to sustainable investments. Even in an attractive financing environment, however, it is possible that the investment required is not undertaken in the necessary amount and timeframe, for example if the price of CO₂ as a key climate policy instrument fails to set a sufficiently increasing price signal as a result of various market imperfections (such as knowledge externalities, network effects or information asymmetries).¹¹

In order to nonetheless ensure the necessary investments, accompanying incentives are needed. The public sector will have to act in two main respects: For one thing, it has a role model function which it can exercise, for example, by modernising the energy systems of public buildings or by converting the fleet of public transport vehicles. But most of all, it is responsible for creating enabling conditions for private investment. To what extent public investment funds will be needed essentially depends on how targeted these will be and to what extent it will be possible for public

incentives to achieve a leverage effect on private investment activities in the relevant areas.

... and political action systematically aligned with the goal of climate neutrality

When meeting financing needs, what is ultimately important is to proceed in a targeted manner in order to incentivise sufficient private and public investment activity. Whereas additional investments are likely to be undertaken particularly when investment obstacles¹² such as time-consuming planning and approval procedures are reduced, the greatest portion of necessary climate action investments is made up of those that would be performed anyway. Therefore, it is not primarily about mobilising additional capital but directing available funds to climate-friendly uses.

Relevant incentives are likely to be generated particularly by providing reliable policy guidance and regulatory frameworks. This includes the systematic elimination of environmentally harmful subsidies, for example. They distort competition at the expense of environmentally friendly technologies and products and are counter-productive in the transition to climate neutrality.¹³ Environmentally harmful subsidies thus make the transition to climate neutrality more costly than it has to be. Furthermore, important investment incentives for business models in the area of sector coupling are lost. Eliminating them could unlock revenues for the state that could already counter-finance around two thirds of the necessary annual additional investment for achieving climate neutrality in Germany.¹⁴ This vividly illustrates that reaching the target in many cases does not really mean mobilising that much additional capital but systematically aligning political action with the goal of climate neutrality.

What is also true, however, is that a climate-friendly economy will initially be more expensive than a fossil-fuel based one so long as there is no sufficiently high global CO₂ price. The challenge therefore consists in encouraging investment while creating global conditions that secure the competitiveness of the German and European economy. The EU is already active in both areas and the planned carbon border adjustment mechanism has the potential to provide important impetus to accelerate international climate diplomacy.¹⁵

Conclusion

Climate change is forcing all sectors of the economy to decarbonise. Encouragingly, it is evident that systems and processes can generally be transitioned using technologies that are already known. However, multiple obstacles may hamper a sustained transition. The steep rise in the volume of necessary climate action investment over the coming years and decades means that in the future, significantly higher amounts must be available to finance green investment than today. At the same time, systematically eliminating environmentally harmful subsidies could already secure a significant portion of the funds required for the necessary additional investment and accompanying policy measures. Against this background, the investment required to achieve climate neutrality is ambitious, to be sure, but manageable.

The findings of the study are corroborated by existing literature. One source is a recently published study by McKinsey, which sees investment requirements for Germany in a similar order of magnitude (EUR 6 trillion).¹⁶ With respect to additional investment, the literature is somewhat more extensive (see for example the analyses performed on behalf of the Federation of German Industries and the Federal Ministry of Economics and Technology).¹⁷ For the previous target year 2050 and an emissions reduction of 87–95%, these studies arrived at average additional annual investment of EUR 43 to 82 billion. Under the assumption that this investment is spread across fewer years as a result of the more ambitious target, that would mean around EUR 51 to 97 billion per year by 2045 – which would be in line with the EUR 72 billion reported here.

Climate action investments must not be seen as stranded costs. Rather, they open up the opportunity to improve Germany's competitiveness and prosperity. They generate long-term positive effects on gross domestic product and employment. They will yield even more positive outcomes when we take into account the true costs of climate change, for example as a result of increased extreme weather events. Without a consistent roadmap to climate neutrality, these will become significantly more frequent in the decades ahead. Continuing business as usual is therefore not an economically sensible option. Instead, Germany would be well advised to make the necessary climate action investments with determination.

¹ Cf. Brüggemann, A. (2021): [Transitioning to climate neutrality by 2050: a major challenge for German industry](#), Focus on Economics No. 322, KfW Research.

² The investment required to offset residual emissions are estimated under the assumption that these emissions are removed from the air by direct CO₂ capture and subsequently stored. The resulting investment of EUR 506 billion and additional investment of EUR 484 billion involve all sectors and represent an upper limit to the expected investment volume.

³ For a detailed presentation of methodology and results cf. Prognos / Nextra / NKI (2021): [Contribution of green finance to achieving climate neutrality in Germany](#), study commissioned by KfW.

⁴ Investment must be moved forward (compared with the underlying analysis) owing to the shorter period. This could result in higher investment amounts due to shortened investment cycles or lower technological maturity or higher specific costs of expansion. The figures should therefore be understood as a lower limit for a rough approximation.

⁵ German Federal Statistical Office (2021): Environmental Economic Accounting. https://www.destatis.de/EN/Themes/Society-Environment/Environment/Environmental-Economic-Accounting/_node.html.

⁶ Cf. also Römer, D., Zimmermann, V. and Brüggemann, A. (forthcoming): The future is green – what opportunities are available to German business? Focus on Economics No. 355, KfW Research, and Abel-Koch, J. and Ullrich, K. (2021): Low globalisation momentum requires adjustment of German companies' growth strategies, Focus on Economics No. 349, KfW Research.

⁷ Cf. Sanderson, B. and O'Neill, B. (2020): Assessing the costs of historical inaction on climate change. Scientific Reports. While many models have so far assumed that damage caused by climate change hardly affects economic growth in the long term, more recent studies are increasingly casting doubt on these calculations. Cf. i.a. Kikstra, J. et al. (2021): The social cost of carbon dioxide under climate-economy feedbacks and temperature variability. Environmental Research Letters, 16(9) and Kahn et al. (2019): Long-Term Macroeconomic Effects of Climate Change: A Cross-Country Analysis, IMF Working Papers. For more on initial estimates for Germany see Kempfert, C. (2007): Klimawandel kostet die deutsche Volkswirtschaft Milliarden (*Climate change costs the German economy billions* – our title translation, in German), DIW Weekly Report 11 / 2007, p. 165–169.

⁸ With a view to the automotive sector, the effects depend on whether Germany succeeds in keeping large shares of value added such as battery production in the country.

⁹ Internal combustion engines are being phased down by the middle of the century, to be sure, but will continue to be permitted. Should vehicles with internal combustion engines be banned earlier, the share of climate action investment would rise once again.

¹⁰ cf. Römer, D. and Steinbrecher, J. (2021), [KfW Energy Transition Barometer 2021](#), KfW Research (in German only).

¹¹ For a detailed discussion cf. Edenhofer et al. (2019), Optionen für eine CO₂-Preisreform (*Options for a CO₂ price reform* – our title translation, in German only), expert opinion for the German Council of Economic Experts, Working paper 04/2019, Wiesbaden.

¹² For a discussion of the various barriers to implementing investment projects cf. Grimm, V., Nöh, L. and Schwarz, M. (2021): Investitionen für nachhaltiges Wachstum in Deutschland (*Investment for sustainable growth in Germany* – our title translation, in German only): Status quo und Perspektiven, Wirtschaftsdienst, issue 3, p. 162–167.

¹³ Cf. also German Council of Economic Experts (2021), [Corona-Krise gemeinsam bewältigen. Resilienz und Wachstum stärken](#) (*Overcoming the coronavirus crisis together, strengthening resilience and growth* – our title translation, in German only), annual report 2020/21.

¹⁴ In a report, the German Federal Environment Agency compiled subsidies of around EUR 57 billion in the year 2012 which it considers environmentally harmful, cf. Köder, L. and Burger, A. (2016): Umweltschädliche Subventionen in Deutschland (*Environmentally harmful subsidies in Germany* – our title translation, in German only), Federal Environment Agency. According to an estimate commissioned by Greenpeace from the Forum Ökologisch-Soziale Marktwirtschaft, internationally known as Green Budget Germany in 2020, the German Federal Government could generate as much as EUR 46 billion in revenue annually by gradually dismantling ten subsidies that are particularly harmful to the climate in the energy, transport and agricultural sectors, cf. Beermann A. et al. (2020): [Zehn klimaschädliche Subventionen im Fokus](#) (*Spotlight on ten subsidies that harm the climate* – our title translation, in German only).

¹⁵ Cf. Römer, D., Schwarz, M. and Liem, E. (2021): [The EU's carbon border adjustment: A trade barrier or an opportunity for global climate action?](#) Focus on Economics No. 345, KfW Research.

¹⁶ The analysis published by McKinsey does not explicitly report the investment requirements in the individual sectors, cf. McKinsey (2021): [Net-Zero Deutschland – Chancen und Herausforderungen auf dem Weg zur Klimaneutralität 2045](#) (*Net zero Germany – opportunities and challenges on the way to climate neutrality in 2045* – our title translation, in German only).

¹⁷Cf. Prognos and BCG (2018): Klimapfade für Deutschland (Climate pathways for Germany – in German), study commissioned by the Federation of German Industries and Prognos, GWS, Fraunhofer ISI and IINAS (2021): Energiewirtschaftliche Projektionen und Folgeabschätzungen 2030/2050 (*Energy sector projections and impact assessments* – our title translation, in German only), overall documentation of the scenarios, study on behalf of the Federal Ministry for Economic Affairs and Energy.