2 Reaching net zero while safeguarding competitiveness and social cohesion

Zeev Krill

Robert Grundke

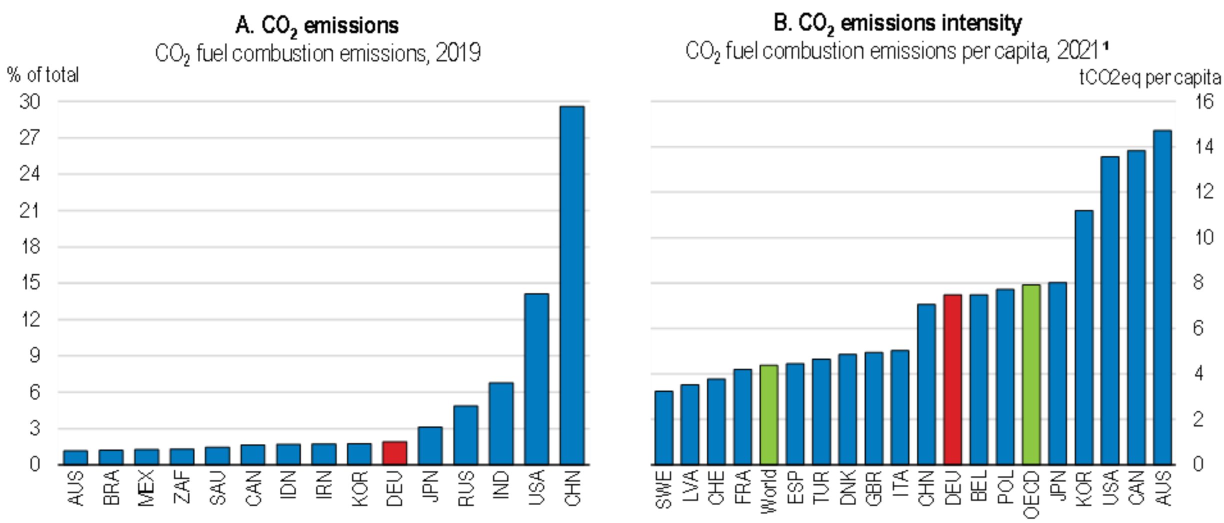
Marius Bickmann

Germany intends to reach climate neutrality in 2045, tripling the speed of emission reductions that was achieved between 1990 and 2019. Soaring energy prices and the need to replace Russian energy imports have amplified the urgency to act. Various policy adjustments are needed to ensure implementation and achieve the transition to net zero cost-effectively. Lengthy planning and approval procedures risk slowing the expansion of renewables, while fossil fuel subsidies and generous tax exemptions limit the effectiveness of environmental policies. Germany should continue to rely on carbon pricing as a keystone of its mitigation strategy and aim to harmonise prices across sectors and make them more predictable. Carbon prices will be more effective if complemented by well-designed sectoral regulations and subsidies, especially for boosting green R&D, expanding sustainable transport and electricity network infrastructure, and decarbonising the housing sector. Subsidies for mature technologies and specific industries should be gradually phased out. Using carbon tax revenue to compensate low-income households and improve the quality of active labour market policies would help to support growth and ensure that the transition does not weaken social cohesion.

Introduction

Germany is still a large emitter of greenhouse gases (GHG) (Figure 2.1), but it is also at the forefront of efforts to reduce emissions. Germany released 39% less GHG emissions in 2021 than in 1990. It intends to reach climate neutrality in 2045, which requires tripling the speed of emission reductions, and lowering the usage of fossil fuels in electricity generation to zero in 12 years by strongly expanding renewable energy supply. This is a massive challenge with considerable economic and social costs. Still, it also holds large potential to create new economic opportunities and improve people's lives, as well as to help to avoid the much higher economic costs of missing global climate change mitigation targets. Russia's war of aggression against Ukraine has revealed vulnerabilities due to an over-reliance on energy imports from Russia and emphasised the possible contribution of renewables to raise energy security. Furthermore, renovating the existing housing stock would improve housing quality and lower energy bills, while shifting to net zero transport would bring greener and less polluted cities. As a country with high technological capacity, Germany can benefit by developing new technologies and providing key competences for the development of new value chains, such as the one for green hydrogen.

Figure 2.1. Germany is still a large emitter of greenhouse gases



1. 2019 for China and World.

Note: Panel A shows countries with the highest share of global emissions.

Source: IEA Greenhouse gas emissions from energy database.

StatLink https://stat.link/peivuf

This chapter identifies a mix of policies, which would help to achieve the transition to net-zero cost-effectively while ensuring that the costs of the transition are shared in a fair way. As the global climate is a public good, the chapter emphasises the important role of international cooperation in addressing carbon leakage and other externalities to achieve substantial progress towards a net-zero global economy. The analyses and recommendations are informed by two new OECD studies on the economic and distributional consequences of different mitigation policy options for Germany (Bickmann et al., forthcoming[1]) as well as on labour market transitions of workers displaced from high carbon-intensity sectors during the last three decades (Barreto, Grundke and Krill, forthcoming[2]). The remainder of the chapter is structured as follows: after describing the high costs of climate change for Germany, the chapter discusses recent progress towards the national climate targets. It then highlights the policy instruments needed to reach a net-zero economy cost-effectively, including by addressing carbon leakage and other challenges to manufacturing. The following section analyses the distributional consequences of more ambitious mitigation policies and discusses ways to reduce adjustment costs for workers and households and build strong public support for the green transition. The last section discusses targeted policies for three main emitting sectors: electricity, transport, and housing. A discussion of the agricultural sector, land use, land use change and forestry (LULUCF) as well as an in-depth chapter on climate change adaptation and nature-based solutions can be found in the OECD Environmental Performance Review of Germany (OECD, forthcoming[3]).

Climate change already has high costs for Germany

Germany is increasingly affected by the consequences of climate change. Since 1951, the number of days with temperatures above 30°C has almost tripled and since 1881, when measurements began, winter precipitation has increased by 27%. The average annual temperature is already 1.6 degrees higher than in 1881 (German Environment Agency, 2021[4]). This has strong effects on the economy and human lives. According to the European Environmental Agency, economic losses due to extreme climate-related events since 1980 accumulated to about 3% of 2020 GDP, with higher losses per capita than in most EU countries (2022[5]). In a recent study conducted for the German Federal Government, the estimated economic loss was almost three times as high (Prognos, IOW and GWS, 2022[6]). Floods and heavy rains caused most of the damage to properties and infrastructure, while heatwaves caused 99% of fatalities, estimated at 1,400 a year (Box 2.1). Existing studies likely underestimate the actual costs of climate change, as indirect effects on biodiversity and health are hard to quantify using available data.

Box 2.1. The 2021 flood disaster as an extreme example of climate risks

The floods that hit Germany in 2021 swept away many buildings and caused severe damage to infrastructure. More than 180 people were killed, and over 800 were injured. The overall damages are estimated at EUR 40 billion, the single most costly event in post-war history of Germany. Climate change increases the likelihood of such an event by a factor of 1.2 to 9, implying that the damage of the floods that could be attributed to climate change ranges from EUR 7.1 to 35.9 billion (Prognos, 2022[7]).

The floods highlighted weaknesses in the German insurance coverage for natural hazards as well as in the warning and response systems and communication channels (OECD, forthcoming[3]). About 30% of the affected residents did not receive any warning. Of those who were warned, 85% did not expect a very severe flooding and 46% did not know what to do (Thieken et al., 2022[8]). In addition, most of the buildings that were hit were not insured against flood damage, which led the government to establish a special fund (of EUR 30 billion) to partially compensate for the losses (Osberghaus, 2021[9]).

With climate change, occurrences of extreme events such as heatwaves, drought and heavy rainfall will rise sharply, and so will the related economic costs (German Environment Agency, 2021[4]). In 2022, a severe drought led to historically low water levels in the Rhine, which disrupted ship transport from Rotterdam to the economic centres in the Southwest of Germany. This further exacerbated supply chain bottlenecks, hindering the post-pandemic rebound of industrial production (see Chapter 1). Climate extremes would occur most frequently in the south, southwest and east of Germany (Figure 2.2) and would have a great impact on agriculture, water management and biodiversity. Loss of yields, forest fire risks and a reduction in fish species and water quality are all among the potential risks, even if better adaptation policies could reduce some of the damages (German Environment Agency, 2021[4]) (Box 2.2).

Box 2.2. Strengthening resilience for a changing climate

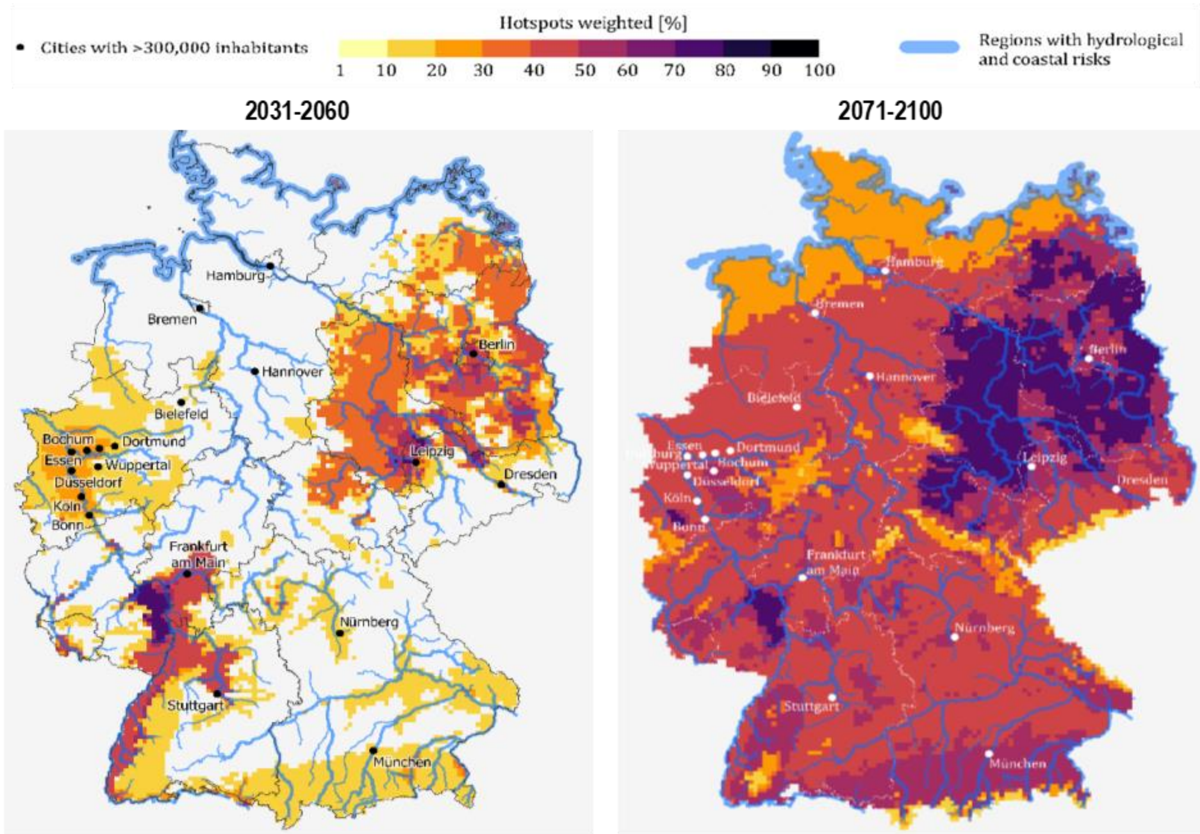
Germany's adaptation efforts have focused on developing regular, robust climate risk assessments. Its results have informed a whole-of-government approach to building climate resilience based on the overarching national adaptation strategy established in 2008. The federal government's role in building climate resilience is focused on technical guidance, facilitation and co-ordination. At the same time, investment and the implementation of adaptation measures are under the responsibility of sectoral agencies and Laender governments. Implementation progress has been sluggish and heterogenous across sectors and regions, with many localities remaining highly exposed and vulnerable to climate change. To improve climate resilience, information should be shared more efficiently with those expected to act, namely local and regional policymakers, infrastructure investors, businesses and property owners. Additionally, incentives to scale up preventive adaptation action need to be strengthened, and measures to support the availability and take-up of insurance against natural hazards should be examined (Box 2.1).

The government sets out an ambitious vision for strengthening its climate adaptation engagement in the 2022 Immediate Programme for Climate Adaptation. It aims to develop a Federal Climate Change Adaptation Act, complementing the Federal Climate Change Act. It shall give the federal government the mandate for developing a new adaptation strategy, revising the nationwide funding mechanism for adaptation, and developing measurable targets to increase accountability for adaptation actions carried out by different actors. The act provides an opportunity to clearly determine roles and responsibilities at different governance levels, and to rethink how adaptation resources can be mobilised in favour of preventative action.

Source: OECD (2023), Environmental Performance Reviews: Germany 2023, OECD Publishing, Paris, forthcoming.

Climate change will affect Germany even more through its economic consequences in other parts of the world. Climate risks are higher for low and medium-income economies that have difficulties to cope with the consequences of climate change due to weaker infrastructure and institutional quality and higher reliance on sectors that are adversely affected by climate change (German Council of Economic Experts, 2021[10]). As a result, climate change will significantly affect trade with and migration flows from these countries.

Figure 2.2.Climate extremes would occur most frequently in the southwest and east of Germany



Note: Maps of extreme values show regions that could be affected by a particularly large number of climatic extremes.
Source: (German Environment Agency, 2021[4])

StatLink https://stat.link/04utq9

Germany has reduced its emissions and set ambitious mitigation targets

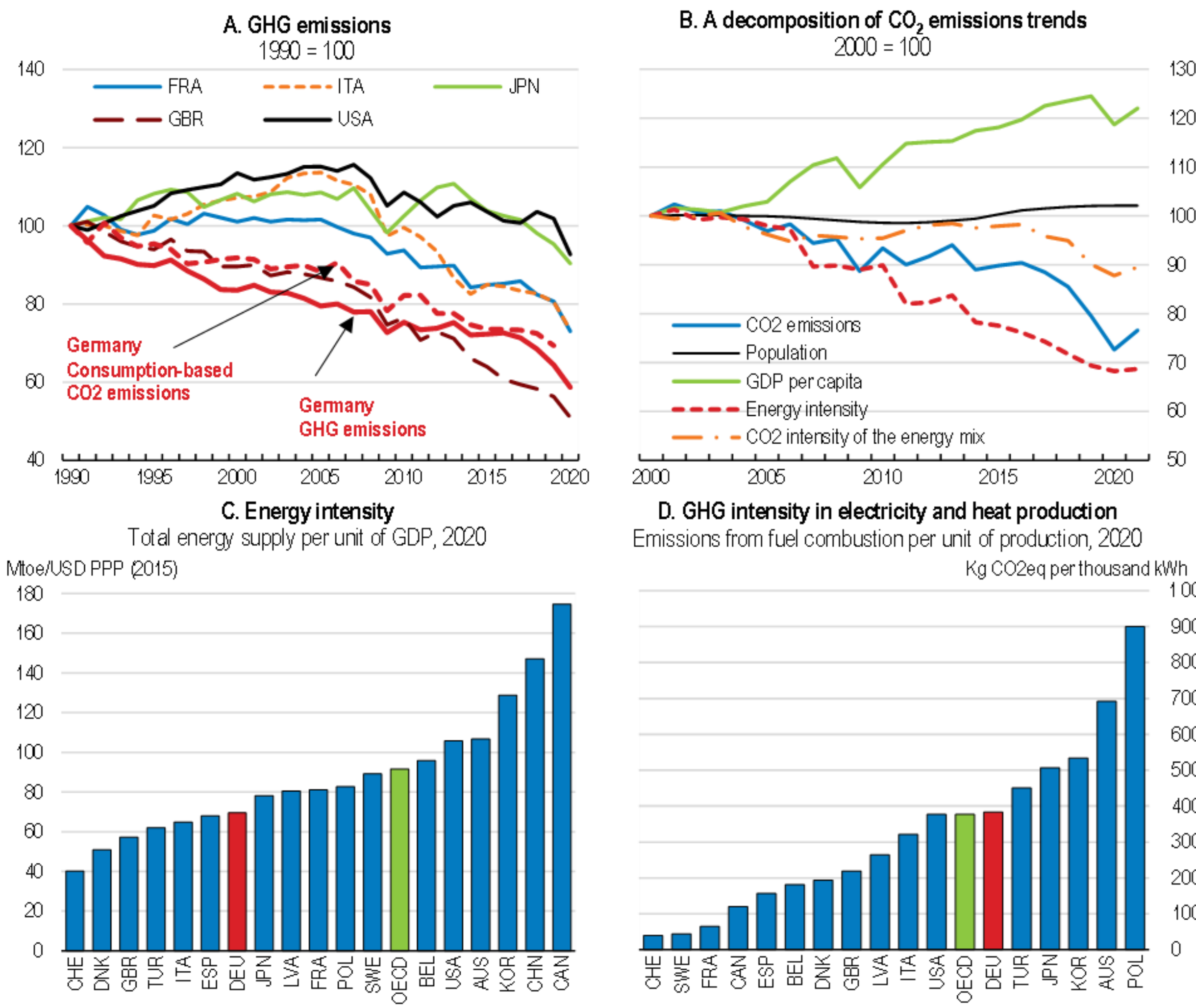
Germany is at the forefront to reduce greenhouse gas emissions

Germany has made considerable progress in reducing greenhouse gas emissions (Figure 2.3, Panel A). Yet, it remains one of the largest emitters of GHG per capita among OECD countries, mainly due to the high share of industry in GDP and fossil fuels, including coal, in the production of power and heat. It has reduced production-based emissions by 36% from 1990 to 2019, among the largest reductions in the OECD and G20 countries, while at the same time GDP increased by 54%. This was achieved without increasing the displacement of emissions to other countries, as the trend after including emissions embodied in imports is similar. Some of the improvement was due to particular circumstances after reunification and not due to policy measures, efficiency gains or structural change (Schleich et al., 2001[11]). From 1989 to 1994, emissions in East Germany fell by almost half, mainly due to a reduction in lignite-based power generation.

So far, the decoupling of emissions from economic activity has been reached mainly by reducing energy use per unit of GDP (Panel B), which is now below most OECD countries (Panel C). Progress in reducing emissions per unit of energy produced has been slower, and the use of fossil fuels in the production of power and heat is still high (Panel D). Nevertheless, progress has accelerated in recent years due to remarkable growth in renewable energy supply and a decline in coal use (Figure 2.4). Germany's share of electricity generation from solar and wind is amongst the highest in G20 countries.

The COVID-19 pandemic and its associated restrictions reduced emissions by 9% in 2020, so that Germany reached its 2020 emissions reduction target. However, little of this reduction is set to be permanent, with over half of the emission reduction due to the temporary drop in economic activity (Council of Experts on Climate Issues, 2021[12]). Already in 2021 (when COVID-19 restrictions continued), emissions increased by about 4.5%. Some changes to working and consumption patterns might persist, but their effects on emissions are uncertain and likely to be limited. For example, if 15% of employees work full time from home, direct effects on emissions due to reduced car commuting are expected to amount to 4.5 million tons of CO_2, about 3% of emissions in the transport sector (Bachelet, Kalkuhl and Koch, 2021[13]). However, over the longer term, working from home can incentivise to move away from expensive inner cities and commute greater distances or slow down the shift to more efficient cars for those who will commute less (Marz, 2022[14]).

Figure 2.3. Germany is at the forefront of efforts to reduce GHG emissions



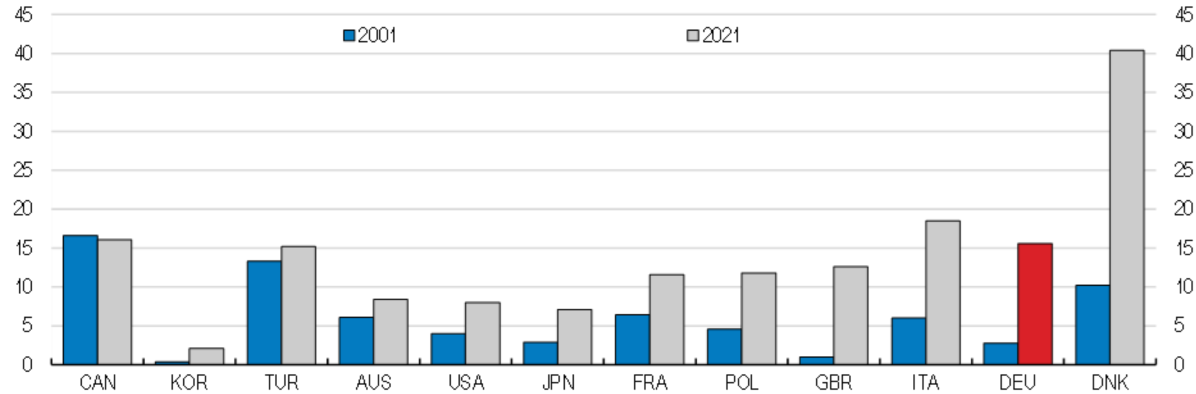
Note for panel A: CO_2 emissions from fuel combustion. GDP per capita refers to GDP USD PPP at 2015 prices divided per population, energy intensity refers to total energy supply per unit of GDP (USD PPP at 2015 prices), and CO_2 intensity of the energy mix refers to CO_2 emissions per unit of total energy supply.

Source: IEA Greenhouse gas emissions from energy database; Our World in Data based on the Global Carbon Project; OECD (2022), Green Growth Indicators, OECD Environment Statistics (database); IEA (2021), IEA World Energy Statistics and Balances (database)

StatLink https://stat.link/qa9ihf

Figure 2.4. The share of renewables has been increasing rapidly

Share of primary energy from renewable sources, %



Note: Renewable energy sources include hydropower, solar, wind, geothermal, wave, and tidal. Countries ordered by the change (in percentage points) in the share of renewables since 2001.
Source: IEA World Energy Balances database.

StatLink https://stat.link/aghc9v

The strong reduction of GHG emissions is a result of sustained political will, substantial changes to the regulatory framework, targeted support, and a history of cooperation with neighbouring countries. Above all, establishing a feed-in tariff scheme in the 1990s encouraged the creation of a protected niche market for renewables, without prioritising a specific technology. The scheme spurred a significant development and deployment of renewable technologies and helped to reduce abatement costs in Germany and other countries. It is a good example of a successful innovation policy, which was adjusted after the market matured (Box 2.3). The ecological tax reform of 1999 and the introduction of the EU emissions trading system (EU ETS) in 2005 have also strongly contributed to breaking the link between GHG emissions and economic growth.

The OECD Environmental Policy Stringency index illustrates the rise of climate mitigation efforts in Germany in the last two decades (Figure 2.5). Like in the average OECD country, non-market-based policy instruments such as performance standards contributed most to this increase. However, in recent years the technology support sub-index shows a significant rise as well. For example, the sub-measure of support for wind energy has increased significantly since 2018. The EU ETS contributed to the increase in the stringency of market-based policies since 2006, and the introduction of the national emissions trading mechanism in 2021 is another important step in that direction. Nonetheless, the scope for market-based policies, including higher and more unified carbon pricing, remains significant (see below).

Box 2.3. The corner stones of the German Energy Transition Strategy

Germany is a pioneer in producing and deploying renewables. Already in 1991, it instituted one of the world's first feed-in tariff schemes to encourage renewables, allowing the related administration to develop technical competence and relevant knowledge. In 2000, the German government decided to gradually phase out nuclear power over 30 years and to expand the feed-in tariff scheme for a wide range of renewable energies that were not yet competitive (the Renewable Energy Sources Act, or EEG). The tariffs incentivised investment by covering the difference between the cost of production and the electricity market price. This was financed by the renewable energy surcharge on electricity consumption.

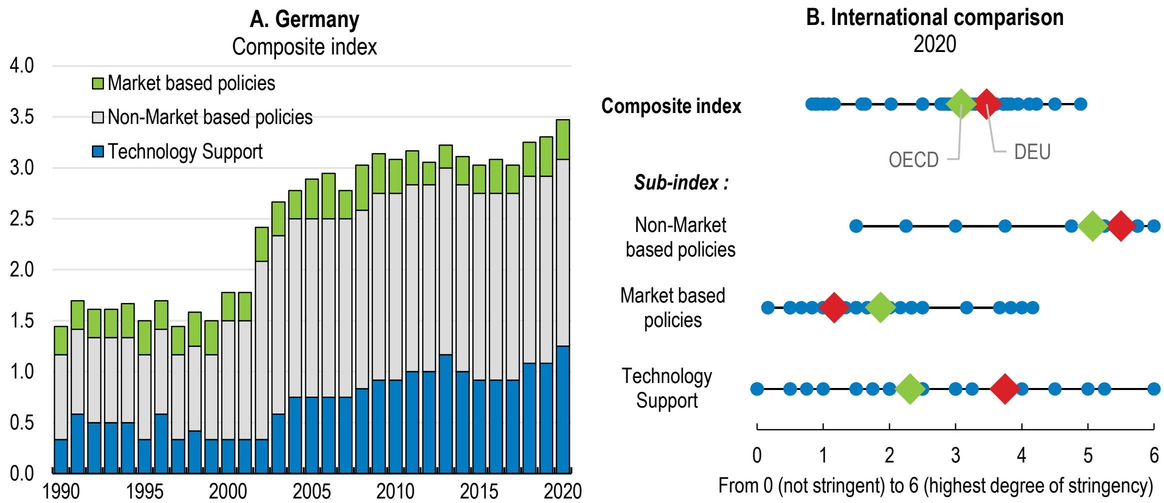
The tariff spurred significant deployment of solar technology, bringing down its cost. However, in 2008 the drop in solar photovoltaic prices, while tariffs adapted only slowly, led to soaring subsidy costs. In response, Germany reformed the scheme and moved to rely on auctions in setting the target price. This brought down the subsidies to less than five cents per kWh in 2017, while keeping renewables competitive (relative to coal). Overall, solar and wind capacities soared from about 9 gigawatts to 118 gigawatts between 2000 and 2015. During this time, Germany accounted for about a third of total renewable installations within the European Union. In addition, new industries were created, and German companies became global champions in the production of renewables by developing cutting-edge technologies. At its peak in 2011, more than 150 000 individuals worked in the solar energy sector. Since then, German distributors have turned to China for scaling up supply at a reduced cost, relying on technology standards and certification that provide reliability.

The cost reductions enabled Germany to increase the ambition of its renewable energy targets. Already in 2010, the government set targets for renewable energy expansion, energy efficiency, CO_2 reduction, and low-carbon transportation. The nuclear fleet was maintained as a "bridge technology", but following the accident in Fukushima the nuclear exit was advanced to the end of 2022. Moreover, during the late 1990s', Germany liberalised and decentralised its domestic energy market. The Federal Network Agency was established in 1998 as part of this process. Its task is to regulate the electricity and gas markets while ensuring fair competition and overseeing the transmission networks.

Sources: (Journalism for the energy transition, 2015[15]), (Pflugmann et al., 2019[16]), (Nemet, 2019[17]), (Pahle et al., 2018[18]).

Figure 2.5. Environmental policies have become increasingly stringent

The OECD Environmental Policy Stringency Index, from 0 (not stringent) to 6 (highest degree of stringency)



Notes: The Environmental Policy Stringency Index includes climate change and air pollution policies, such as performance standards for NOx, SOx, and PM. OECD is an unweighted average of countries with available data.

Source: Kruse, T., et al. (2022), "Measuring environmental policy stringency in OECD countries: An update of the OECD composite EPS indicator", OECD Economics Department Working Papers, No. 1703, OECD Publishing, Paris, https://doi.org/10.1787/90ab82e8-en.

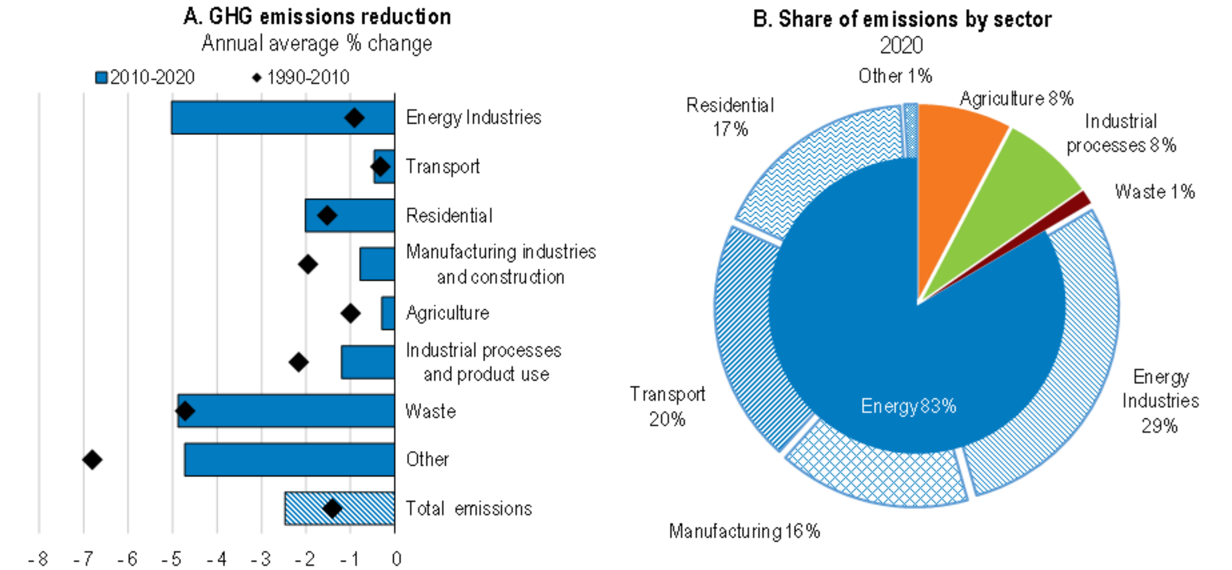
StatLink https://stat.link/i1s48x

Despite progress in lowering overall emissions, Germany struggled to meet its 2020 sectoral emission reduction targets. So far, electricity production has been the largest source of emission reductions, with a rapid shift in electricity generation away from coal towards renewable energy. The share of renewables in electricity generation increased from 17% in 2010 to 41%% in 2021. However, progress is slower in other sectors (Figure 2.6). Emissions in international aviation, for example, rose sharply since 2005, and in 2021, emissions in the transport and buildings sectors were above the annual targets specified in the Federal Climate Change Act. The uneven progress largely reflects differences in matured green technologies and abatement costs between sectors, with higher costs in the building and transport sectors (Council of Economic Experts, 2019[19]). Nonetheless, too many people use motorised vehicles for most of their trips due to urban sprawl and the allocation of public space and investment in favour of private cars. Low coverage of effective policy instruments such as carbon pricing also plays a major role in explaining the variation in mitigation progress between sectors.

Progress is also uneven across households. The average emissions per capita in the highest decile of the household income distribution is 5.8 times larger than in the bottom 50% of the distribution. Even though a large share of emission reductions has come from higher-income households, their reduction has been smaller in relative terms. Emissions in the upper decile declined by 42% from 1990 to 2019, whereas the average decline was 57% for individuals in the bottom half of the income distribution (Chancel, 2021[20]).

Figure 2.6. The progress in emission reduction is uneven across sectors

GHG emissions (excluding land use, land-use change and forestry)



Source: OECD Environment Statistics.

StatLink https://stat.link/k2z1jm

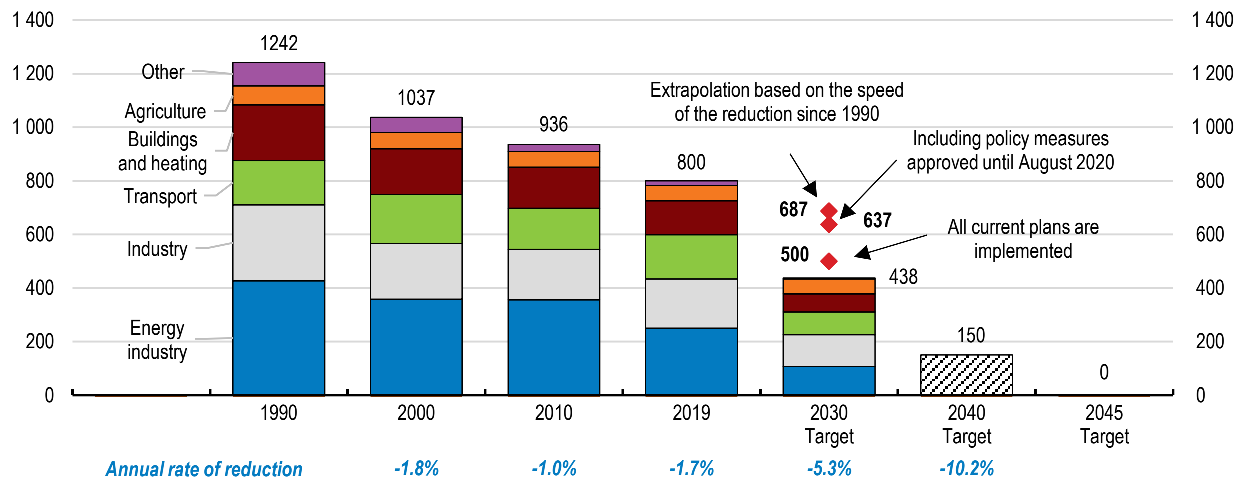
Germany has set ambitious emission reduction targets

Germany has raised the ambition of its climate targets, building on a strong consensus across the population on the importance of fighting climate change and in a reaction to a Supreme Court decision in April 2021, which declared the Climate Change Act as partly unconstitutional because it shifted the burden to future generations. In June 2021, the German Bundestag passed an amendment of the Federal Climate Change Act, aiming to reach climate neutrality (net-zero) by 2045, five years earlier than previously planned. In addition, GHG emissions shall be reduced by 65% in 2030 compared to 1990 levels (excluding Land Use, Land-Use Change and Forestry) and by 88% in 2040. This would require tripling the speed of progress since 1990. The Act also stipulates permissible annual emission volumes for each sector. After 2050, negative greenhouse gas emissions are to be achieved. The EU Fit for 55 proposal and the national targets are broadly aligned in terms of emission reduction (see below).

Until recently the announced policy measures were insufficient to triple the speed of emission reduction and reach these ambitious targets (Figure 2.7) (Umweltbundesamt, 2022[21]). However, the Federal Government introduced two ambitious policy packages: the "Easter Package" in April 2022 and the "Summer Package" in July 2022, focusing on expanding renewables capacity. The legally binding goal is to double the share of renewables in total electricity supply, to reach 80% by 2030 (Table 2.1). Planning and approval procedures for infrastructure investments were facilitated by a law that declares the expansion of renewable energy production as an objective of national interest and prioritises it over nature protection objectives as well as other social and environmental concerns. Likewise, the law obligates Germany's large states to dedicate between 1.8% to 2.2% of their lands (depending on their wind conditions) to onshore wind power by 2032. Moreover, the policy packages introduced measures to accelerate the expansion of the electricity grid and boost incentives for switching to renewables for heating (e.g., from gas heating to heat pumps). Likewise, the renewable energy surcharge, which is a levy on electricity consumption to finance renewables subsidies, was abolished to lower electricity prices and incentivise switching to electric driving and heating systems. The new government also aims to phase out coal "ideally by 2030", ahead of the previously agreed timelines. It is the first industrialised economy aiming to phase out both nuclear and coal. According to the Climate Action Tracker, if all measures planned in the coalition treaty were implemented in legislation, Germany would get close to its domestic emissions target by 2030, with emissions cut by 57% to 63% below the 1990 level (Climate Action Tracker, 2022[22]). Nonetheless, achieving carbon neutrality in 2045 will require full implementation of these measures and many additional policy adjustments to reach the target cost-effectively.

Figure 2.7. Emission reductions need to accelerate

Greenhouse gas emissions (excluding LULUCF), tonnes of CO_2 equivalent, millions



Note: The Climate Protection Act also states that the footprint of the LULUCF must be improved to at least -25m tonnes of CO_2 eq. by 2030, at least -35 million tonnes of CO_2 eq. by 2040, and at least -40 million tonnes of CO_2 eq. by 2045.
Source: OECD Environment Statistics; Umweltbundesamt, Climate Action Tracker.

StatLink https://stat.link/sr9xcm

Table 2.1. Main emission reduction policies by sector

Sector	Main instruments in place
Electricity generation	EU ETS; phase-out of coal generation, ideally by 2030 and no later than 2038; 2% of Germany's territory is to be dedicated to onshore wind energy; roofs of new commercial buildings are to be used for solar energy; policies to expand electricity grids; improving grid connections with neighboring countries.
Manufacturing, Industrial processes and product use	EU ETS (large emitters); subsidised loans by KfW; Funding green hydrogen plants and pilot programmes; minimum quotas of climate-neutral products in public procurement.
Transport	Expanding the rail network and better connecting the train with airport hubs; excise duty on transport fuels; National Emissions Trading System in the heating and transport sectors; limiting new registrations of cars and vans to carbon-neutral vehicles from 2035 onwards (EU regulation); purchase premium for carbon-neutral cars until the end of 2025; technology development support to manufacturers; public investment in public charging points and support for the installation of private charging points; distance-based toll charges for trucks of more than 7.5 tonnes.
Heat and buildings	National Emissions Trading System in the heating and transport sectors; building standards for energy efficiency; various funding schemes to support energy efficiency and heat pumps, including on-site energy consultation with experts; every newly installed heating system is to be run on at least 65% renewable energy from 2024; banning the installation of oil-fired heating systems from 2026.
Agriculture	Agri-environmental payment schemes (voluntary programmes paying farmers to achieve environmental criteria); expansion of organic farming; aid programmes to protect forests and encourage carbon sink.

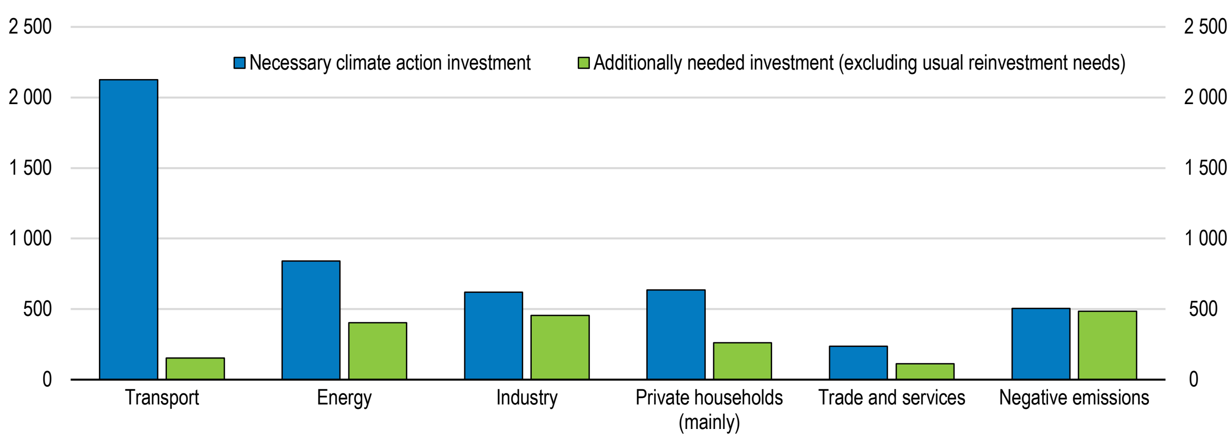
Source: Author's compilation based on various sources.

The energy crisis due to Russia's invasion of Ukraine has helped to build the necessary consensus to accelerate the transition towards renewables, which could also raise energy security. Soaring fossil fuel prices created strong incentives to shift to renewables and have facilitated consensus on new measures across levels of government. Nonetheless, some measures to raise energy security could turn out to be counterproductive for climate policy. For example, a sequence of gas supply deals, such as the agreed 15-year gas supply partnership with Qatar (supply is expected to start in 2026), and further expansion of LNG import infrastructure risk to lock in fossil fuels-based technologies, even though the government required the new infrastructure to be compatible with hydrogen fuels. Moreover, Germany has allowed the restarting of coal-fired power plants, which were initially scheduled to close in 2022 and 2023, as long as the gas emergency plan's second "warning phase" remains in place (Chapter 1). According to the Federal Network Agency, if renewables are expanded as planned and the European electricity market continues to function well, Germany will not experience an electricity shortage from 2025 to 2031. This holds true even if electricity consumption rises due to the electrification of transport and heating, the nuclear power plants are shut down, and coal is phased out by 2030 (Bundesnetzagentur, 2023[23]). Energy security will be at lower costs if the expansion of renewables supply is combined with available measures to shift electricity use across time and reduce peak demand times on the grid (see the section on modernising the transmission network below). Ensuring that infrastructure investments in renewables progress fast is crucial to achieve both energy security and the ambitious mitigation targets.

Achieving carbon neutrality will require massive investment in technologies and infrastructure by both the private and the public sectors. According to KfW (the German state-owned investment and development bank), the total volume of necessary investments is estimated at EUR 5 trillion, including about EUR 0.5 trillion in emission removal technologies that could compensate for sectors, such as agriculture, that are more difficult to decarbonise. If this sum is spread out evenly until 2045, EUR 191 billion or 5.2% of Germany's 2021 GDP would need to be invested each year. This high amount includes investments that would be undertaken anyway but must be adjusted to include low-carbon technologies. The additional necessary climate action investment averages EUR 72 billion per year until 2045, about 2% of 2021 GDP. Other estimates range from EUR 52 to 97 billion (Brand, Römer and Schwarz, 2021[24]). Investment as a share of GDP was 20.3% on average in 2011-20, down from 22.5% in 2001-10. The increase in investment by 2 percentage points of GDP to above 22% of GDP seems feasible. A significant part of the additional investment is needed in industry and energy sectors to modernise the electricity grid or develop and scale up green technologies (Figure 2.8). The public investment share is projected at around 500 billion, 10% out of the total needed investment (Brand and Römer, 2022[25]).

Figure 2.8. Massive investment is needed to meet Germany's ambitious climate targets

Total investment needed to achieve the target of net-zero climate neutrality until 2045, EUR billion

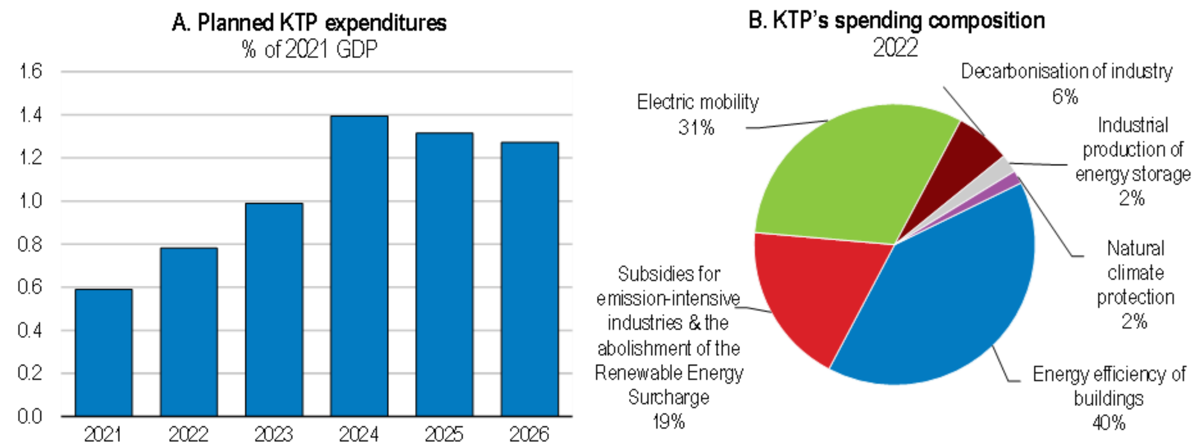


Source: Prognos / Nextra / NKI (2021).

StatLink https://stat.link/knaurw

Substantial public support to increase investment is planned in the next few years. The federal government has adopted several comprehensive climate programmes before and during the COVID-19 crisis, totalling over EUR 80 billion (BMF, 2022[26]). For example, about 40% of the German Recovery and Resilience Plan (EUR 11.5 billion) was dedicated to climate policies and the energy transition. These programmes include a mix of direct investments and subsidies for firms and households that would mainly be financed by the Climate and Transformation Fund (KTP). This Fund receives revenues from three sources: the EU ETS, the national emission trading system, and direct transfers from the federal budget (expected to account for about 50% of total revenues in 2021-26). In 2020-22, the Fund received an additional EUR 100 billion in credit allowances from the federal budget, as the national debt brake was suspended for three years due to the COVID-19 crisis and unused funds for pandemic related support programmes were redirected to the EKF to counter the pandemic-related reluctance to invest (Chapter 1). The Fund is expected to spend EUR 180 billion from 2022 to 2026, mainly for supporting the green transition in transport, building and industry sectors and abolishing the Renewable Energy Surcharge (Figure 2.9). Boosting public investment is timely as financing costs are still low, although skilled labour shortages in the construction and planning sector as well as material shortages will likely limit the speed of implementation of investment projects and increase their prices (Figure 2.10). Further promoting the transition between secondary education and VET positions in high demand, expanding VET and adult education opportunities for low-skilled and unemployed workers, and facilitating the migration of skilled workers from non-European countries, as envisioned under the *Fachkraeftestrategie*, are essential to ease labour shortages (see Chapter 1). Facilitating the ability of EU construction companies and material producers to operate in Germany by removing trade barriers, such as the additional testing requirement for construction products, and fostering digitalisation of the construction sector would increase market competition, lower prices and help boost investment (European Commission, 2018[27]).

Figure 2.9. Government support for green investment will expand substantially

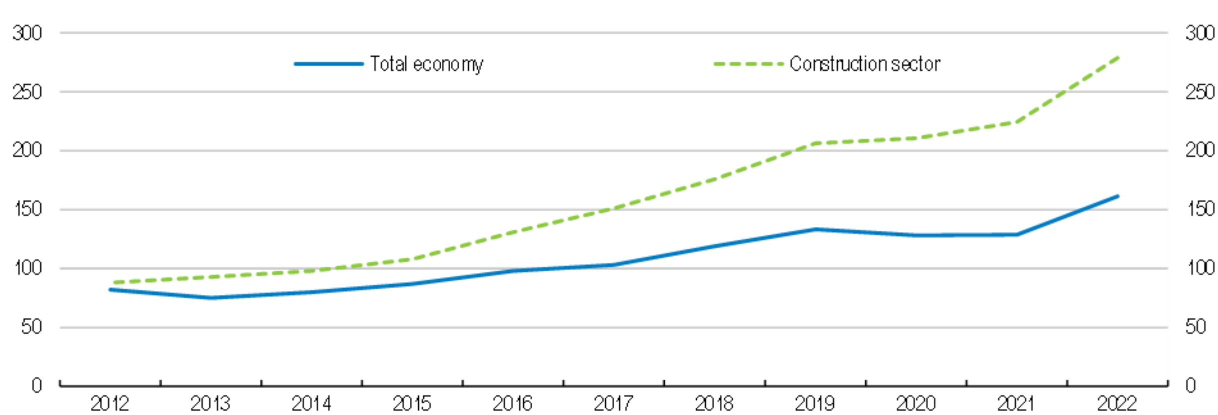


Source: Ministry of Finance.

StatLink https://stat.link/52iv9r

Figure 2.10. Labour shortages in the construction sector are mounting

Completed vacancy time, number of days



Note: The numbers refer to the values in November of each year.
Source: Federal Employment Agency.

StatLink https://stat.link/pw6xh7

Germany has strengthened its institutional framework for climate mitigation policies

Two independent, interdisciplinary bodies advise the Federal Government on climate policies and contribute to evidence-based policy making. From 2022 onwards, the Council of Experts on Climate Issues will regularly present its assessment of climate policies to the Bundestag and the Federal Government. If the Council finds in its annual examinations that a sector has missed its emission targets, the relevant federal ministry must present an action programme within three months to ensure the sector will comply with its annual emission budget in the subsequent years. The Science Platform on Climate Policy, a body of scientific experts, supports the German Federal Government in evaluating climate protection measures and conduct policy analysis, including on the economic consequences of the mitigation efforts.

To better evaluate the efficiency of public spending, impact assessment studies should be an integral part of all existing and new policy programmes and plans, which requires better data collection and analysis (Chapter 1). Better data collection is also required to assess emissions from land use, land-use change, and forestry (LULUCF) in a timely way and define a sensible target, which is in line with other sectoral targets (Council of Experts on Climate Issues, 2021[12]). Furthermore, it is key to regularly monitor trade-related emissions. So far, the trend in total emission reduction after including emissions embodied in imports is broadly in line with the trend according to the production-based definition (Our World in Data, 2022[28]). Nevertheless, this could change, especially if carbon prices in Germany rise to levels required to reach ambitious emission reduction targets but remain low in other countries (see below).

Key policy instruments for a net-zero economy

Keep relying on pricing mechanisms to reduce emissions

The cost of cutting emissions differs between emission sources, abatement measures and over time. Setting a price on emissions helps to find the most cost-efficient solution. It encourages firms, households and the government to realise all opportunities to reduce emissions which cost less than the marginal emission price and allow activities where abatement costs are higher than the marginal emission price (de Serres, Murtin and Nicoletti, 2010[29]) (D'Arcangelo et al., 2022[30]; Pisany-Ferry, 2021[31]). Due to high uncertainty and information asymmetry about the heterogeneity of abatement costs across the economy, more directive approaches, such as regulations and standards, raise total abatement costs compared to emission pricing by missing opportunities for low-cost emission reductions. Nonetheless, these policy tools are still needed in specific cases to overcome market failures and coordination problems (see below). Emission pricing is also technology-neutral and a transparent policy that simplifies the decisions for the government and reduces the scope for lobbying influences, as the only information required is the measurement of emissions. Pricing mechanisms have been shown to substantially alter behaviour for GHG emissions (Andersson, 2019[32]) (Dechezleprêtre, Nachtigall and Venmans, 2018[33]). For example, the United Kingdom has substantially reduced emissions by adopting a carbon price floor on top of the EU-ETS price in 2013. This led the coal share in electricity production to fall from 40% to 5% by 2018, and to a shift to less-emission intensive gas power plants (Blanchard and Tirole, 2021[34]).

Emission pricing is well recognised in Germany as an efficient way to achieve the green transition (Ministry For Economic Affairs and Climate Action, 2022[35]). Germany participates in the EU ETS, a cap-and-trade system that sets a carbon price for obligated participants, namely power generators, large emission-intensive industrial facilities, and airlines for flights within the European Union. The cap declines over time, ensuring that the desired emission mitigation target in the EU ETS sectors is achieved cumulatively. Due to the high share of industry in GDP and the high coal share in electricity generation, around half of German emissions are covered by the scheme, compared with only 40% on average in the European Union. The permit price has increased substantially since 2019 and stood at around EUR 85 per tonne in 2022. Moreover, in 2021 Germany implemented a national trading system for emissions in the non-ETS sectors (i.e., buildings and transport), with a fixed price of EUR 30 per tonne in 2023 that will rise to EUR 45 in

2025. From 2026, allowances will be auctioned within a price corridor of EUR 55 to EUR 65. The price corridor beyond 2026 will be decided in 2024 after an evaluation of the first phase of the system and depending on policy developments at the EU level (Box 2.4). In 2022, revenues from carbon pricing stood at 0.3% of GDP (EUR 13.2 billion).

Meeting Germany's ambitious objective of reducing emissions by 65% in 2030 (compared to 1990 levels) will require higher carbon prices. Simulations conducted for this Survey show that raising carbon prices to reach the EU Fit for 55 targets for ETS and non-ETS sectors would reduce emissions in Germany by 67% in 2030, indicating that Germany's national targets and the Fit for 55 targets are aligned (Box 2.4, Box 2.5, Table 2.2). This requires a doubling of the ETS carbon price compared to a benchmark scenario, which is based on 2021 policies. In the benchmark scenario, the European Union and Germany reduce their emissions by 44% and 53% in 2030, respectively.

The carbon price in sectors covered by the Effort-Sharing-Regulation (ESR), which are not covered by the ETS, would need to increase to about USD 323 (EUR 273) in 2030 in Germany, which is much higher than in other EU countries. This is because Germany has pledged higher emission reductions in the ESR sectors than other EU countries and faces higher marginal abatement costs. Abatement costs are higher because GHG intensity in the ESR sectors (especially in transport) is lower, implying fewer emission savings potential compared to other EU countries (Box 2.4) (Bickmann et al., forthcoming[1]).

Box 2.4. The EU "Fit for 55" package

Fit for 55 is a set of policy proposals to reduce net greenhouse gas emissions by 55% in 2030 (compared to 1990 levels). The package aims to reduce emissions in the EU ETS by 62% compared to 2005 levels (a decrease of 19 percentage points compared to the current target), to include the maritime shipping sectors in the ETS, increase the share of renewables in electricity supply to 40% and create a new, separate emissions trading system for the buildings and road transport sector from 2027 (although in case the energy prices are "exceptionally high", it will be delayed to 2028).

The Commission also proposes to gradually remove free emission allowances from the EU ETS, which are currently allocated to non-power producers, and simultaneously introduce a carbon border adjustment mechanism (CBAM) to address the risk of carbon leakage. Currently, these free allowances are allocated based on an efficiency benchmark equal to the average emissions of the best-performing 10% of the installations producing the same product. Installations that meet the benchmarks and are, therefore, among the most efficient in the European Union receive the allowances they need to cover their emissions for free. According to the proposal, installations that will benefit from free allocations will need to comply with several additional requirements, including in the form of energy audits. The CBAM will initially apply to imports of certain goods and selected inputs whose production is carbon intensive and at most significant risk of carbon leakage: cement, iron and steel, aluminium, fertilisers, electricity and hydrogen. In these sectors, the free allowances will be phased out from 2026 until 2034.

Country-specific emission reduction targets in sectors that are not covered by the ETS are established for the year 2030 in the context of the EU's Effort Sharing Regulation (ESR). The target for Germany is a 50% reduction in 2030 compared to 2005 levels, which is higher than for other countries. For example, France is supposed to reduce ESR emissions by 47.5%, Italy by 43.7% and Poland by 17.7% in 2030. The carbon price in the new EU trading system for the buildings and road transport sectors is expected to be restricted in the first years. If the price of allowances exceeds EUR 45, additional allowances will be released, increasing the supply on the market. In addition, a new Social Climate Fund will help vulnerable households, micro-enterprises, and transport users cope with higher carbon prices. The fund would be part of the EU budget and be financed by assigned revenues of up to EUR 65 billion.

Source: European Commission.

Table 2.2. Economic effects of implementing the EU Fit for 55 targets for 2030

Main EU Fit for 55 scenario

	Germany	Rest of European Union
Total CO_2 emissions reduction vs 1990	-67%	-46%
CO_2 emissions reduction in the ETS sectors, compared to benchmark	-36%	-17%
CO_2 emissions reduction in the ESR sectors, compared to benchmark	-27%	-10%
Change in welfare (real consumption), compared to benchmark	-0.86%	-0.29%
Change in GDP, compared to benchmark	-1.22%	-0.34%
Renewables share in electricity generation (change in p.p compared to benchmark)	77% (+15)	60% (+3)
Coal share in electricity generation (change in p.p compared to benchmark)	5% (-15)	5% (-2)
Change in total electricity supply, compared to benchmark	-7.8%	-2.1%
Change in electricity generation, compared to benchmark	-9.9%	-2.4%
Change in electricity imports, compared to benchmark	+22.9%	+1.9%
Change in electricity price, compared to benchmark	+4.7%	+2.8%

Note: Simulations are conducted using a Computable General Equilibrium Model (CGE) (Box 2.5). The table shows results from a scenario implementing the EU Fit for 55 targets, which means that the EU as a whole reduces emissions by 55% in 2030. Results are shown relative to a benchmark scenario, which assumes based on 2021 policies that the EU and Germany reduce their emissions by 44% and 53% in 2030, respectively. Non-EU countries are assumed to reduce emissions as in the benchmark scenario. The results of the CGE simulations should not be interpreted as projections but can be used to analyse reallocation and distributional effects across regions, sectors and households. The welfare measure does not account for the beneficial environmental aspects of emission reduction.
Source: (Bickmann et al., forthcoming[1]).

Box 2.5. The economic and distributional consequences of reaching the EU Fit for 55 target – a Computable General Equilibrium analysis

This Survey applies a multi-sector, multi-region Computable General Equilibrium (CGE) model to analyse the economic and distributional effects of different policy scenarios of carbon emission abatement for Germany (Bickmann et al., forthcoming[1]). The model uses a standard top-down structure for representing production, consumption, and trade and includes a discrete representation of alternative power generation technologies. CO_2 emissions enter the model in two ways: First, they arise from the energy sector, where they are linked in fixed proportions to the use of fossil fuels, with CO_2 coefficients differentiated by the specific carbon content of different fuels. Second, the model also accounts for process-based CO_2 emissions. Constraints on the amount of emissions in each region are implemented through a cap-and-trade system and endogenous carbon price adjustments. Emission reductions take place by fuel switching, energy savings or output reductions.

The model relies on data from the global macroeconomic balances published by the EU Joint Research Centre (JRC) (Vandyck et al., 2021[36]). They include detailed macroeconomic accounts and information on physical energy flows and carbon emissions for 49 regions and 31 sectors in five-year intervals until 2070, which rely on nationally determined contributions (NDCs) to emission reductions. These data are used to establish a benchmark scenario for the year 2030, which is based on 2021 policies and against which all other model scenarios are compared. For the European Union, the benchmark presumes a GHG emission reduction of 44% below 1990 levels by 2030. Germany reduces its GHG emissions by 53% in the benchmark. In addition, the JRC data set assumes that the United States and other OECD countries reduce their emissions by 27% and 18% compared to 2005, whereas China increases emissions by 108% compared to 2005.

All simulations depart from the benchmark scenario and implement the EU Fit for 55 targets: A reduction of ETS emissions by 61% compared to 2005 levels and national emission reductions in ESR sectors, which in the case of Germany correspond to a 50% reduction compared to 2005. Overall, these targets lead to an EU-wide emission reduction of 55% in 2030 (compared to 1990 levels). Importantly, the model does not quantify the total effects of emission abatement from today’s perspective, but rather the impact of implementing these stricter climate targets for 2030 compared to the benchmark scenario. Relative to the benchmark scenario, the EU Fit for 55 targets correspond to an EU-wide ETS emission reduction of 22%. In the ESR sectors, Germany needs to reduce emissions by 27% compared to the benchmark, whereas the remaining European countries need to reduce emissions by 10%.

The **main EU Fit for 55 scenario** keeps the ETS and ESR cap-and-trade systems in the EU separated and allows for trade in emission rights across countries in the ETS, but not the ESR. Revenues from the ETS carbon price in non-power producing sectors are fully recycled back as output-based subsidies/rebates. These subsidies/rebates are a simplified representation of the free allowance allocation in the EU ETS, as they are exogenous from the perspective of the firm and keep marginal emission reduction incentives in place. The remaining revenues from power producers and the carbon tax on ESR (non-ETS) sectors are collected by the government, which recycles them to households as (net) transfers after ensuring that government spending remains constant in real terms. Non-EU regions do not reduce emissions compared to the benchmark. The remaining scenario analysis focuses on different policy options by changing assumptions compared to the main EU Fit for 55 scenario:

1.) Reforming the EU cap and trade system by including the ESR sectors in the ETS. One scenario with full integration and one scenario with only partial integration, i.e., all economic sectors are included in the ETS, but households remain outside of the scheme.

2.) Addressing carbon leakage and protecting the competitiveness of domestic industries. One scenario expands the output-based subsidies (at the expense of recycled revenues to households) to include automotive and machinery and equipment sectors, which are not part of the ETS and therefore do not receive full rebates from emission pricing in the main EU Fit for 55 scenario. In a second scenario, carbon tariffs equal to the carbon price difference between the import partner and the European Union are applied to the direct carbon content of imports. At the same time, output-based subsidies are set to zero.

3.) Multilateral abatement efforts. This scenario assumes that the United States and China reduce emissions according to their new NDCs. The United States pledged to cut emissions by 52% relative to 2005, whereas China committed to limit the increase in emission to 69% compared to 2005. Other OECD countries reduce emissions by the same proportion as the United States.

4.) Additional regulations for the German electricity market. One scenario models a complete coal exit in Germany by 2030. The second scenario introduces a subsidy scheme for renewable energy, which transfers all CO_2 pricing revenues that are not rebated to non-power producers in the ETS sectors to the renewable energy sector.

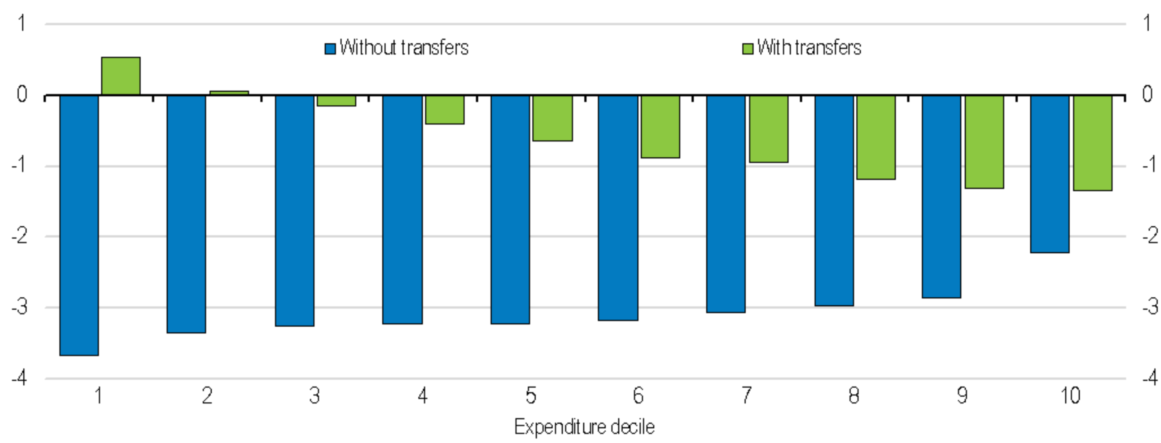
To analyse the distributional effects of mitigation across different types of households, the model links the CGE results to micro-simulations using detailed German survey data on household incomes and consumption expenditures and econometric estimates of behavioural parameters of the demand system. Using sectoral gross value-added shares at Laender level, the CGE simulation results are further disaggregated regionally.

The Computable General Equilibrium model shows that reaching the EU Fit for 55 targets by increasing carbon prices would lead to a loss in GDP and welfare (measured as real purchasing power) by 2030 as production costs rise (Table 2.2). Still, these transition costs will help to avoid the much higher economic costs of missing global climate change mitigation targets, which are not considered in the simulations. GDP and welfare are expected to decline more in Germany than in other EU countries, due to higher carbon prices in ESR sectors, but also to higher emission reductions in the ETS sectors in Germany. With rising ETS prices, coal-based electricity generation becomes less profitable due to its high emission intensity. As Germany uses much more coal for electricity generation than the EU average, it will reduce emissions in the ETS sectors more strongly than other EU countries. The sharp drop in coal-based electricity generation leads to a substantial increase in renewables supply, and its share in electricity production almost reaches the 2030 renewables target of 80% of electricity supply without any further regulation (Table 2.2). However, increased renewables supply and rising electricity imports cannot fully compensate for the exit of coal power plants. Therefore, total electricity supply falls and prices rise, which particularly hurts energy-intensive industries (see below).

Recycling revenues generated through carbon pricing strongly influences the distributional effects of more ambitious emission abatement (Figure 2.11). If revenues from carbon pricing are not recycled to households, poorer households lose a considerable share of their real income compared to the benchmark scenario because wages decline, and labour is their main income source. In addition, they spend a higher share of their income on electricity, transport and heating, which become more expensive relative to other goods due to carbon pricing. In the poorest household decile, expenditures on energy and transport amount to 18.9% of total expenditures, while the highest decile only spends 10.1%. However, if revenues from rising carbon prices are recycled as an equal lump sum to each household, real household income in the lower two deciles rises compared to the benchmark scenario. For other households, labour and capital income losses as well as increases in energy and transport prices outweigh the gains from transfers. Overall, lump-sum revenue recycling results in a progressive effect of emission abatement (Bickmann et al., forthcoming[1]).

Figure 2.11. If additional revenues are recycled as a lump sum, low-income households will benefit from the increase in carbon prices in the main EU Fit for 55 scenario

Real household income changes by expenditure decile, compared to the benchmark scenario (in %)



Note: Carbon price-related revenues are recycled, transferring the same amount to each household.
Source: (Bickmann et al., forthcoming[1]).

StatLink https://stat.link/lcpjms

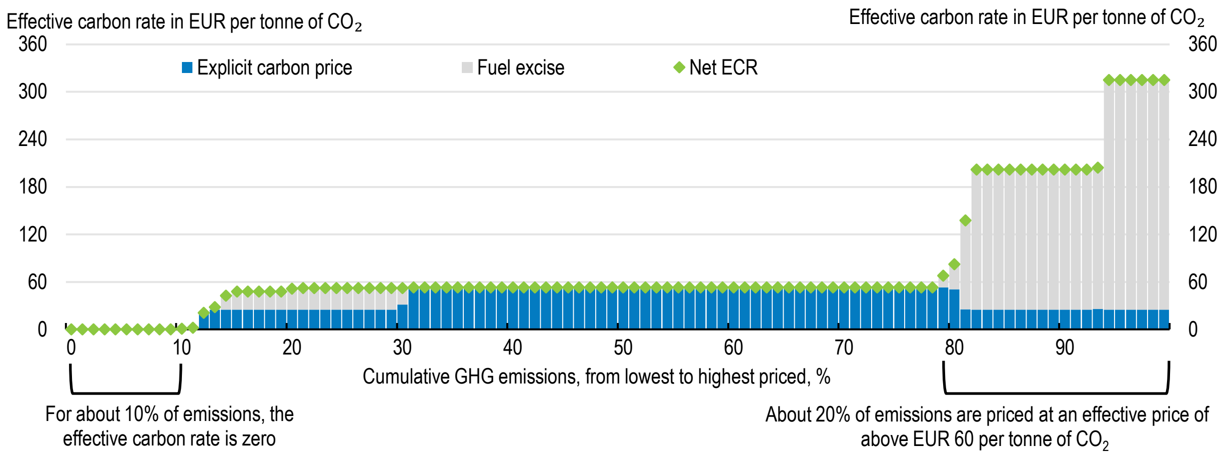
The carbon price level needed to reach emission targets and its impact on GDP and welfare is highly sensitive to the institutional set-up. Harmonising carbon prices across sectors, enabling countries to trade emission allowances in the ESR sectors, increasing the predictability of future carbon prices, and phasing out fossil fuel subsidies and distorting tax exemptions would allow reaching the targets with lower prices and economic costs. Likewise, facilitating the expansion of renewable energy supply and better integrating the European electricity grid would mitigate electricity price rises and volatility and support energy-intensive industries (see below). The following sections discuss policies to improve the carbon pricing strategy and the institutional set-up.

Carbon prices vary largely across sectors

In 2021, Germany priced 90% of its GHG emissions, explicitly or implicitly, with an average effective marginal carbon rate of EUR 81 (in 2021 prices), up by 46% since 2018. However, heterogeneity across sectors is large. Most unpriced emissions were from shipping and aviation fuels and from other GHG emissions rather than CO_2 (like F-gases and methane). A small part of industrial CO_2 emissions, not covered by the EU ETS, were unpriced as well. Emissions from road transport, accounting for about 20% of total emissions, were priced at a relatively high marginal effective price due to fuel excise taxes, which implicitly tax GHG emissions (Figure 2.12).

Figure 2.12. Emission pricing coverage is significant, but levels are uneven

Share of CO_2 emissions subject to different levels of Net Effective Carbon Rates (Net ECR), 2021



Note: The explicit carbon price comprises the EU-ETS and the national emissions trading scheme. The Net Effective Carbon Rate measures the effective marginal price of an additionally emitted tonne of CO_2, which differs from the average emission price. For example, free allocations of emission rights in the EU ETS to non-power producers do not affect marginal prices and incentives to reduce emissions. Still, they affect the average carbon price (not presented in the chart) and may affect investment decisions. The Net Effective Carbon Rate measure does not include all subsidies or tax exemptions for fuel and electricity use, which considerably weaken carbon price incentives in Germany (Burger and Bretschneider, 2021[37]).

Source: OECD (2022), Pricing Greenhouse Gas Emissions: Turning Climate Targets into Climate Action, OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris, https://doi.org/10.1787/e9778969-en.

StatLink https://stat.link/80efm5

Carbon prices across sectors are also further impacted by many fossil fuel and other harmful environmental subsidies and tax expenditures amounting up to EUR 65 billion (Burger and Bretschneider, 2021[37]). These subsidies and tax expenditures weaken and distort price signals, hamper the market breakthrough of environmentally-friendly products, and jeopardise climate goals (Table 2.3). Furthermore, energy-intensive industrial companies and airlines receive free allowances under the current EU ETS and other support, which hinders necessary resource reallocation and makes carbon prices less effective in changing consumption habits. For example, energy intensive companies are expected to receive EUR 27.5 billion until 2030 as partial refunds (up to 75%) to compensate them for higher electricity prices resulting from the EU ETS. Under current EU legislation, up to 43% of the emission cap can be distributed as free emission allowances to industrial installations.

Table 2.3. Main environmentally harmful subsidies and tax expenditures

Subsidy description	Estimated annual cost, 2018
Tax exemption for kerosene fuel in the aviation industry[1]	EUR 8.4 billion
Energy tax concession for diesel fuel	EUR 8.2 billion
Distance allowance – a tax deduction of traveling from home to work, regardless of means of transport[2]	EUR 6.0 billion
Lower VAT on meat and other animal products	EUR 5.2 billion
Lower concession electricity and gas charges for public spaces	EUR 3.6 billion
Favourable tax treatment for privately used company cars[2]	EUR 3.1 billion
Electricity and energy tax reductions for the manufacturing and agriculture sectors[3]	EUR 2.9 billion
Relief from electricity and energy taxes for certain energy-intensive processes and procedures	EUR 1.3 billion
Concessions for energy-intensive industry regarding electricity grid fees	EUR 610 million
Exemption of agricultural vehicles from the vehicle excise duty (agriculture diesel)	EUR 470 million
Tax concession for agricultural diesel fuel	EUR 470 million

Notes: (1) Including international flights taking off or landing in Germany. (2) This measure does not necessarily support fossil fuels (for example, electric cars can also benefit from the measure). However, most allowances end up supporting the usage of combustion-engine vehicles. (3) Including reimbursements of the peak equalisation charges for manufacturing companies.
Source: (Burger and Bretschneider, 2021[37])

Concerns about German firms' competitiveness and increased cost of living, especially for poor households, are the main reason for many of these subsidies and tax expenditures. For example, after introducing the national emissions trading system in 2021, the German government raised subsidies to emission-intensive trade-exposed industries under the provision that they undertake emission reduction measures. Although sometimes overstated, these concerns are valid. Simulations for this Survey show that higher carbon prices in the European Union would increase electricity prices and reduce output, employment and exports in Energy-Intensive Trade-Exposed (EITE) industries in Germany more than in other sectors (Box 2.5, Table 2.2, Table 2.4, Main EU Fit for 55 scenario). Nonetheless, not all sectors will lose competitiveness, even within the EITE industries. This is due to substantial market power in export markets, which allows to pass on part of the costs to consumers in other countries. Likewise, some industries are less carbon- and energy-intensive than others, which provides them with a comparative advantage and allows them to benefit from reduced factor demand in shrinking sectors and lower factor prices. In the CGE model, the expected output reduction is strongest for oil refineries, ferrous and non-ferrous metal industries as well as some ESR sectors such as consumer goods and transport services, while chemical, automobile and machinery and equipment increase output and exports (Table 2.4).

Table 2.4. Sectoral effects of reaching EU Fit for 55 targets under different policy designs for Germany

Change in production by sector, compared to benchmark scenario (in %)

Sector (share in employment)	**Main EU Fit for 55 scenario**	**ETS full integration**	**Extending output-based subsidies**	**Carbon tariffs**	**Multilateral abatement**	**Coal exit**	**Renewable subsidies**
EITE industries Total (6.6%)	**-1.7%**	**-1.7%**	**-1.8%**	**-2.9%**	**-0.1%**	**-1.9%**	**-0.6%**
Chemical products (3.5%)	0.4%	-0.8%	0.3%	0.6%	0.8%	0.2%	0.7%
Paper products (1.2%)	0.1%	-0.7%	0.0%	0.3%	0.4%	-0.2%	0.6%
Non-metallic minerals (0.9%)	-0.5%	-0.9%	-0.6%	0.4%	0.3%	-0.6%	-0.3%
Ferrous metals (0.7%)	-1.4%	-2.1%	-1.3%	-11.0%	0.7%	-1.6%	1.8%
Non-ferrous metals (0.4%)	-1.0%	-1.6%	-1.1%	-2.0%	1.2%	-1.3%	2.0%
Oil refinery (0.0%)	-18.8%	-8.9%	-18.8%	-18.5%	-16.9%	-18.7%	-15.0%
Other industries							
Machinery and equipment (8.1%)	0.6%	0.0%	0.8%	0.2%	0.1%	0.6%	-0.2%
Transport equipment goods (3.4%)	0.2%	-0.1%	0.5%	-0.3%	-0.6%	0.1%	-0.8%
Consumer good industries (3.2%)	-2.1%	-0.8%	-2.2%	-1.8%	-2.5%	-2.2%	-2.8%
Services							
Land transport (2.1%)	-9.4%	-2.0%	-9.4%	-9.3%	-7.8%	-9.3%	-10.2%
Air transport (0.3%)	1.4%	-0.2%	1.3%	-4.4%	13.1%	1.5%	1.0%
Water transport (0.1%)	-14.2%	0.5%	-14.2%	-13.9%	-11.4%	-14.1%	-16.2%
Market services (36.9%)	-0.1%	-0.2%	-0.1%	-0.1%	-0.4%	-0.1%	-1.2%
Non-market Services (27.9%)	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	-0.3%

Note: Please see Box 2.5 for a description of the methodology and simulation scenarios.
Source: (Bickmann et al., forthcoming[1]).

Existing subsidies and tax expenditures should be carefully evaluated and better targeted. Subsidies favouring EITE industries can help to address competitiveness concerns (see below) (Böhringer, Lange and Rutherford, 2014[38]). However, not all EITE industries will suffer from higher carbon prices, and many of the existing subsidies are not limited to companies exposed to international competition and should be abolished. Moreover, by hampering a stronger decline of output and emissions in EITE industries, these subsidies and ETS payment rebates lead to higher demand and prices for emission certificates in the ETS, causing higher emission reduction requirements and costs for other firms and sectors (Böhringer, Lange and Rutherford, 2014[38]).

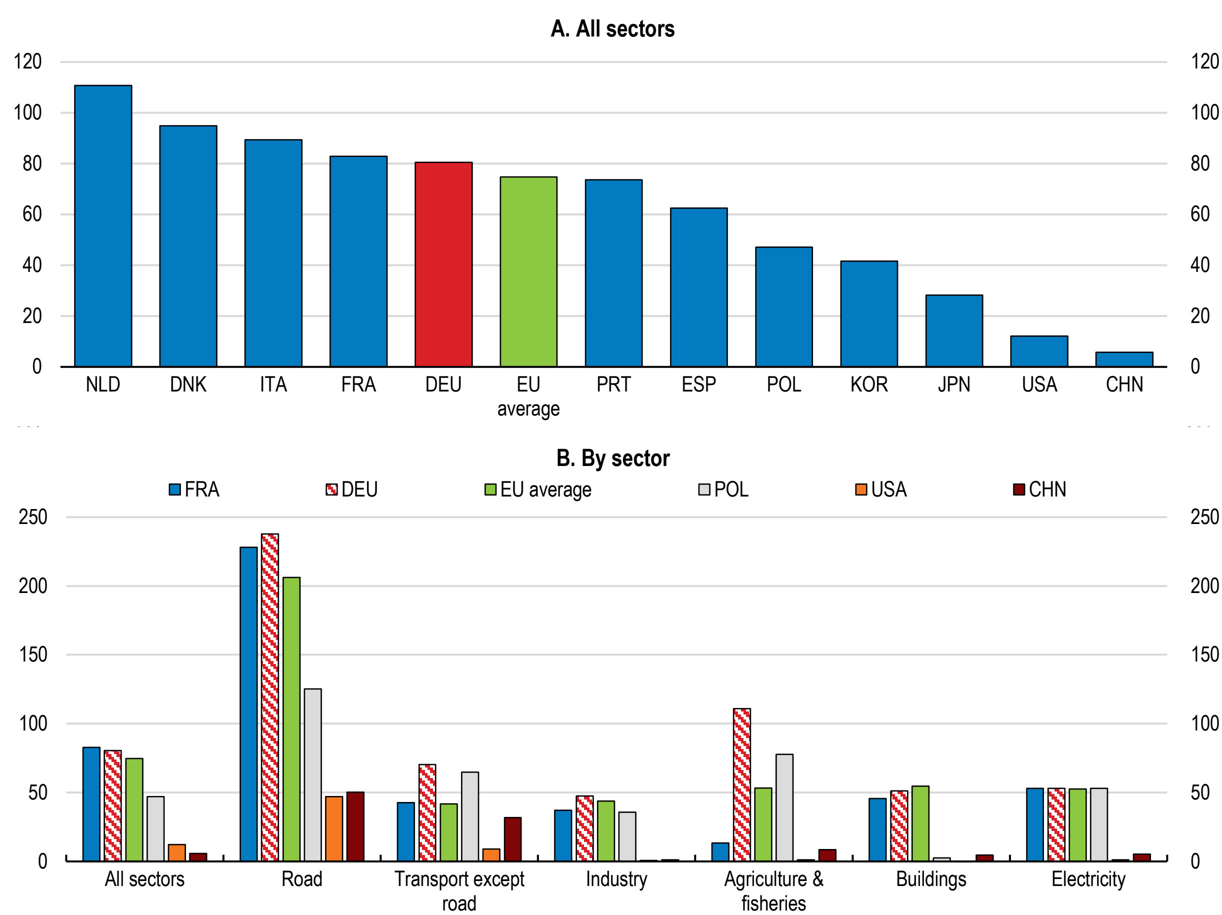
Remaining firm support should be well targeted and incentivise emission reductions, for example by supporting the development of green technologies (see below). Providing high polluters with free allowances as part of a grandfathering scheme or using abatement subsidies to incentivise emission reductions below a pre-defined baseline are other options to reduce the effective tax burden of firms, while maintaining high marginal cost of CO_2 emissions (D'Arcangelo et al., 2022[30]). Nevertheless, it is crucial that all subsidies include sunset clauses, announced upfront, to strengthen abatement incentives and reduce future fiscal costs. Subsidies indirectly supporting households, such as the tax exemptions for diesel and kerosene fuel and reduced VAT rates for meat and other animal products, should be phased out and partly replaced by direct transfers to vulnerable households. The phase-out of subsidies could also support the financing of public investments and rising pension and health care costs (see Chapter 1). As energy prices are high, the phase-out could be linked to energy price levels: accelerating the phase-out in case the energy prices decline, and vice-versa.

Harmonising carbon prices across sectors would reduce the economic costs of the green transition

Carbon prices do not only differ strongly across sectors, but also across countries (Figure 2.13). In the European Union, many countries do not explicitly price emissions in non-ETS sectors and where emission pricing exists, emission allowances cannot be traded across countries or with the EU ETS, preventing the equalization of abatement cost across countries and sectors. In particular, the largest emitting sectors – electricity production and industry – faced relatively moderate effective carbon rates in 2021. Harmonising carbon prices across sectors and countries would help to reduce emissions where it is the least costly but imply higher carbon prices for emission-intensive industries (D'Arcangelo et al., 2022[30]).

Figure 2.13. Carbon prices differ substantially between sectors and countries

Net Effective Carbon Rates, EUR per tonne of CO_2, 2021



Note: The Net Effective Carbon Rate measures the effective marginal price of an additionally emitted tonne of CO_2.
Source: OECD (2022), Pricing Greenhouse Gas Emissions.

StatLink https://stat.link/63m7fy

According to simulations conducted for this Survey, Germany would benefit significantly from the expansion of the EU-ETS to all sectors in the EU economy (Box 2.5, Table 2.5). Including the ESR sectors in the ETS would raise welfare as marginal abatement costs in ESR sectors are much higher compared to other EU countries and ETS sectors, and because Germany has pledged to reduce emissions in ESR sectors by much more. As a result of merging the two systems, German firms in ESR sectors can buy emission certificates from other EU countries and ETS sectors, allowing them to expand production and employment. Particularly, some emission-intensive ESR sectors such as land and water transport as well as consumer goods industries would raise output compared to the main EU Fit for 55 scenario (Table 2.4). However, the increased demand for ETS emission certificates would raise the ETS price and reduce-emission intensive electricity production, which in turn would raise electricity prices and lower output and emissions in many EITE industries in Germany (Table 2.5). Particularly, ferrous and non-ferrous metal and chemical industries but also automotive and machinery and equipment industries would shrink. In contrast, oil refinery would strongly expand due to higher fuel demand from ESR sectors. Overall, total emissions in Germany would decrease by only 64% in 2030, while emissions reductions in other EU countries would be larger than in the main EU Fit for 55 scenario.

Table 2.5. Reaching EU Fit for 55 targets under different policy designs – aggregated effects for Germany

	Main EU Fit for 55 scenario	ETS full integration	Extending output-based subsidies	Carbon tariffs	Multilateral abatement	Coal exit	Renewable subsidies
Total CO_2 emissions reduction vs 1990	-67%	-64%	-67%	-66%	-67%	-69%	-71%
CO_2 emissions reduction in the ETS sectors vs 2005	-64%	-66%	-64%	-63%	-67%	-68%	-74%
CO_2 emissions reduction in the ESR sectors vs 2005	-50%	-38%	-50%	-50%	-50%	-50%	-50%
The ETS CO_2 price, times higher than in the benchmark	1.84	1.95	1.84	1.75	2.00	1.66	1.35
The ESR CO_2 price, in USD (which equals 0 in the benchmark)	323	78	323	322	337	321	334
Change in welfare (real consumption), compared to Benchmark	-0.86%	-0.52%	-0.87%	-0.77%	-0.87%	-0.87%	-1.38%
Change in GDP, compared to Benchmark	-1.22%	-0.52%	-1.22%	-1.19%	-1.25%	-1.23%	-1.40%
Renewables share in electricity generation	77.2%	79.1%	77.2%	74.4%	80.7%	81.6%	100%
Coal share in electricity generation	5.3%	3.7%	5.3%	8.5%	1.4%	0.0%	0.0%
Change in total electricity supply, compared to benchmark	-7.8%	-6.0%	-7.8%	-7.4%	-8.7%	-8.6%	-3.0%
Change in electricity generation, compared to benchmark	-9.9%	-9.0%	-9.9%	-8.9%	-9.6%	-11.7%	10.4%
Change in electricity imports, compared to benchmark	+22.9%	+38.2%	+23.0%	+15.0%	+5.1%	+37.8%	-64.5%
Change in electricity price (consumer prices), compared to benchmark	+4.7%	+7.6%	+4.7%	+3.3%	+6.9%	+6.1%	-13.8%

Note: See Box 2.5 for a description of the methodology and simulation scenarios.
Source: (Bickmann et al., forthcoming[1]).

To mitigate the adverse effects of an expanded ETS on EITE and other industries, it is crucial to facilitate the expansion of renewable energy supply and better integrate the electricity grid with neighbouring countries (see below). This would mitigate electricity price increases in Germany when coal power plants exit the market due to higher ETS prices (Bickmann et al., forthcoming[1]). Moreover, as high energy prices due to the war in Ukraine currently weigh on energy-intensive industries, a gradual phase in of carbon price harmonisation would be prudent. Introducing a separate cap-and-trade system for ESR sectors as currently discussed for the European Union, at least for residential heating and transportation fuels, would prevent ETS and electricity prices from rising too strongly, while allowing for harmonisation of carbon prices in ESR sectors due to emission rights trading across countries. If the carbon price in this scheme exceeds the ETS price by more than a certain threshold, a limited number of allowances could be traded between the two systems to mitigate price differences (Edenhofer et al., 2021[39]). The number of tradable allowances could increase gradually over time until the two systems are unified. Another option would be to expand the ETS to some more specific sectors. A partly integrated ETS system excluding households is not as efficient as a fully integrated ETS system, but still welfare improving (Bickmann et al., forthcoming[1]).

As mentioned above, Germany implemented a national trading system for emissions in the non-ETS sectors in 2021, with a growing fixed price until 2025. From 2026, allowances are to be auctioned. Until the European trading system for road transport and heating starts operating (Box 2.4), Germany should set the emissions cap in its national trading system according to its national targets and issue a quantity of tradable emission allowances consistent with this cap. In addition, Germany should expand its use of the existing EU mechanism that allows trading ESR emission reduction obligations with other EU countries to avoid the need to reduce emissions drastically in a very short period.

International agreements could help to address carbon leakage problems

A fundamental challenge in climate policy is that climate protection constitutes a global public good and each country has an incentive to free ride on the emissions abatement of other countries while contributing little itself. International agreements are trying to minimise this problem and following the 2015 Paris Agreement, many countries have announced ambitious national targets to reduce GHG emissions. Still, there are considerably differences in environmental stringency and effective carbon prices between countries, with increasing divergence in recent years (Figure 2.13) (OECD, 2021[40]). Countries with the highest effective (implicit and explicit) carbon rates in 2018, including Germany, saw carbon rates rise further, while there was little change in countries with low initial rates (OECD, 2022[41]). The war in Ukraine and the soaring energy prices in Europe are only amplifying those differences. Further mitigation actions risk the migration of economic activities abroad to enjoy lower costs in countries with lower environmental standards. This so-called carbon leakage increases global emissions and could hurt the competitiveness of the German economy in the domestic and export markets (OECD, 2021[42]; OECD, 2020[43]). Moreover, it is an obstacle to public support for the implementation of climate mitigation policies, especially in Germany, where economic growth in recent decades has been driven by a strong export-oriented manufacturing sector (D'Arcangelo et al., 2022[30]).

Simulations for this Survey show that implementing EU Fit for 55 targets without more ambitious mitigation action in non-EU countries would lead to reduced output and exports in many German EITE industries (see above). However, the simulations also show that output-based subsidies, which redistribute carbon tax revenues back to producers as lump sums at the industry level and keep emission reduction incentives for firms in place (Box 2.5), can mitigate these negative competitiveness effects from unilateral climate mitigation policies. In contrast, introducing a tariff that equilibrates carbon prices between domestic and imported products, while phasing out output-based subsidies, would hurt industries with a high share of imported and emission-intensive intermediate goods and – if not complemented by export rebates – would not address competitiveness concerns on export markets (Table 2.4). This would particularly hurt the ferrous and non-ferrous metal, automotive and the machinery and equipment industries, which are highly integrated in global value chains. A carbon tariff would only support a few industries by protecting them from emission-intensive imports, such as chemicals, paper products, non-metallic industries as well as consumer goods (Table 2.4). On the macro level, the simulations show that abolishing the output-based subsidies in favour of a carbon tariff would be slightly welfare-improving because it leads to a more efficient labour and capital allocation and generates additional income that can be distributed to households, indicating that the design of a carbon price for imports should be carefully evaluated.

International agreements that enforce faster global emission reduction would limit the risk of carbon leakage and at the same time lower the risk of climate change (Nordhaus, 2015[44]) (G7, 2022[45]). Simulations conducted for this survey show that multilateral abatement, where the European Union reaches EU Fit for 55 targets and non-EU countries reach their NDCs in 2030, would significantly improve production and exports for EITE industries in Germany compared to the main EU Fit for 55 scenario of unilateral EU abatement (Table 2.4). Due to higher carbon prices in non-EU countries, the relative competitiveness of German EITE industries would increase in both export and domestic markets. However, stronger emission reductions in non-EU countries would lower demand for German products and increase prices of imported intermediate inputs. This would hurt other export-oriented manufacturing sectors in Germany, which are less emission intensive and highly integrated in global value chains, such as automotive and machinery and equipment, but also the services sectors (Table 2.4). The total effect on Germany's GDP and welfare compared to unilateral EU abatement would be minimal (excluding the long run gains from reducing global emissions).

Well-designed standards and regulations should be part of the policy mix

Even if carbon pricing is unified across sectors and carbon leakage issues are addressed, there are arguments for complementing carbon pricing with other mitigation policy tools. Market failures such as imperfect information and collective decision problems are hard to solve just by setting prices. Likewise, carbon pricing may be less effective for long-run investments of households, either because of liquidity constraints or because of a present bias. For example, some might not retrofit their homes even when it makes economic sense because savings will be realised far in the future (see the section on the building sector). High uncertainty, a lack of complete future markets, and technological path dependence reduce the effectiveness of carbon pricing to support innovation, which could lower the costs of replacing fossil fuels (Acemoglu et al., 2012[46]). Moreover, government commitment problems to carbon pricing can be severe. Carbon prices will have to reach high levels to meet net-zero emissions, which will cause strong reallocation and distributional effects hurting certain groups more than others (see the section on distributional consequences of emission reductions below). If distributional consequences are unaddressed, public opposition and lobbyism of interest groups can derail abatement efforts. If firms anticipate these commitment problems and expect prices to remain low, they might underinvest in innovative green technologies (Edenhofer et al., 2021[39]). Therefore, a mix of policy instruments is needed to reduce the economic and social costs of the green transition (D'Arcangelo et al., 2022[30]).

Well-designed regulations and standards can help overcome coordination failure and realise network effects, for example, by setting technical standards for electric vehicle charging stations or green hydrogen (D'Arcangelo et al., 2022[30]). Likewise, they can help to solve problems such as split incentives between homeowners and tenants, causing households to underinvest in energy efficiency measures (see the section on the building sector). Nevertheless, in a country like Germany, where carbon pricing mechanisms are already in place, the use of regulations should be done sparingly. Ill-designed and uncoordinated regulations risk to increase the cost of decarbonisation by complicating performance monitoring and blurring price signals. Regulations are also more open to lobby influence of special interest groups than a transparent carbon pricing scheme.

Accelerating the coal phase-out signals a higher government commitment to reducing emissions and expanding renewables. Nonetheless, simulations conducted for this Survey show that introducing additional regulation to mandate the exit of coal power plants by 2030 would raise electricity prices and hurt EITE and other industries compared to the main EU Fit for 55 scenario, where Fit for 55 targets are reached without additional regulation (Box 2.5, Table 2.4). Increasing electricity prices would incentivise the expansion of renewables to reach a share of 82% of electricity production, but supply increases are insufficient to compensate for the coal exit and cover electricity demand, and electricity imports increase strongly (Table 2.5). Emissions in the German ETS sectors would fall strongly due to higher electricity prices allowing to reduce overall emissions by 69% in 2030. However, if total emission allowances in the EU ETS are not reduced, the shrinking demand for emission rights due to the coal exit and higher electricity prices would lower the ETS price and allow polluting firms in other EU countries to increase production and emissions, including to export electricity to Germany (the so-called waterbed effect). This problem is even more severe in the case of using carbon tax revenues to subsidise renewable energy supply (see below), where falling ETS prices strongly increase output in emission-intensive industries in other EU countries. The European Union introduced the Market stability reserve in 2019, among others, to reduce these waterbed effects. It makes automatic adjustments to the supply of certificates in the EU ETS based on the surplus in the market so that the price does not fall. The higher the surplus, the more certificates are withheld from auction. Germany could support initiatives to expand these kinds of mechanisms so that additional national regulations, such as the coal exit or other regulations concerning the expansion of renewables, would be more effective in reducing total emissions.

The amended version of the Federal Climate Change Act stipulates permissible annual emission volumes for each sector, which risk limiting the cost-effectiveness of mitigation policies. The breakdown of targets by sector increases liability and facilitates the design of specific mitigation strategies. However, it might also raise the cost of decarbonisation due to limited knowledge of sectoral abatement costs and their evolution over time. Having strict sectoral targets and regulations could create a substantial deadweight loss and lead to waterbed effects, especially in sectors covered by the EU ETS. In some contexts, overlapping regulations risk not only inducing substantial excess costs but even raising emissions (Knut et al., 2009[47]) (Böhringer and Rosendahl, 2010[48]). Moreover, relying on ad hoc criteria might increase compensation demands from polluting firms harmed by the regulation, for example in the case of the German coal phase out that included firm compensations of about EUR 5 billion (see the OECD 2020 Economic Survey of Germany). Regular ex-post performance reviews and evaluations help minimise these risks and should remain an integral part of policy planning and design. A welcome recent government decision to flexibilise the sectoral targets could strengthen the functioning of the existing emission pricing schemes by allowing sectors that have missed their sectoral emission reduction targets to compensate their underperformance with stronger emission reductions in other sectors, but a draft bill is still pending. A unified target for all sectors regulated under the National Trading System should be introduced when the system starts operating as a cap-and-trade system.

Boosting investment and innovation

Well-designed subsidies can effectively spur investment and innovation

Well-designed subsidies can spur innovation and accelerate the decarbonisation of infrastructure networks if they include transparent long-term incentives to abate emissions. Subsidising green research and development (R&D) as well as technologies which are still at prototype or demonstration stage will reduce future abatement costs and allow other mitigation policies to be less stringent. Subsidies to upgrade the infrastructure network are key to crowd in private investment, mainly in the transport and energy sectors. For example, the uptake of electric vehicles is constrained until charging infrastructure is available, while investments in infrastructure require more certainty about electric vehicle uptake (see the section on the transport sector). However, when subsidies are applied to scale up matured technologies, the risk of distorting competition and wasting public resources is higher. Moreover, many subsidies might be regressive and encounter public opposition, as they benefit more affluent households and are financed by the general budget (Blanchard and Tirole, 2021[34]). These risks need to be addressed appropriately in the policy design.

Higher carbon prices make solar and wind technologies attractive even without subsidies. Simulations conducted for this survey show that using carbon tax revenues to subsidise renewable energy expansion instead of financing lump-sum transfers to households helps to mitigate the negative effects of unilateral emission reductions on the EITE industries, but comes at a significant economic and social cost (Box 2.5, Table 2.5). The strong expansion of renewables increases electricity supply and lowers electricity prices compared to the main EU Fit for 55 scenario, strongly supporting EITE industries, which increase production, employment, and exports. The renewables share in electricity production comes close to 100% and emissions fall by more than 71% in 2030 (compared to 1990). However, as carbon pricing revenues recycled to households strongly decrease to finance renewable energy subsidies, households' purchasing power and consumption decline despite the fall in electricity prices. Sectors with lower energy-intensity suffer from decreased demand and reduce output and employment, in particular market services, consumer goods, automotive and other equipment goods (Table 2.4). As these sectors are also more labour intensive than EITE industries, poorer households are more adversely affected compared to the main EU Fit for 55 scenario with full recycling of carbon tax revenues to households. Overall GDP and welfare decrease compared to the main scenario, as using scarce resources to subsidise the scale up of commercialised technologies such as wind and solar power reduces economic efficiency. To mitigate the effects of emission abatement on electricity prices, it is more efficient to further accelerate planning and approval procedures for energy related infrastructure and improve the integration of the electricity grid with neighbouring countries (Bickmann et al., forthcoming[1]). A gradual shift in support from renewable energy subsidies towards more targeted subsidies for green R&D (see below) and deploying near-zero-emission industrial technologies, especially those in pre- or initial steps of commercialisation, could be another way to support the EITE sectors and reduce future abatement costs (IEA, 2022[49]).

Predictable prices would reduce risks for investing in low-carbon projects

There is substantial uncertainty about the carbon price needed to reach net-zero and the price path that will materialise in a cap-and-trade system because of many unknowns, e.g., the effect of prices on emissions, the cost and speed of developing green technologies and the future political commitment to address climate change. The war in Ukraine only amplified these uncertainties. The high uncertainty makes it harder for firms, households, and entrepreneurs to plan their investments. Unsurprisingly, countries with higher environmental policy uncertainty have suffered from lower investment in the green transition (Dechezleprêtre, Kruse and Berestycki, Forthcoming[50]). Predictable prices are especially crucial for investment in sectors characterised by a long lifetime of capital goods, such as building and industry (Harthan et al., 2022[51]).

In Germany, high uncertainty about future carbon prices exists in both the ETS and the ESR sectors. The volatility of allowance prices in the EU ETS has been high (Figure 2.14). In the housing and transport sectors, the design for setting prices from 2026 on is still unclear, and recent changes to the price path until 2026 have weakened policy credibility. One way to credibly signal future carbon prices would be to incorporate an automatically escalating price floor in the national trading scheme (Black et al., 2021[52]). In the Netherlands, for example, a national carbon levy on industrial emissions was implemented in 2021 on top of the EU-ETS price, establishing a transparent price trajectory reaching EUR 125 per tonne of CO_2 in 2030, including the ETS price (D'Arcangelo et al., 2022[30]). In addition, a price floor would limit the risk that more ambitious mitigation policies in one sector would reduce carbon prices and thus allow for higher emissions in other sectors without changing total emissions (see above). Issuing securities that would compensate emission allowance holders if the future price of carbon fell relative to the announced path could secure the commitment to the price path (Blanchard and Tirole, 2021[34]).

Figure 2.14. Carbon prices are volatile

European Union Emissions Trading System (EU ETS) allowances, spot price, Euro per ton

Source: International Carbon Action Partnership (ICAP) based on EEX data.

StatLink https://stat.link/govnb5

Expanding the use of Carbon Contract for Difference (CCfD) schemes would be an efficient way to shield investors against regulatory risks, as a direct link between the level of subsidies and the carbon price is established (Edenhofer et al., 2021[39]). Based on a strike price for emissions reductions resulting from an auction, a CCfD guarantees investors a fixed revenue per tonne of non-emitted CO2. The government reimburses the difference if carbon prices are below the strike price. Conversely, investors return the difference if carbon prices exceed the strike price to avoid windfall profits. The auction design encourages competition and minimises the fiscal cost of reaching policy objectives, as the most cost-effective project is selected (Richstein et al., 2021[53]). In the United Kingdom, CCfDs have successfully mobilised the private sector to invest in renewables.

While this approach could be attractive for all mitigation projects, it is especially well suited to address challenges associated with emissions reductions in hard-to-abate sectors such as the steel and cement industries (Richstein, 2017[54]). Technological developments to reduce emissions in these sectors are often beyond the typical scope of R&D funding yet are not mature enough to be financed purely via the markets, even with high carbon prices (the so-called valley of death). However, applying CCfD auctions to specific sectors or technologies faces a dilemma: Increasing the scope of technologies to participate in the auctions risks crowding out technologies at a current cost disadvantage but with high potential to become competitive in the future. In contrast, excluding certain technologies may waste resources by lowering competition.

The government recently established a scheme based on the concept of Carbon Contract for Differences ("climate protection agreements"), which awards companies in energy-intensive industries 15-year subsidy arrangements in return for reducing emissions in their production. The government should carefully evaluate the impact of this scheme on investment and consider expanding the use of Carbon Contract for Differences schemes while, in principle, keeping the auctions as technology-neutral as possible. To promote experimentation and technological diversity, some auctions should allow for a higher strike price for less matured technologies or sectors with slower improvements (Richstein et al., 2021[53]). However, clear and widely accepted definitions should be used to guide support so that by 2030 only production that is already near zero emission, or has demonstrated a pathway to soon become near zero emission, is eligible for government finance (IEA, 2022[49]).

Crowding- in private investment to finance the green transition

Long-run public infrastructure planning that reduces regulatory risks as well as higher public investment in the transport and electricity networks can crowd-in private capital needed for the transition. For example, upgrading the electricity network is crucial to manage the increasing share of electricity produced by intermittent energy sources and the increasing load to the grid as more activities are electrified. Emerging technologies, such as hydrogen and energy storage, may also require large investments in production, storage, and pipeline infrastructures (D'Arcangelo et al., 2022[30]). Streamlining the planning and approval procedures and providing agile and pro-active public services is highly needed for accelerating these investments (Chapter 1).

To encourage firms to prioritise investment in green (and ICT) infrastructure and accelerate the green transition, the government plans to temporarily increase the generosity of tax depreciation allowances ("super depreciation") for firms investing in climate protection for a two-year period. Accelerated depreciation would increase the expected return on investment, lower liquidity constraints and shift some proportion of the investment risk to the government. It could raise green investment spending by up to 10% in the first years after implementation (Funke and Terasa, 2022[55]) (House and Shapiro, 2008[56]). However, targeting the depreciation allowance only to green infrastructure introduces issues related to the definition of green infrastructure, increasing administrative burden, and complicating the tax system. Expanding existing targeted innovation support tools might be a better use of public resources (see below).

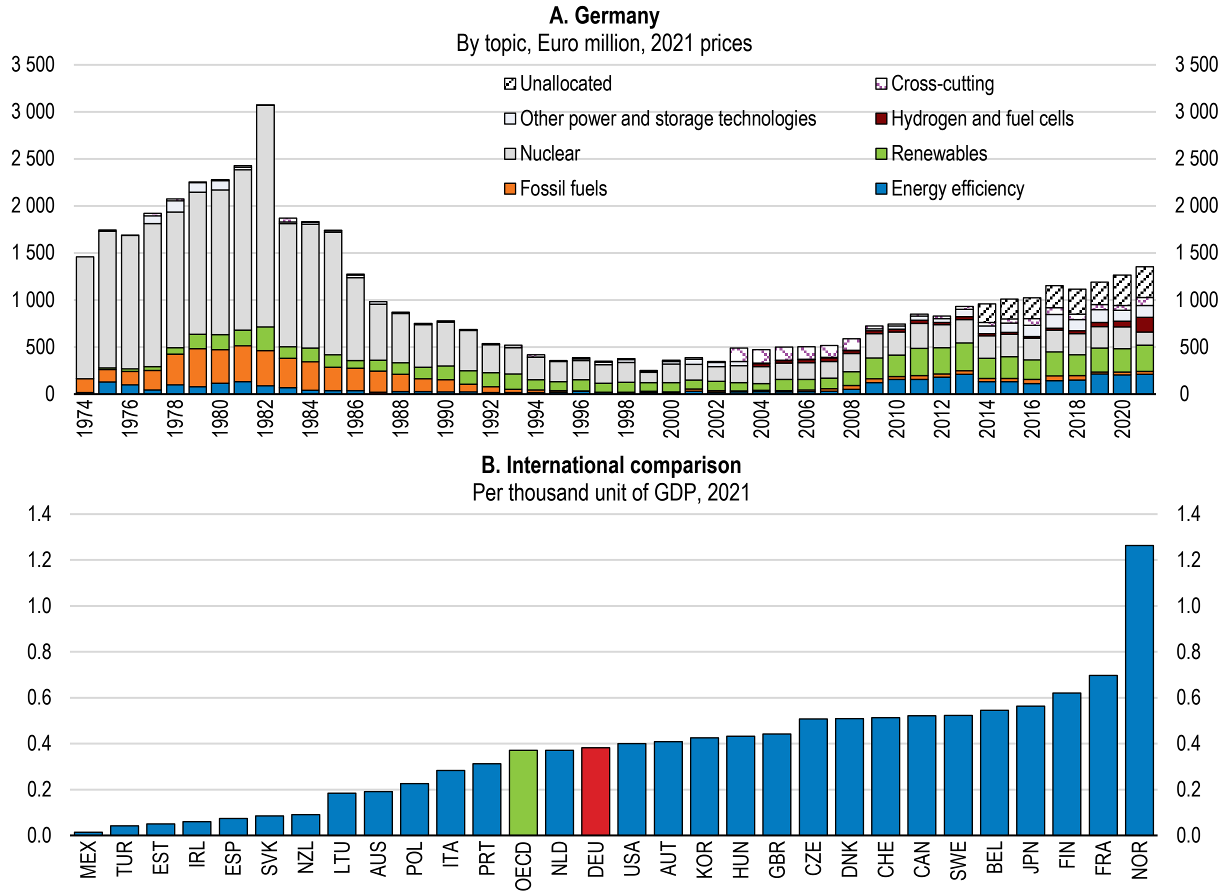
Innovation policy should support the development of new key technologies

Accelerating the deployment of existing technologies is key for reaching Germany's short-term targets, but not enough for reaching net-zero in 2045. Almost half of the reductions until 2050 will have to come from technologies that are currently at the demonstration or prototype phase (IEA, 2021[57]). Scaling up these technologies requires massive production cost reduction. For example, even with a high carbon price, green hydrogen is not yet competitive with fossil-based alternatives (Cammeraat, Dechezleprêtre and Lalanne, 2022[58]). Public support to green R&D can improve the overall cost-effectiveness of the policy mix by reducing future costs of low carbon technologies. Without government support, the level of research is likely to be inefficiently low because of positive knowledge externalities.

Public spending on R&D in the energy sector has been rising in real terms since the early 2000s, but it is still much below the 1970s levels (Figure 2.15, panel A). In 2021, it accounted for around 0.04% of GDP, which is lower than in many other European countries (Panel B). The government target to increase total R&D investment as a share of GDP to 3.5% by 2025 is an opportunity to raise support for breakthrough green technologies. As spending on green R&D is a global public good, this should be complemented by improved cooperation with other countries. Initiatives to set mutual clean energy R&D investment goals have not been successful so far (Cunliff, 2019[59]). A European green technology funding institution equivalent to the American ARPA-E, would support high-risk research in the private and public sectors (Blanchard and Tirole, 2021[34]). European Alliances for batteries (since 2017) and for green hydrogen (since 2020) are positive examples of public-private collaboration. A Global or European institution that uses funds to incentivise countries to expand their green R&D spending could be another option to foster innovation (Stern, 2022[60]).

Figure 2.15. Public spending on R&D in the energy sector is limited

Public energy research, development, and demonstration (RD&D) budgets



Source: IEA, Energy RD&D Budget/Expenditure Statistics.

StatLink https://stat.link/17lpgm

Germany has room to improve its innovation system. Its strengths are heavily intertwined with the needs of its existing industry, while the green and digital transitions require technological disruptions and significant breakthroughs. Innovation suffers from weak business-creation dynamics, lengthy and costly administrative procedures, weak access to finance for start-ups, and difficulties in marketing new ideas and technological solutions developed in public research institutions (see the 2020 Economic Survey of Germany). Moreover, strict and complex data privacy regulations, slow progress in improving digital infrastructure and a finance industry dominated by banks, which require traditional collateral for lending, particularly complicate digital innovations (see Chapter 1). Expanding the use of regulatory sandboxes and creating a public-private laboratory would support experimentation, implementation and monitoring of innovation policy tools. In addition, the government should promote open platforms and networks for data-based innovation and enhance university engagement with industry, including by better encouraging the development of funds for academic spin-offs (OECD, 2022[61]).

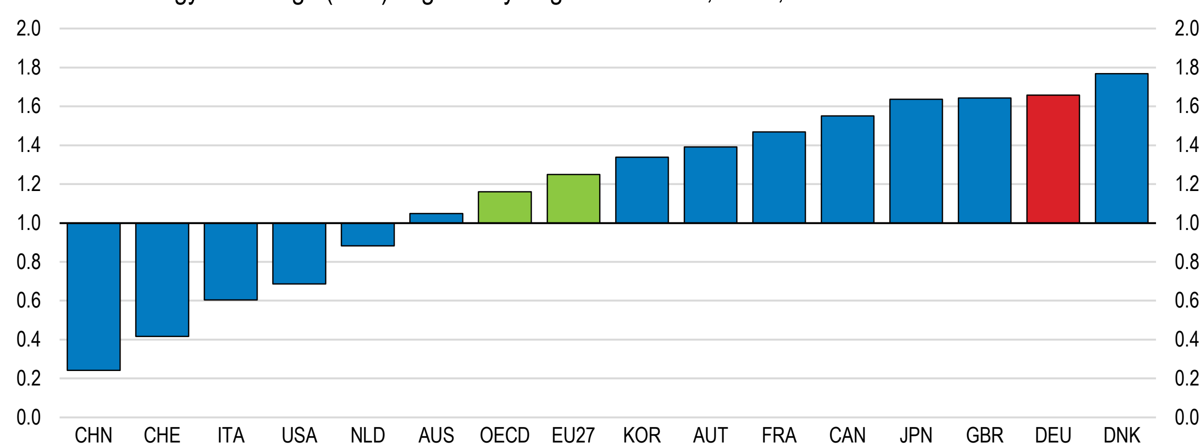
Green hydrogen can play an important role in hard-to-abate industries

Production of hydrogen through electrolysis using water and electricity produced from renewables (green hydrogen) can play an important role in reducing greenhouse gas emissions. It has potential to replace fossil fuels in high-temperature industrial processes of hard-to-abate sectors such as steel production, in road freight traffic, and to store energy produced from intermittent sources. In most net-zero emission scenarios, green hydrogen plays a pivotal role, although the production of green hydrogen is still about three times more expensive than hydrogen made from natural gas (Cordonnier and Saygin, 2022[62]). Major cost reductions will crucially depend on R&D and large-scale demonstration projects. Reducing uncertainties for investors through standardisation and infrastructure investments is also needed (Cammeraat, Dechezleprêtre and Lalanne, 2022[58]).

Germany is a world leader in hydrogen-related patents and trademarks, especially hydrogen production and hydrogen storage (Figure 2.16). It plans to develop 5 gigawatt of green hydrogen production capacity by 2030 and 10 gigawatts by 2040. The EU-ETS and the abolishment of the EEG surcharge incentivise the use of hydrogen in electricity storage and industry. The National Hydrogen Strategy supports the development of a domestic market and enhances international cooperation, as Germany will have to import large quantities of green hydrogen due the comparative advantage of other countries in renewable energy sources. An annual budget of more than EUR 300 million is dedicated to support green hydrogen by investing in R&D and establishing regulatory sandboxes (Cammeraat, Dechezleprêtre and Lalanne, 2022[58]). As some hydrogen technologies have matured, many support measures focus on implementation such as funding for electrolyser development and developing a hydrogen refuelling infrastructure. Although the strategy is well-designed, better evaluation mechanisms are needed. The strategy does not include sufficient evaluation mechanisms providing independent, systemic feedback that is not tied to the responsible ministries (OECD, 2022[61]). In addition, Germany should work towards better harmonising quality standards across countries and shared definitions of the different types of hydrogen (green, blue, turquoise etc.) to reduce uncertainty and facilitate coordination, including at the EU level (BMBF, 2022[63]).

Figure 2.16. Hydrogen-related innovation

Relative technology advantage (RTA) in green hydrogen innovation, index, 2015-19



Note: This index is obtained by dividing each country's share of hydrogen patents with the global share of hydrogen patents. The share of hydrogen patents is obtained as the number of PCT hydrogen patents divided by the total number of PCT patents filed by the same country or region. Data refer to PCT patents in hydrogen technologies. Patent counts are based on the filing date and the inventor's location, using fractional counts. Only economies featuring more than 50 hydrogen technology patent families over the period 2014-19 are included.
Source: Innovation and industrial policies for green hydrogen, OECD Science, Technology, and Industry Policy Papers February 2022 n. 125.

StatLink https://stat.link/d3ikv4

Public procurement can help to strengthen innovation incentives

Until effective carbon prices are high enough and cover all sectors, including shadow prices for carbon emissions in public procurement decisions could help to create markets for innovative green products and services. Given that public procurement represents an estimated 15% of German GDP, this could have a substantial effect on emission reduction. Such a shadow price would be compatible with the concept of "economically most advantageous bid" inscribed in the European public procurement directives. A study conducted in Berlin found that purchasing 15 frequently procured product groups in an environmentally friendly way could result in a 47% reduction in CO_2 emissions compared to conventional procurement (Öko-Instituts e.V., 2015[64]). Nonetheless, many potential hurdles limit the attractiveness of using shadow prices in public procurement. Developing and administering a non-discriminatory and objective measurement of shadow prices, which is defendable in courts against the claims of competing bidders, is a very complex and costly task for the public administration. This is particularly problematic for municipalities with financial difficulties, which suffer from staff shortages and weak IT infrastructure. It will also create high administrative burden for firms, and the additional legal complexity risks further delaying the implementation of infrastructure projects, jeopardising the green transition (Löschel and Schulze, 2022[65]).

Finding the right balance is therefore essential. The government should publish and use shadow carbon prices for procuring strategic products and services, such as the public vehicle fleets. In Baden Württemberg, for example, the local government uses a shadow price of EUR 180 per ton of CO_2 for public renovations projects. For the procurement of other products and services, minimum standards and negative lists of products and services should be used. The government could also enable contractors to apply for a CO_2 performance ladder certificate, like in the Netherlands. To receive the certificate, contractors in the Netherlands need to take steps towards reducing their carbon footprints that increases their chances of winning contracts (OECD, 2019[66]).

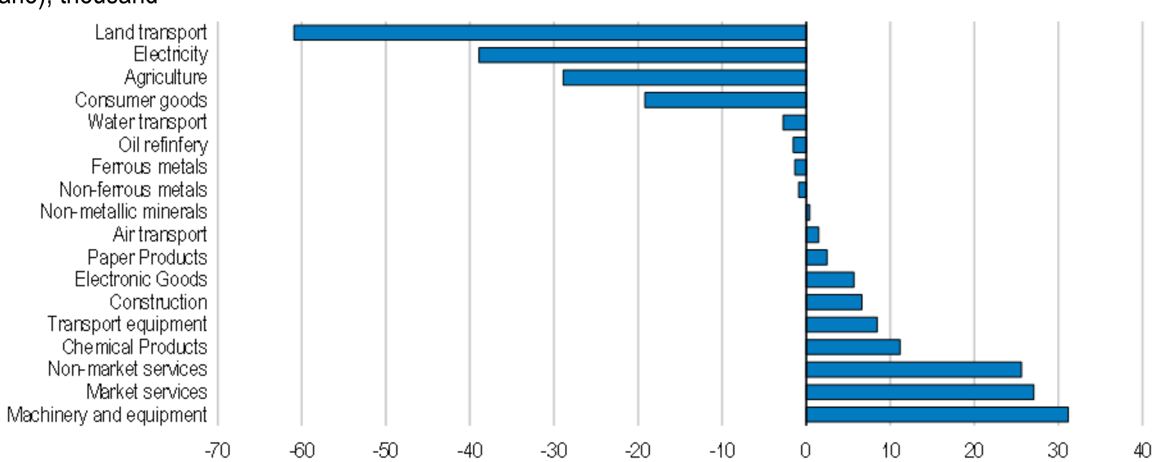
Protecting social cohesion and building strong public support for climate policy

Carbon abatement would lead to reallocation of labour across sectors and firms and increase income and regional inequality

Significant GHG emission cuts have not prevented strong economic and employment growth in the last three decades. Nonetheless, more stringent policies to reach ambitious emission reduction targets will have significant effects on the allocation of labour and capital across sectors and firms (Mohommad, 2021[67]). Some sectors and firms will strongly expand production and employment, others will need to shrink and shed labour or even exit the market (Dussaux, 2020[68]). For example, in the main EU Fit for 55 scenario, employment in land transport strongly declines (compared to the benchmark), while employment in machinery and equipment increases (Figure 2.17).

Figure 2.17. Reaching Fit for 55 targets would lead to labour reallocation

Contribution to the change in total employment until 2030, main EU Fit for 55 scenario (compared to the benchmark scenario), thousand

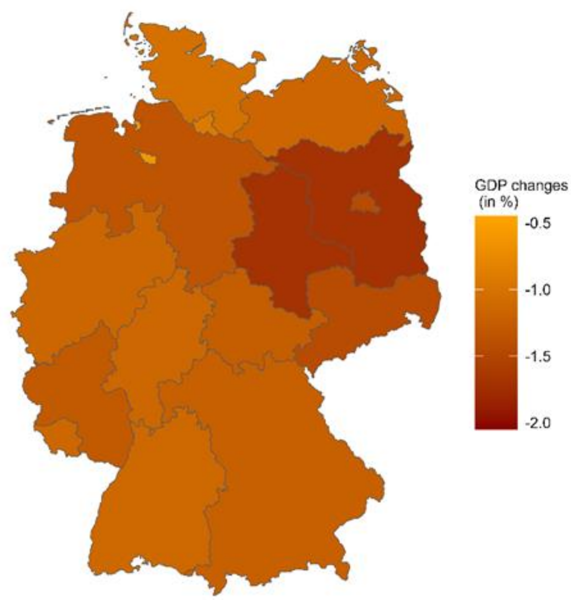


Note: See Box 2.5 for a description of the methodology and simulation scenarios.
Source: (Bickmann et al., forthcoming[1])

StatLink https://stat.link/251px4

The economic effects of emission reductions will also vary across regions according to their economic structure (Figure 2.18). Simulation results for this Survey suggest that losses in regional GDP would be particularly strong in East Germany and noticeably weaker in the north, risking to increase regional inequality, which is already pronounced (Immel and Peichl, 2020[69]). The East German states Brandenburg, Sachsen and Sachsen-Anhalt would be among the most affected Laender due to a higher share of fossil fuel-based energy supply and mining in regional gross value added. Fostering regional labour mobility through mobility subsidies and improved employment services is one important policy lever to reduce adjustment costs for affected workers (see below). Regional development policies are another important policy tool. While the potential to expand solar and wind power in some of the adversely affected areas is limited due to less suitable weather, some of these regions are less densely populated, which could facilitate renewables expansion (OECD, 2021[70]). Regional development policies could build on this latent relative comparative advantage and support the attraction of investments in green technologies and R&D. To mitigate the asymmetric regional effect of the coal exit, in 2020, the federal government pledged to support the affected coal mining regions, which include Brandenburg, Sachsen and Sachsen-Anhalt, with EUR 40 billion (1.1% of 2021 GDP) until 2038, focusing on improving infrastructure, innovation, and job markets.

Figure 2.18. Climate mitigation policies would have the strongest effect on East Germany



Note: Simulations are conducted using a Computable General Equilibrium Model (CGE) for Germany (Box 2.5). The graph shows changes in real GDP for the Main Fit for 55 scenario compared to the benchmark scenario.
Source: (Bickmann et al., forthcoming[1]).

StatLink https://stat.link/pdzkwy

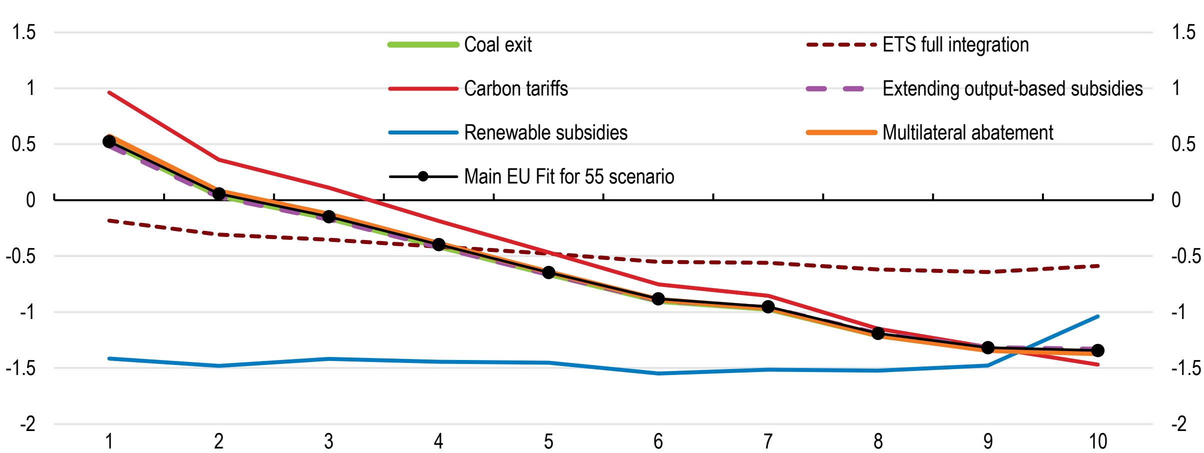
Reallocation would also occur across firms within sectors, with the most energy-intensive and the least productive firms tending to experience the most significant declines in employment. At the same time, less energy-intensive or more productive firms may benefit and increase employment (OECD, 2021[42]). For example, an OECD study that investigated the impact of energy prices on employment in French manufacturing found that rising carbon prices did not affect total manufacturing employment. However, employment declined in large firms with low energy-efficiency, while it increased in smaller and more energy-efficient firms (Dussaux, 2020[68]). Nonetheless, the overall job reallocation rates triggered by environmental policies will likely be relatively small compared to other major structural transformations, such as automation and globalisation, partially because employment in emission-intensive industries, which are most affected by higher carbon prices, is relatively low (OECD, 2021[42]; Grundke and Arnold, 2022[71]).

The reallocation of labour across sectors and firms will change relative factor prices, which has heterogenous effects on the incomes of households along the income distribution. It will also lead to significant adjustment costs for displaced workers (discussed below). Moreover, rising carbon prices will significantly affect the relative consumer prices of goods and services depending on their carbon content. As poorer households spend a higher share of their income on carbon-intensive items, distributional effects on the consumption side are likely to be regressive (SVR, 2019[72]). The total effects of stronger emission reductions on inequality are highly dependent on the economic structure and can be significantly influenced by policy design. Lump-sum recycling of carbon price revenues mitigates adverse effects on low-income households and is efficient, as it has a limited effect on labour supply decisions of households (Figure 2.11). However, it requires accelerating the establishment of a central register and expanding the use of existing payment mechanisms (such as reimbursement of taxes and pension benefits) to transfer the money to households (Färber and Wieland, 2022[73]). More targeted transfers to vulnerable households could be preferred as they tend to be less expensive and more popular (see below), but they could also distort incentives to work (D'Arcangelo et al., 2022[30]). A broader compensation mechanism could seek to reduce the labour tax burden on lower-income households or second earners, which could positively affect labour supply and increase support for explicit carbon pricing (see below and Chapter 1). However, relying on carbon price revenues to finance major tax reforms would be problematic because carbon receipts will shrink as emissions are reduced. The government should also continue to use the fiscal space provided by the additional revenue (from carbon price receipts) to support green investments and R&D, which has high potential to reduce future abatement and transition costs and is also one of the policy designs that enjoys the highest public support (see below).

The distributional effects also strongly depend on the policy set-up (Figure 2.19). Low-income households would benefit from pricing the carbon content of imports, as this would generate additional revenues that can be redistributed (on top of carbon pricing receipts, see above). For higher-income groups, the negative effect of the carbon tariff on many manufacturing industries and shrinking capital and labour incomes outweigh the positive transfer effect. In contrast, expanding the EU ETS would reduce the negative effects for higher income groups, as the implied efficiency gains increase capital and labour income, whereas revenues from carbon pricing, and therefore also transfers to households, considerably decline. Lastly, using a larger share of carbon tax revenues for subsidising renewables leads to more regressive effects of carbon mitigation, as it strongly benefits capital-intensive EITE industries by lowering electricity prices at the expense of transfers to households.

Figure 2.19. Distributional effects of emission abatement differ across policy options

Household welfare changes by expenditure decile, compared to the benchmark scenario (in %)



Note: See Box 2.5 for a description of the methodology and simulation scenarios.
Source: (Bickmann et al., forthcoming[1]).

StatLink https://stat.link/pizryn

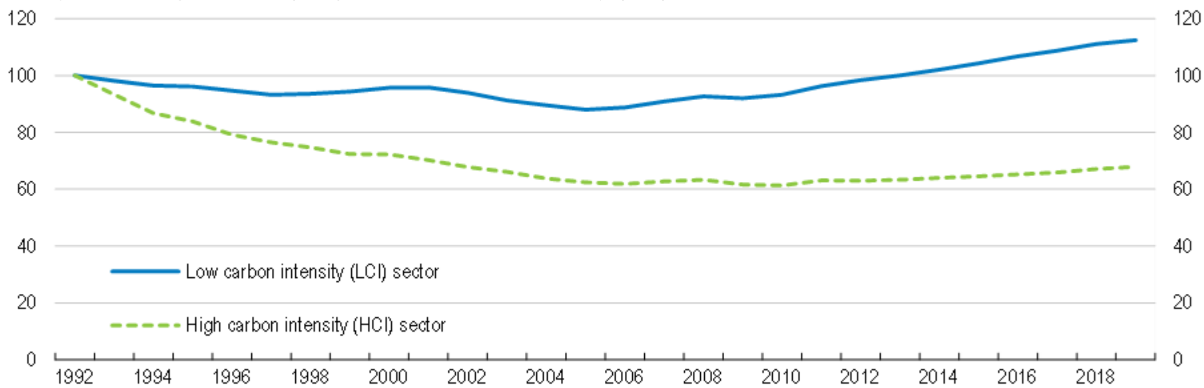
Reducing adjustment costs for displaced workers and facilitating the move to new jobs

Adjustment costs for displaced workers can be high

If they are well-designed, mitigation policies are likely to have only a moderate total negative net employment effect, reflecting the limited initial shares of employment in carbon-intensive sectors. A large part of the adjustment has already happened in Germany, as employment in carbon-intensive sectors has decreased by a third since 1992 (Figure 2.20).

Figure 2.20. Germany has already experienced significant employment losses in High Carbon-Intensity sectors

Employment in high carbon (HCI) and low carbon intensity (LCI) sectors, 1992 = 100



Source: (Barreto, Grundke and Krill, Forthcoming [79]) based on data from the IAB.

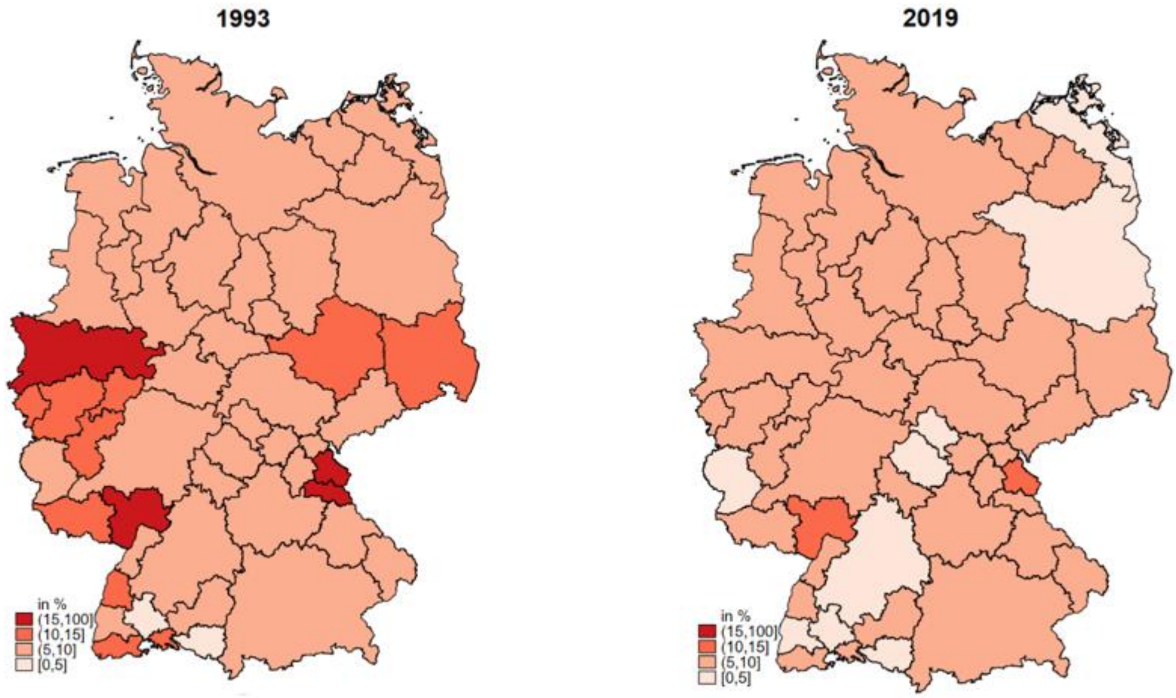
StatLink https://stat.link/oqgjfd

However, remaining workers in carbon-intensive sectors will likely face considerable adjustment costs due to the green transition. Displaced workers will lose their wage income; they have to search for a new job, learn new skills, and often have to bear, together with their families, the social costs of moving to other locations to find a new job (Grundke and Arnold, 2022[71]). Job creation in sectors that benefit from the green transition might happen in locations that are different from the locations suffering from the decline of carbon-intensive industries. Job-search and matching frictions, rigid labour market regulation, duration and costs of necessary training courses as well as low geographical mobility of workers can prolong unemployment spells and even lead older workers to exit the labour force (Hyman, 2018[74]). Moreover, workers who stay in their jobs also need to update their skills through on-the-job and formal training. As firms upgrade production processes through more advanced and greener technologies, the task content and skill requirements of existing jobs changes (Hummels et al., 2012[75]; Becker, Ekholm and Muendler, 2013[76]).

To better understand the adjustment costs and main obstacles to job mobility for workers in carbon-intensive industries, this chapter exploits the strong drop in employment in carbon-intensive industries since the 1990s to investigate employment transitions following mass-layoffs (Box 2.6, Figure 2.20). From 1993 to 2019, the share of workers in high carbon-intensity sectors (out of all workers) declined by a third: from about 9.7% to about 6.4%. As workers from high-carbon intensity sectors are concentrated in certain regions in the east and west of Germany, the employment drop has been particularly pronounced there, but layoffs have also affected other regions (Figure 2.21).

Figure 2.21. Employment losses in High Carbon Intensity sectors have been heterogenous across regions

Share of HCI workers in total employment (by labour market region)



Source: (Barreto, Grundke and Krill, Forthcoming [79])

StatLink https://stat.link/69tohu

Involuntary job losses entail a lasting and significant reduction in employment and earnings for workers in all industries and services sectors (Jacobson, Lalonde and Sullivan, 1993[77]) (Schmieder et al., 2022[78]). However, analysis conducted for this survey finds that displaced workers from high carbon intensity (HCI) sectors experience (on average) even higher and more persistent losses compared to other displaced workers (Box 2.6). Five years after the job separation, displaced workers from HCI sectors have 23% lower earnings compared to individuals with similar characteristics that haven't been displaced, while the loss for workers in other economic sectors is only about 17% (Figure 2.22, Panel A). Earnings of workers in HCI sectors that remained employed after a mass layoff event were broadly stable. The more severe job loss effect is driven by a sharp decline in daily wages for workers in the High Carbon Intensity sectors, while the employment gap is less substantial. Displaced workers from HCI sectors are more likely to change occupation, sector, and workplace district after displacement than other workers (Figure 2.22, Panel B). Five years after displacement, 49% of displaced workers in HCI sectors had found a new job in other sectors, 31% moved to a new job within HCI sectors, 12% were still unemployed and 9% had left the labour market. However, switching occupations or sectors is, on average, associated with lower earnings compared to displaced workers that find a new job in the same occupation or sector. In contrast, switching workplace district seems to result in higher earnings compared to displaced workers who remained in the same district after displacement.

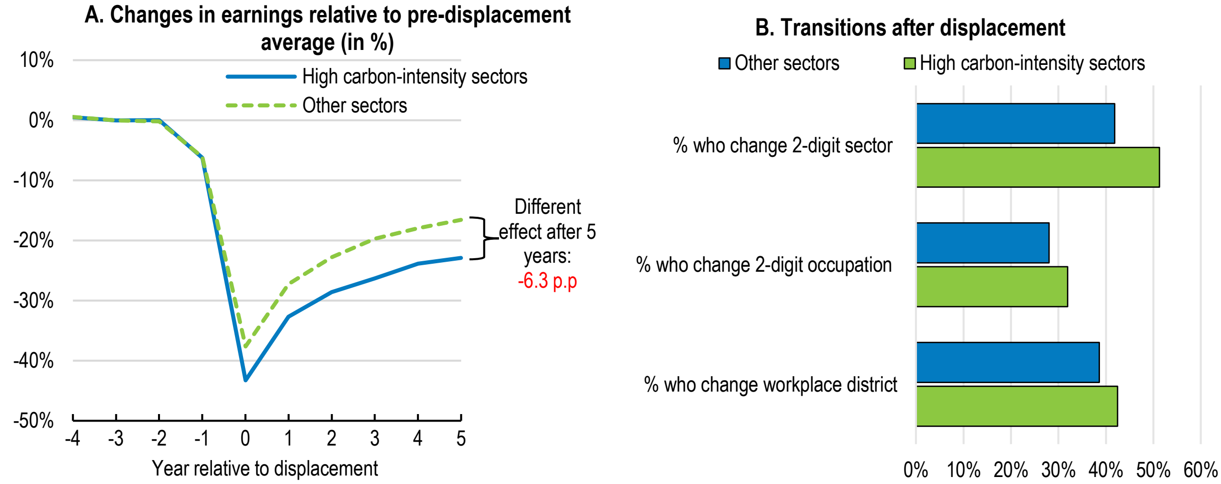
Box 2.6. Estimating the job loss effect for workers in high carbon-intensity sectors

This analysis is presented in a technical background paper prepared for this Survey (Barreto, Grundke and Krill, forthcoming[2]). It uses a random sample of 10% of workers from the Integrated Employment Biographies (IEB) dataset, which comprises all workers registered in German Social Security records and includes information on wages, employment status, economic sector, location and firm ID as well as a range of individual characteristics, such as education and age of the worker. The analysis focuses on the period of 1993-2020 to be able to include eastern Germany in the analysis. To identify workers in high-carbon intensity sectors (HCI), data from the World Input-Output Database Environmental Accounts is used to compute the average carbon intensity from 2000 to 2016. HCI sectors are defined as the top two deciles of the carbon intensity distribution, accounting for 81% of total CO_2 emissions during this period.

The administrative worker-level data is matched to the Establishment History Panel (BHP), which allows to identify workers that have been laid off during a mass layoff. Focusing on displacements during mass layoff events enables identifying the causal effects of involuntary job separations (Jacobson, Lalonde and Sullivan, 1993[77]) (Schmieder et al., 2022[78]). Mass layoff events are classified as a drop in employment of at least 30% among establishments with at least 50 employees. About 2% of establishments with more than 50 employees experienced a massive layoff event each year during the relevant period, and mass layoffs are dispersed across regions. Estimations include full-time employees aged 20-55 with at least two years of tenure. Overall, 8089 individuals in the sample were displaced from mass layoffs in high-carbon intensity sectors.

To control for different characteristics between displaced and non-displaced workers, the estimation uses a matching technique combining exact matching and Propensity Score Matching to pair each displaced worker with a non-displaced worker, separately in cells defined by high- and low-carbon intensity sectors, 1-digit economic sector, year, and gender (exact matching on all of these variables). Propensity scores are based on workers' wages before displacement, age, job tenure, education level, occupation, nationality, the establishment's size and indicator variables for East Germany and urban/rural area. This technique allowed to construct a control group with similar individual characteristics and pre-displacement trends in outcomes compared to displaced workers. This allows quantifying the effects of job displacement on labour market outcomes, such as hourly wages, employment status and job transitions, up to five years after the displacement event, and separately for workers in the high- and low-carbon intensity sectors.

Figure 2.22. Displaced high carbon intensity workers suffer lasting and significant reductions in earnings



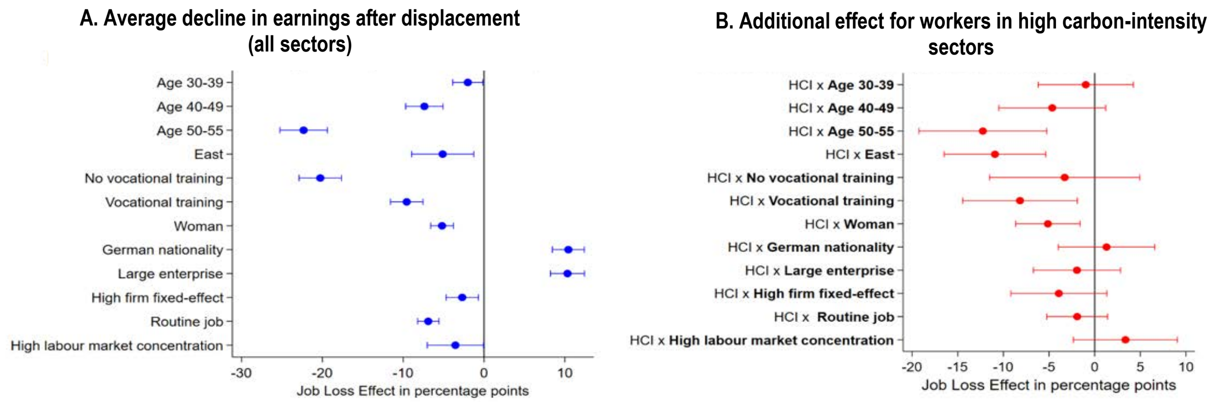
Source: (Barreto, Grundke and Krill, forthcoming[2])

StatLink https://stat.link/g0y1u3

Displacement costs for workers in HCI sectors were higher than for other workers due to observable differences in worker, job and regional characteristics, which explain two-thirds of the earnings gap (Barreto, Grundke and Krill, forthcoming[2]). Workers in High Carbon Intensity sectors are (on average) older and have higher tenure, are more likely to have vocational education rather than more general tertiary education, and work in very specific occupations, which have a higher routine task content. Employees with these characteristics experienced higher earning losses after displacement (Figure 2.23). For example, chemical plant operators and mechanical workers were among the occupations with highest average displacement costs. The negative effects of these characteristics on earnings after displacement suggest that human capital specificity, particularly related to routine tasks, and lower basic skills, especially of older workers, play a major role in explaining the higher displacement costs for workers in HCI sectors (Utar, 2018[79]; Dauth, Findeisen and Suedekum, 2020[80]). If displaced workers in HCI sectors succeed to move to another occupation, the distance between the required skill set of the new and the old job is higher than for workers in Low Carbon Intensity sectors. This calls for more fundamental formal education courses to help displaced workers from HCI sectors to move into well-paid occupations in expanding sectors and firms (Hummels et al., 2012[75]; Hyman, 2018[74]; Autor et al., 2014[81]). Necessary improvements in general cognitive skills, such as literacy and numeracy, and new occupation-specific skills will require large investments in formal and vocational education courses for adults (Bechichi et al., 2018[82]; Bechichi et al., 2019[83]).

High concentration of HCI firms in specific regions, higher restrictions to regional mobility and high firm wage premia are other major explanations for higher displacement costs in HCI sectors (Barreto, Grundke and Krill, forthcoming[2]). Outside options in the most affected regions are more limited and employer concentration is higher, complicating employment transitions (Figure 2.23). These effects are more severe in eastern Germany (Barreto, Grundke and Krill, forthcoming[2]). Moreover, a mass layoff in a large firm could create a domino effect on the region as a whole, reducing employment and labour productivity, due to negative agglomeration effects and the decline in consumer demand (Gathmann, Helm and Schönberg, 2018[84]; Helm, 2019[85]; Dix-Carneiro and Kovak, 2017[86]). However, displaced workers that are more mobile and transition to a new job outside their local labour market have lower displacement costs. This calls for active labour market and other policies to facilitate the regional mobility of workers, while at the same time emphasising the role of well-designed regional development policies to counter negative agglomeration effects and improve employment opportunities in local labour markets.

Figure 2.23. Older, low-skilled, and female workers as well as those in East Germany experience steeper earning losses due to involuntary displacement



Note: Point estimates refer to changes in relative earnings in case of involuntary displacement. A negative effect indicates earning losses 5 years after displacement. Horizontal bars indicate the estimated 95% confidence interval based on standard errors clustered at the district level. The base groups are the age group 25-29 years, having an academic degree, being male, from West Germany and without the German nationality. Large enterprises are firms with more than 250 employees. Labour market concentration is calculated by 2-digit occupation as the number of employers that hire workers of the specific occupation within a commuting zone. The index ranges from 0, no market concentration, to 1 in the case of a single firm hiring all workers with the same occupation (2 digits) in the market. An HHI larger than 0.15 is considered as high.

Source: (Barreto, Grundke and Krill, Forthcoming [2])

StatLink https://stat.link/8xrc7j

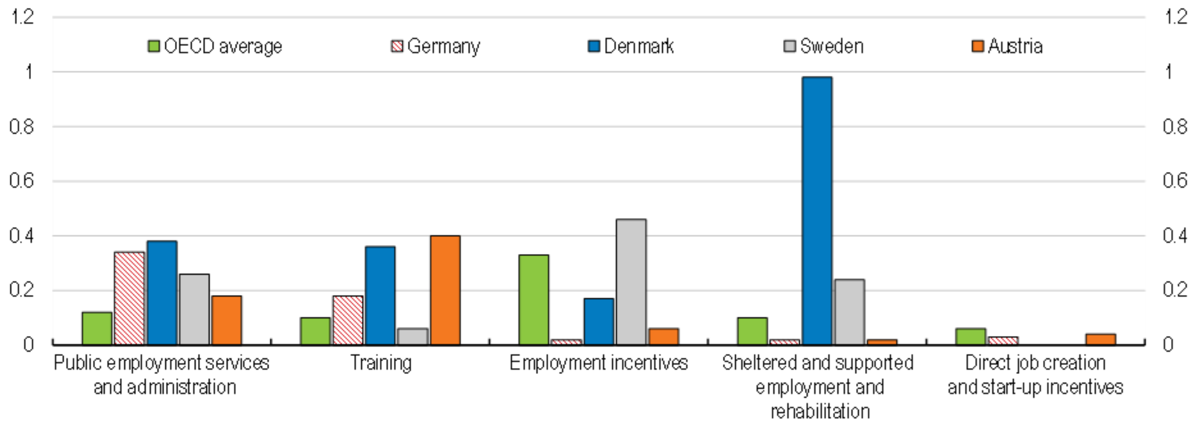
Policies to reduce adjustment costs and smooth the transition

Flexible labour market regulation and an effective social safety net focusing on the protection of workers and not of jobs combined with efficient job placement services would facilitate the transition of workers to new job opportunities in low carbon-intensity industries (Grundke and Arnold, 2022[71]). Germany has quite robust social safety nets, but has room to improve labour market flexibility: Employment protection against collective and individual dismissals is high, which might postpone necessary resource reallocation and increase adjustment costs. As discussed in the previous Economic Survey of Germany, many occupational entry regulations, limited housing supply in big cities, where job opportunities are more spread, and underfunded public transport (see below) hinder job mobility (OECD, 2020[87]). Improving policies in these areas is key for mastering the green transition, but also other structural transformations such as the globalisation of production processes, technological change and population ageing that affect relative prices and the reallocation of workers and capital across firms, sectors, and occupations (OECD, 2012[88]; OECD, 2005[89]).

Expanding the scope of Active Labour Market Programmes (ALMP) can help displaced workers find a good quality job. In countries with higher ALMP spending the average earnings loss due to displacement is lower (Bertheau et al., 2022[90]). Spending for ALMP was around 0.6% of GDP in Germany in 2019, slightly lower than the OECD average (0.7%) and much lower than in Sweden (1%) and Denmark (1.9%), two countries in which displaced workers experience modest earning losses. While spending on labour market services such as guidance, counselling and other forms of job-search assistance is relatively high, spending on training and start-up incentives is moderate (Figure 2.24). The proportion of jobseekers benefitting from participation in activation measures in Germany has declined since 2008 (Kristine, 2019[91]).

Figure 2.24. There is scope to increase spending on training

Public expenditure on active labour market policies, % of GDP, 2019



Source: OECD Labour Force Statistics.

StatLink https://stat.link/yqz3x1

Undertaking more fundamental re-training and support for acquiring basic skills are essential to raising employability and life-time income for the unemployed and would help to reduce skilled labour shortages (van den Berg, Uhlendorff and Wolff, 2021[92]; Wolff, 2021[93]). In 2022, about 55% of the unemployed had no university or vocational degree (Bundesagentur für Arbeit, 2022[94]). The recent basic income support reform (*Bürgergeld*) is an important step to promote more reskilling and upskilling for registered job seekers, as it abolishes the prioritisation of job placement over additional training. Completing a VET degree will be possible within three instead of two years. Additionally, registered job seekers will receive support for acquiring basic skills and a monthly allowance of EUR 150 if they are enrolled in training measures leading to a professional degree. However, as low basic skills of many unemployed persons complicate the successful completion of a VET degree, adult education opportunities to update basic skills need to be further expanded and better linked with public employment services (OECD, 2021[95]; OECD, 2022[96]). This requires better cooperation across levels of government, as ALMP is a federal and adult education a Laender responsibility. In addition, mobility assistance programmes should be expanded. These programmes increase jobseekers' search radius, leading to higher employment probabilities and wages. While such programmes already exist in Germany, their provision varies substantially between Laender (Caliendo, Künn and Mahlstedt, 2017[97]).

About 15% of employed workers have low basic skills, which makes them particularly vulnerable to the green transition (OECD, 2022[96]). They are less likely than other workers to participate in Continued Vocational Education and Training (CVET) programs, which emphasises the need to better promote and target adult education programmes. One way to promote participation is to rely more on partial qualifications that allow individuals to complete single training modules on a step-by-step basis and combine this with better recognition of prior learning, particularly of knowledge accumulated on the job. This would reduce entry costs, provide more flexibility, shorten training time and encourage low-skilled workers to participate in CVET and eventually complete a VET degree (OECD, 2021[95]). So far, partial qualifications only exist in Germany for certain occupations, are not standardised across training providers, and not well linked to career guidance or the skill validation system. Implementing nationwide quality standards in career guidance, skill validation and partial qualifications and setting precise qualification requirements for career guidance counsellors in calls for tender would improve the services given to workers with low skills (OECD, 2022[96]). As the German CVET system is highly fragmented, introducing nationwide quality standards and certifications for CVET courses and better coordinating and marketing the existing supply across all regions, for example by introducing a common digital platform, is key for raising training participation (OECD, 2021[95]). Expanding support for acquiring basic skills and better targeting them to low-skilled workers is also crucial, as many CVET courses require a minimum level of basic skills. In the context of rising skilled labour shortages, employers and employer associations should play a larger role in promoting adult education opportunities by providing workers with sufficient training time and supporting efforts to raise awareness and disseminate information on adult education opportunities among low-skilled workers.

Targeted hiring subsidies should complement improved training and education opportunities to strengthen the employability of the most vulnerable groups (Brown, 2015[98]) (Card, Kluve and Weber, 2018[99]). The Participation Opportunities Act, which has been in force since 2019, provides targeted wage subsidies as well as coaching and training and helps long-term unemployed to find a stable job, but these services are exclusively available for individuals who have been unemployed for at least two years (German Council of Economic Experts, 2022[100]). This programme could be expanded to vulnerable groups already in early stages of their unemployment spell to improve their re-employment chances. To better identify these groups and to limit cream-skimming effects, whereby public employment agencies could prioritise individuals with higher re-employment chances to maximise their performance outcomes, profiling tools that rely on statistical models to predict jobseekers' likelihood of becoming long-term unemployed should be used to select participants. Well-known examples are the *Work Profiler* in the Netherlands, the *Job Seeker Classification Instrument* in Australia and the *Worker Profiling and Reemployment Services* (WPRS) initiative in the United States (Desiere, Langenbucher and Struyven, 2019[101]) (Box 2.7).

Box 2.7. Data-driven employment services for displaced workers

Statistical profiling of jobseekers draws on both the characteristics of the jobseeker to be profiled and on observations of previous jobseekers with similar characteristics. It is used in several OECD countries to identify early on those jobseekers who have a high risk of becoming long-term unemployed. This allows concentrating the efforts of the public employment service on high-risk jobseekers, as well as providing leaner services to jobseekers who do not need help with finding employment.

As a result of profiling, the interaction with jobseekers can vary strongly. In the Netherlands, for example, initially only high-risk jobseekers are invited for an interview with a caseworker, while the interaction with low-risk jobseekers is typically limited to online services unless their unemployment duration approaches six months. Similarly, an individual action plan (IAP) is concluded early on for high-risk jobseekers in Ireland, but only after 6 months for low-risk jobseekers. Along these lines, the interaction with jobseekers in Germany could be targeted more strongly at those profiled as having a high risk of long-term unemployment or likely to experience a significant decline in earnings.

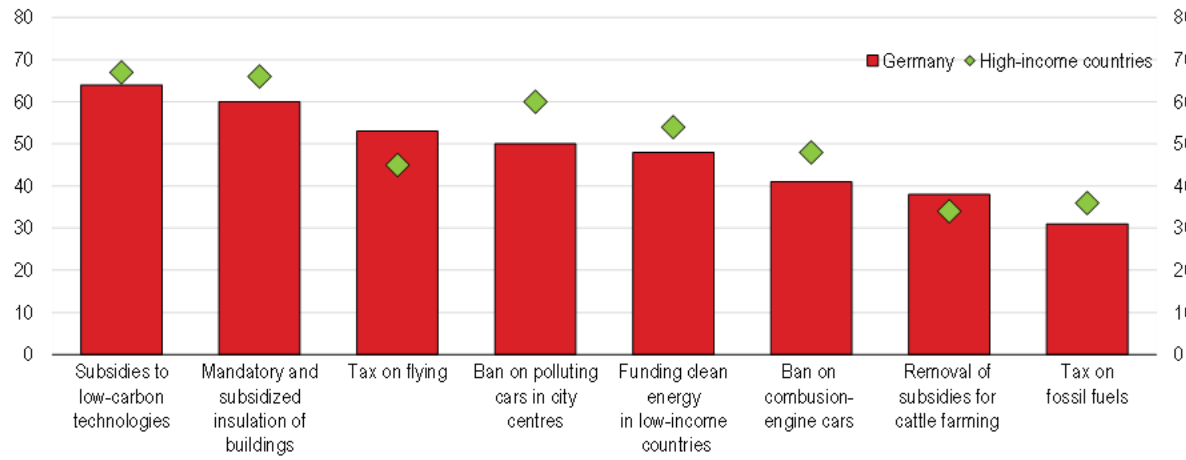
Source: (Desiere, Langenbucher and Struyven, 2019[101]).

Designing climate policies to build strong public support

A cross-country OECD survey found that 80% of German respondents agree that "climate change is an important problem" and that Germany "should take measures to fight climate change", in par with results in other high-income countries. Yet, attitudes about different mitigation measures vary significantly. The most popular policies are subsidies for low-carbon technologies, investment in thermal renovations for buildings and taxes on flying (Figure 2.25). Germans are less prone to accept measures such as a tax on fossil fuels (without earmarking of revenues), bans on combustion engines or removing subsidies for cattle farming. Car users are less supportive of climate policies, especially regarding bans on combustion engine cars, and so are individuals who live in small cities and rural areas. However, public transport availability increases support significantly and it is a stronger predictor of support than city size (Dechezleprêtre et al., 2022[102]).

Figure 2.25. Policies to tackle climate change receive unequal support

Share of respondents who somewhat or strongly support climate change policies, %



Source : Dechezleprêtre, A., et al. (2022), "Fighting climate change: International attitudes toward climate policies", OECD Economics Department Working Papers, No. 1714, OECD Publishing, Paris, https://doi.org/10.1787/3406f29a-en.
Note: High-income countries include Australia, Canada, Denmark, France, Germany, Italy, Japan, Poland, South Korea, Spain, UK and the US.

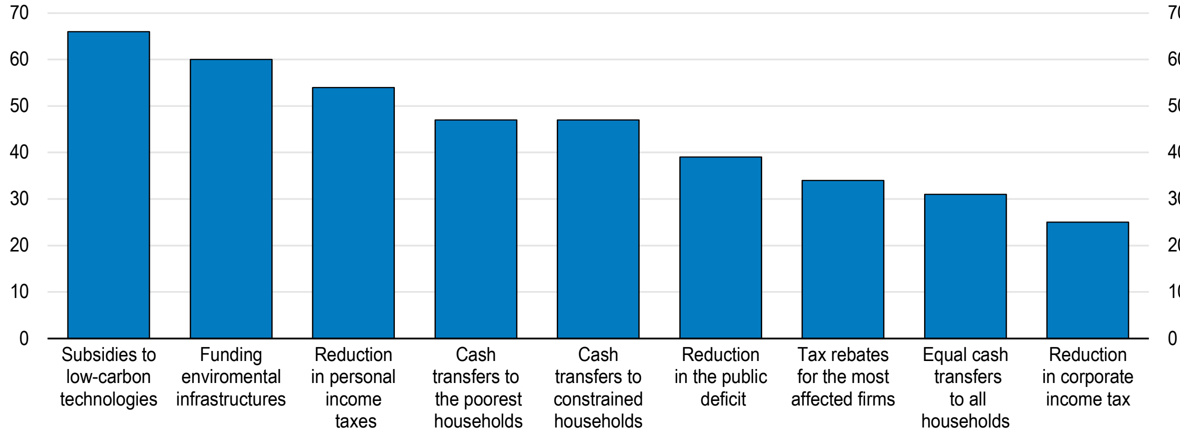
StatLink https://stat.link/0vy6l7

Carbon pricing by itself is not a popular measure but it can receive majority support when the revenues are used to fund green infrastructure and clean technology adoption or to reduce personal income taxes (Figure 2.26). Using carbon price-related revenues for targeted support to poor households could also increase support for carbon pricing. In contrast, using revenues to lower corporate income taxes or distributing revenues equally via lump-sum cash transfers are unpopular, although the latter is still supported by a relative majority when excluding "indifferent" respondents from the sample.

Information about climate policies, how they work and about how revenues are distributed can increase support for pricing policies (Dechezleprêtre et al., 2022[102]) (Douenne and Fabre, 2022[103]). For example, only a minority of Germans believes a carbon tax would encourage people to drive less. However, explaining (using pedagogical videos) how higher taxes on fossil fuels contribute to reducing emissions and explaining their distributional effects were found to increase support significantly. Public information and education campaigns should be an important part of climate policy implementation and need to be introduced before pricing is fully phased in. Nevertheless, high quality information requires better ex-ante evaluation of economic and social effects of mitigation polices.

Figure 2.26. Support for carbon pricing strongly depends on revenue use

Share of respondents who somewhat or strongly support policy combination (with carbon tax), %



Source: Dechezleprêtre, A. et al. (2022), "Fighting climate change: International attitudes toward climate policies", OECD Economics Department Working Papers, No. 1714, OECD Publishing, Paris, https://doi.org/10.1787/3406f29a-en.

StatLink https://stat.link/6as4no

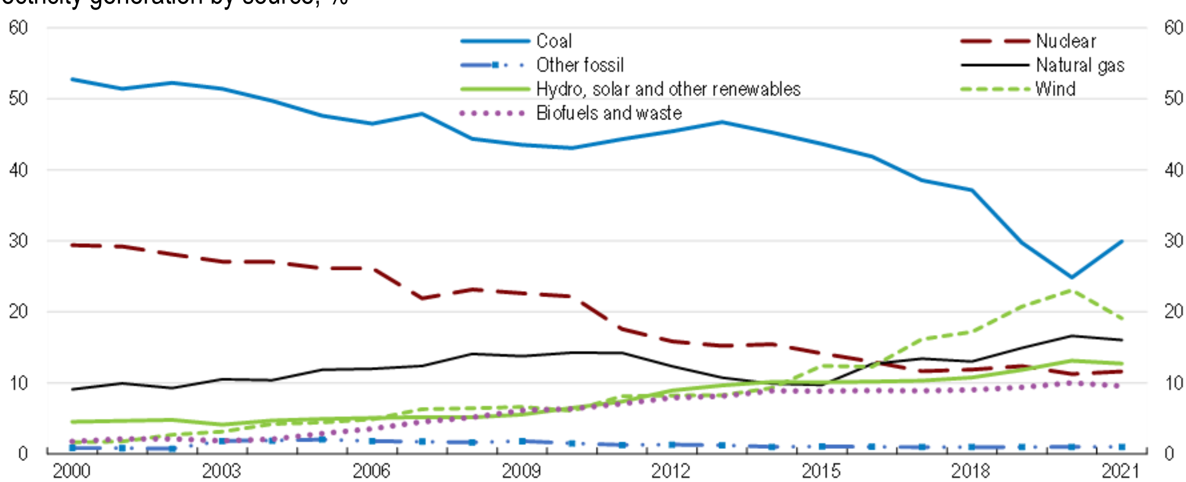
Targeting policies to the sectoral context

Removing barriers to expanding renewables

The electricity sector is Germany's largest source of GHG emissions, contributing 29% of total emissions. In 2021, more than half of the electricity in Germany was still generated by fossil sources. Nonetheless, use of renewables has expanded significantly, and coal usage trend has been declining rapidly (Figure 2.27). Germany led the G20 in deploying wind and solar energy with a share of 29% in 2021, ahead of the United Kingdom (25%) and Australia (22%). Even so, many windless days in the first half of 2021 reduced their share in the total electricity generation mix. Along with the expansion of renewables, the reliability of the electrical grid improved. In 2020, the average power outage duration was 0.25 hours, amongst the lowest in Europe and the world (World Bank, 2020[104]).

Figure 2.27. Coal uses for electricity generation steadily declined until 2020

Electricity generation by source, %



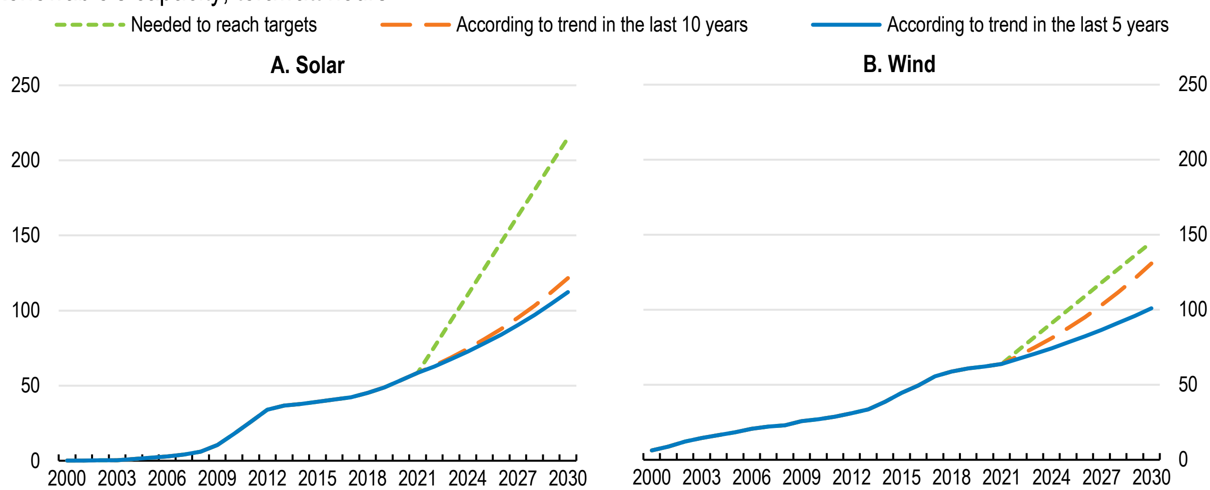
Source: IEA Electricity Information 2022.

StatLink https://stat.link/kln14h

Germany will have to expand renewables even faster to replace coal-fired and nuclear power capacity being taken off the grid and to cover the future rise in demand due to the shift to electric transport and heating. The government aims to reach 80% of electricity generation from renewables by 2030, which requires accelerating the installed capacity dramatically: The annual growth in installed capacity of solar energy should be about three times higher compared to the average progress between 2016 to 2021, and of wind 2.2 times higher (Figure 2.28). In addition, it phased out nuclear power in April 2023 and aims to phase out coal (ideally) by 2030. Although costly in the short run, the renewables installations could benefit German consumers in the long run. New wind and solar installations deliver decentralized electricity at a cost of between four and five cents per kilowatt-hour – roughly half of the 2021 level of electricity prices on the exchanges. Accelerating the installations will also help to reduce energy imports from foreign countries and improve energy security (BMWK, 2022[105]).

Figure 2.28. Faster deployment of renewables is needed

Renewable's capacity, terawatt hours



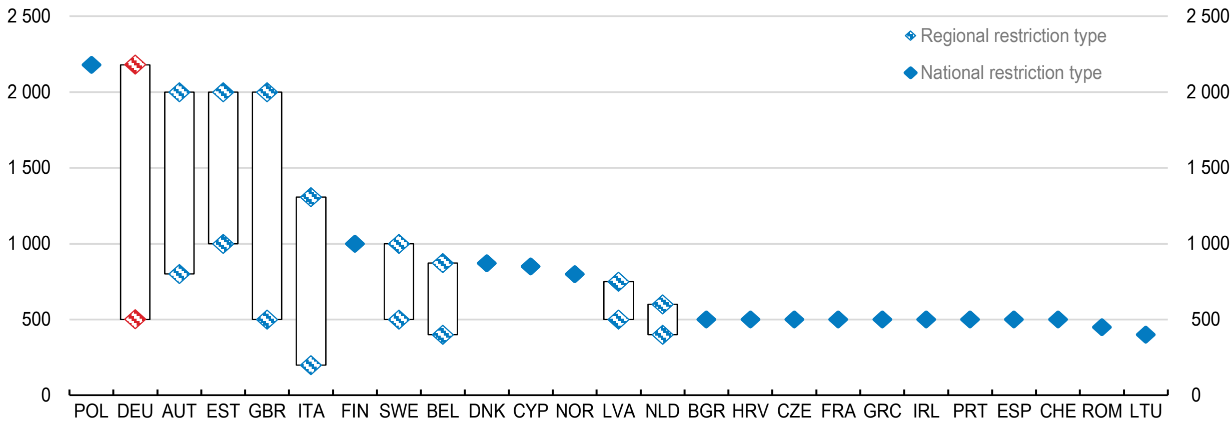
Source: Ember, https://ember-climate.org

StatLink https://stat.link/9uloy2

Public opposition, conflicts with nature protection objectives and lengthy planning and approval procedures are the main barriers to expanding renewables. This is especially true for onshore wind power. From 2019 to 2021, Germany added, on average, only 5 gigawatts of wind capacity, compared to 14 in the previous three years. The slowdown is partially due to strong resistance in some Laender that, among others, have imposed restrictive minimum distance regulations for onshore wind turbines (Figure 2.29). In Bavaria, for example, the introduction of minimum distance rules decreased the number of construction permits for wind turbines by 90% (Stede and May, 2020[106]). The new Onshore Wind Energy Act tackles this challenge by limiting the ability of Laender to set overly restrictive rules. According to the Act, Germany's 13 larger Laender must designate 1.8% to 2.2% of their surface area to onshore wind power by 2032, depending on their wind conditions and the size of their nature protection areas, while the three city states need to dedicate 0.5% of their respective surface areas. Laender will keep relying on their own planning capabilities and can, in principle, stick to individual distance rules. However, if they don't manage to assign enough space to wind turbines, wind power investors will be automatically allowed to build turbines in restricted areas. According to the law, states are allowed to exchange up to 50% of their designated sites with overachieving Laender to fulfil their obligations.

Figure 2.29. Strict regulations slow down the deployment of renewables

Minimum distance of wind turbine from settlements, meter



Note: A Vestas V136 turbine with 218m tip height is assumed.
Source: Ember, https://ember-climate.org

StatLink https://stat.link/4r8xfo

The German government took essential steps to streamline permitting procedures but the ambitious targets demand reducing administrative and legal burdens further. The government adopted an amendment to the Renewable Energy Act, which emphasises that the use of renewable energies is of "overriding public interest" and will be given priority over conservation concerns until net-zero is achieved. It also enables the building of wind turbines closer to air traffic control and meteorological systems and sets uniform federal standards for species protection assessments. Setting a single contact point for all permitting procedures, being transparent on deadlines, roles and responsibilities of the different authorities and applying silence-is-consent rules could lower the administrative burden. Raising capacity and allowing for more specialisation of administrative and court staff, in accordance with the expected increase in tenders, and adopting a population-based approach to biodiversity protection (i.e., protecting species numbers instead of individual creatures) could help as well (Wind Europe, 2022[107]). Collaborative planning approaches and public campaigns that emphasise the positive effects of expanding renewables to rural areas due to the creation of new jobs could help lessen local resistance (Wolsink, 2000[108]) (Brunner and Schwegman, 2022[109]). Nonetheless, the impact of accelerated and streamlined permitting processes on biodiversity goals should be carefully analysed to inform future policy design.

Simplifying permitting and improving planning procedures is also crucial for the expansion of solar energy. Over the last decade, the number of solar panels deployed has increased massively while their costs have declined drastically. In 2021, Germany added almost 5 gigawatts of solar power capacity, 9% more than in 2020 (but still much less than around 2010). Rising energy prices since Russia's invasion of Ukraine have boosted demand for solar installation further (BSW solar, 2022[110]). Nonetheless, massive expansion of free-standing plants, especially big solar farms, could lead to conflicts and acceptance problems. Integrating solar panels into existing built-up areas, mainly on buildings, agricultural lands, and roads can be a solution (Fraunhofer ISE, 2022[111]). The government opens more agricultural areas to solar panel installations, allows community solar parks to be built without participating in tenders, makes installing solar roofs mandatory for all new commercial buildings and has suspended the feed-in tariff payment reductions until the beginning of 2024. Upgrading the capacity of municipal planning offices and streamlining administrative procedures could help accelerate deployment.

Modernise the transmission network

A rapid expansion of wind and solar energy poses challenges for the transmission network: Electricity generation from renewables is less stable over time and the electricity generated by wind turbines in the north must be transported to the major power consumption regions in the west and south. Therefore, considerable expansion of the electricity network and a better balance of supply to variations in demand are needed. However, the expansion and restructuring speed is lagging far behind what is needed, mainly due to lengthy planning procedures (BMWK, 2022[105]). The government intends to simplify the permit procedures by partially dispensing with the spatial planning and approval procedures and replacing them with federal sectoral planning.

Nevertheless, little progress has been made in changing grid charge incentives to better balance electricity demand and supply. Overall, price signals on the consumer side are weak due to static levies, taxes, and grid charges. In addition, the grid charges – that account for about 28% of industrial consumer electricity price – incentivise stable consumption of electricity. For instance, the Electricity Network Fee Ordinance grants large energy-intensive industrial consumers reduced grid charges for keeping their electricity consumption constant over time (Hanny et al., 2022[112]). Moreover, grid charges are higher in the north and east than elsewhere, lowering incentives to establish energy-intensive plants (such as electrolysis plants to produce green hydrogen), despite a large amount of wind power. Encouraging the establishment of new plants where energy is more abundant should be combined with abolishing the concessions for energy-intensive industries and introducing time-variable electricity charges as well as peak pricing to ensure that the costs of grid utilisations are based on the actual state of the grid (Fritz, Maurer and Jahn - Projektleitung, 2021[113]). This would incentivise the use of available technologies, such as smart thermostats and water heating, to shift electricity use across time and reduce peak demand times on the grid (raise load flexibility), thereby minimising generation and transmission costs. Therefore, the government's plan to require all electricity suppliers to offer dynamic tariffs from 2025 is welcome.

As electricity generation from renewable energy sources fluctuates, a better communication network is needed to link generation, consumption, and the grid. Smart meters and contracts together with better storage units can help households optimise their electricity consumption and even feed the grid in times of high demand. Likewise, they can provide decision makers with a more precise picture of energy consumption patterns and save resources by eliminating the need to visit the traditional meter readers. Nonetheless, the rollout of smart meters in Germany is lagging considerably, mainly due to data protection issues and the fear of cyber-attacks (European Commission, 2020[114]). In 2021, the Federal Office for Information Security (BSI) withdrew its target for the roll-out of 10% of the measuring points with smart meters until 2023 due to a lawsuit by municipal utilities. By contrast, in Sweden, Finland and Estonia, 100% of households now have smart meters and in Italy a second round of deployment is already taking place. The Government agreed on a bill that should accelerate the rollout of smart meters by setting a roadmap for their deployment, reducing unnecessary regulations and facilitating the installation of smart meters' secure communication unit at the grid connection points. The proposed bill also seeks to cap the annual costs of the meters for consumers (EUR 20) so the grid operators will have to bear a more significant share of the cost. This measure may reduce the incentives of the grid operators to accelerate the deployment of smart meters and should be evaluated carefully. Dedicating more investment to strengthening data protection and cyber security could help to increase public acceptance for the deployment of smart meters.

Rising electricity demand and the coal and nuclear phase-out limit the amount of flexible capacity in the electricity market, creating a risk that producers will raise electricity prices by withholding capacity. In 2021, RWE – the largest electricity supplier in Germany, accounting for 25% of the market – was indispensable for meeting the electricity demand in a significantly higher number of hours, which means it has substantial market power (The Monopolies Commission, 2022[115]). Promoting competition in the market is crucial for keeping electricity affordable. The regulatory set-up in Germany's electricity sector is competition-friendly, but the share of consumers who switch suppliers is lower than in other EU countries (OECD, 2018[116]). Upgrading grid connections with neighbouring countries and improving transparency and data access for investigating anti-competitive behaviour could help to strengthen competition as well as energy security. Fostering competition in the cross-zonal intraday market by expanding trading times is also key. It could boost competition between electricity exchanges, which in turn will promote innovation and investment in the intraday market (The Monopolies Commission, 2021[117]).

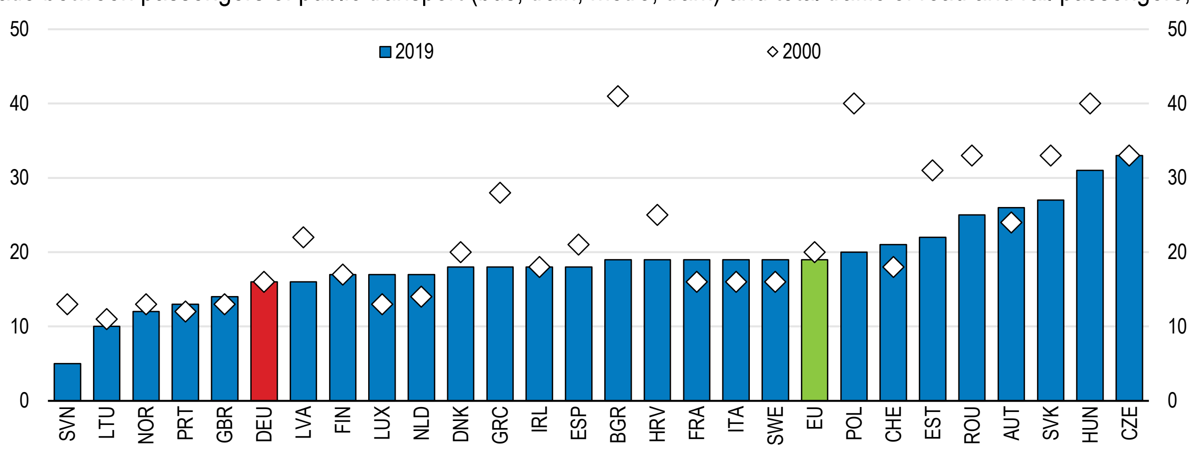
Decarbonising transport and shifting to more sustainable transport modes

Transport is the second largest source of GHG emissions in Germany, contributing 20% of total emissions. The actual share is likely higher because international aviation, shipping, and emissions from electricity consumption in transport are not included in the data. Greening transport is challenging. For some forms of transport – notably maritime and aviation – economically viable solutions are not yet available (IEA, 2021[57]). Nonetheless, most emissions from transport arise on land for which mature technological solutions, such as electric vehicles or rail are available.

The decarbonisation of Germany's transport sector is not on track: emissions from transport in Germany were broadly stable in the last two decades. Emissions per kilometre of Germany's car fleet have decreased by 9% since 1995, but heavier cars and rising mileage in passenger transport cancelled out the positive effect of improved engine efficiency. Furthermore, the shift to public transport has been limited (Figure 2.30). Simultaneously, emissions in domestic freight transport increased by about 75% from 1990, with a twofold increase in road freight and slower growth in rail (Federal Ministry for the Environment, 2021[118]). Travel and freight movements are projected to rise over the coming years due to rising living standards and trade. Considering the increase in travel movements and all mitigation measures adopted until 2022, emissions in transport are projected to reach 126 million tonnes of CO_2 by 2030, which is 40 million tonnes above the sectoral target (UmweltBundesamt, 2022[119]). Thus, major policy changes are needed. Focusing only on either greening road transport or improving public transport would fall short of bringing Germany close to net-zero.

Figure 2.30. Public transport remains limited

Ratio between passengers of public transport (bus, train, metro, tram) and total traffic of road and rail passengers, %



Source: Odyssee-Mure database.

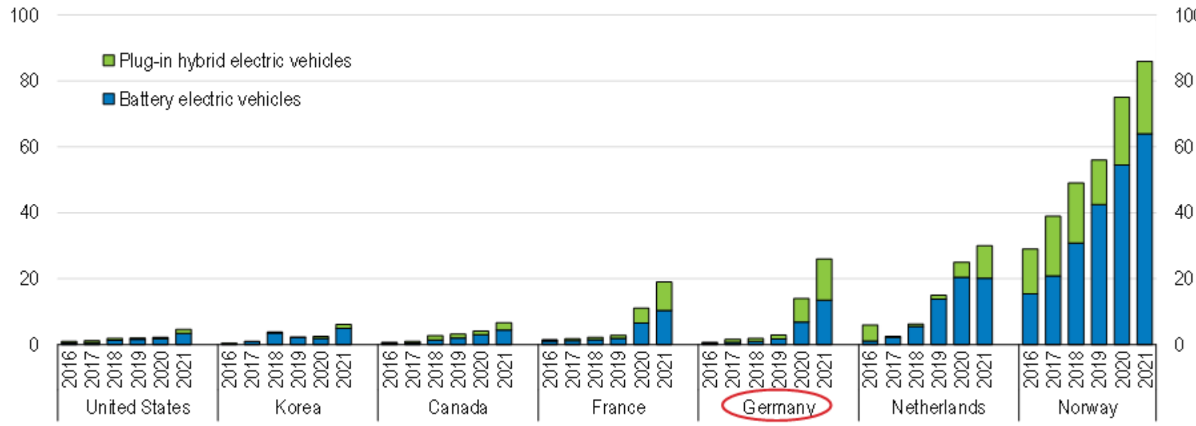
StatLink https://stat.link/nvkdp6

Cutting emissions per kilometre travelled on the road

The share of low-emissions vehicles in new car registrations (26% in 2021) is among the highest in the OECD and EU countries and has been growing rapidly since mid-2020 (Figure 2.31). This is related to tightening European CO_2 standards, restricting access of fossil-fuel cars to dense areas and subsidies for the purchase and maintenance of electric cars. To reach the government's target of at least 15 million passenger cars to be fully electric by 2030, which would allow closing about half of the gap between current transport emissions and the 2030 climate target, the share of electric cars among new registrations should reach at least 50% by 2025 and 85% in 2030 (Federal Ministry of Economic Affairs and Climate A, 2022[120]). This is only feasible with a much quicker expansion of charging infrastructure. Moreover, the efforts to electrify the car fleet should be better coordinated with other national targets, such as increasing the share of alternative modes of transport (like walking and cycling) and reducing congestion and car accidents (European Commission, 2019[121]).

Figure 2.31. The share of low-emissions vehicles is growing rapidly

Electric car sales, share in new registrations, %



Source: IEA, Global EV Data Explorer

StatLink https://stat.link/e9pnam

Government subsidies strongly incentivise the purchase of electric and hybrid cars and operating expenses are already around 40% lower for electric vehicles than for fossil fuel-powered cars (Table 2.6). For example, consumers receive a subsidy of up to EUR 4 500 for purchasing an electric car, which is expected to decline to EUR 3 000 in 2024, and EUR 900 for purchasing a home charging station. Additionally, the government supports the deployment of fast-charging infrastructure along the countries' highways and has eliminated the renewable energy surcharge. Due to these subsidies and the high oil prices in 2022, driving a median electric car has become cheaper than driving a median conventional car (Table 2.6) (Miotti et al., 2016[122]),(Agora Verkehrswende, 2022[123]). In the executive and luxury vehicle classes, battery-electric vehicles are already cheaper than their combustion-engine counterparts even without subsidies, as other equipment features are more important price determinants compared to engine parts (Agora Verkehrswende, 2022[123]).

Table 2.6. Government subsidies strongly incentivise the purchase of electric cars

Breakdown of the costs for different cars, per 100 kilometres, in euros

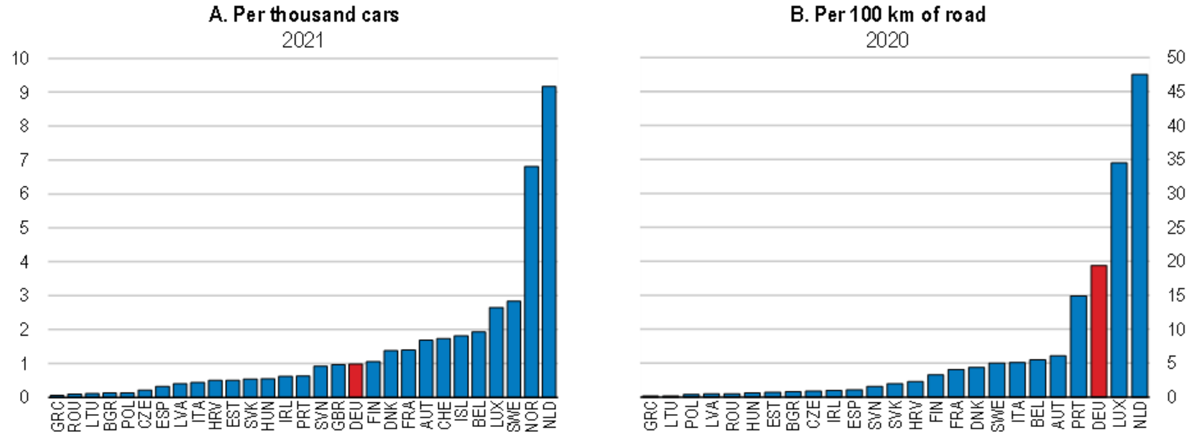
	Battery Electric Vehicle (BEV)	Plug-in hybrid	Petrol car	Diesel car
Capital Costs				
Purchase cost (Incl. VAT)	28.43	24.27	18.48	19.56
Subsidies (-)	4.31	3.38	-	-
Operational Costs				
Fuel/charging cost	5.08	8.40	9.99	7.96
Maintenance cost	4.91	5.76	6.62	6.62
Insurance	3.05	3.66	4.28	4.33
Yearly car tax	Exempt	0,53	0.75	1.72
Total, excluding subsidies	**41.45**	**42.63**	**40.12**	**40.20**
Total, including subsidies	**37.16**	**39.25**	**40.12**	**40.20**

Note: The analysis is based on 2022's data. The expenses are calculated for an average driver. Capital costs include the purchase expenses of a car and a home-charging station. Operating costs are calculated as the annual and lifetime mileage of 13,700 and 160,000 km, respectively. The car models were picked within the same classification according to the “Europe-wide safety assessment programme”. For the electric vehicle, the Volkswagen ID.3. is chosen. It was the third most sold electric vehicle in Germany in 2021 and is classified in the “small-family car” segment by Euro NCAP. The counterpart within the same category (small-family car) in the petrol and diesel variation is the Volkswagen Golf. For the plug-in hybrid, the Volkswagen GTE is chosen. There are several possibilities to charge electric car’s battery: Charging publicly at a slow-charging station (AC), charging publicly at a fast-charging station (DC) and charging at home. Since no driver would use solely one option, the simulation assumed that alternative powertrains “refuel” energy for 66.6% of the time at home and 33.3% at public charging points. For internal combustion engine vehicles, average fuel prices are based on data from June 2022. Average figures for car-insurance premiums in 2020 are used, assuming the vehicle owners opt for mandatory vehicle insurance and additional full-coverage insurance.
Source: Author’s calculations based on data from Euro NCAP, the Central Association of the German Motor Trade, EnBW, and Institut der Automobilwirtschaft.

Besides myopia, high uncertainty regarding future fuel prices and a lack of reliable information on cost differences, a main reason for not purchasing an electric vehicle is concerns about practicability, such as range and the availability of charging stations (IEA, 2022[124]). Vehicle uptake will be constrained until sufficient charging infrastructure is available, but private investments in infrastructure require more certainty about vehicle uptake. Thus, the government has a pivotal role in developing this market to make electric vehicle charging at least as easy as filling a conventional vehicle tank. In Germany, public charging points per 1 000 vehicles are below the EU average, with wide variation between Laender (Figure 2.32, Panel A) (ACEA, 2021[125]). When charging points are related to roads length, performance looks slightly better (Panel B). The government plans to install 1 million public charging points with non-discriminatory access by 2030, focusing on developing fast-charging infrastructure. In November 2022, only 72 000 charging points were in operation, of which 11 850 were fast charging points. Thus, more than 9 000 new charging points need to be deployed every month until 2030 to reach the government’s target. However, a smaller number of public charging points might be enough to supply services for 15 million electric cars, particularly if the deployment of fast charging points is accelerated. In that case, fewer charging points will be needed overall (PwC, 2022[126]).

Alongside the deployment of infrastructure, fostering competition in the charging infrastructure market is crucial. Individual operators in the market often control a high proportion of the charging points in particular regions (Monopolies Commission, 2021[127]). Customers often cannot access information about operators’ prices when charging directly without preliminary registration. Subsidies should be targeted at small players in the charging point market (those who own less than 40% of all charging points in a local area) and support the diversity of operators. Standardizing market access and pricing, such as per kilowatt of energy, and linking public tenders and support measures to performance targets could help to ensure access to reliable information and quality service as well as to ease cross-border mobility (IEA, 2022[124]).

Figure 2.32. Germany lags top performers in the number of charging points



Source: German Association of the Automotive Industry; European Automobile Manufacturers' Association (ACEA).

StatLink https://stat.link/ugvkd1

The purchase subsidies for electric cars should gradually abolished to create fiscal space for other support measures, including the scale up of charging infrastructure. Purchase subsidies are costly, amounting to EUR 2.1 billion in 2022, and should be confined to the initial marketing step of a new technology (Federal Ministry of Finance, 2021[128]). They are regressive, as most electric car buyers are richer than the average household, and they have supported the purchase of heavier cars, lowering energy efficiency and driving up demand for critical minerals. The speed of the subsidy phase-out should consider the decline in battery costs, the expected rise in carbon prices and developments in the oil market to prevent a strong drop in incentives to buy electric cars. Simulations conducted for this survey show that the incentives to buy an electric car are highly sensitive to changes in battery and fuel prices (Figure 2.33, Box 2.8). To enable consumers to conduct more accurate cost comparisons, the government can require car dealers to prominently display the total typical cost of vehicle ownership for consumers (Agora Verkehrswende, 2022[123]). Currently, the purchase price tends to be a prominent and more salient factor in consumer purchase decisions.

Box 2.8. What determines the attractiveness of buying an electric vehicle?

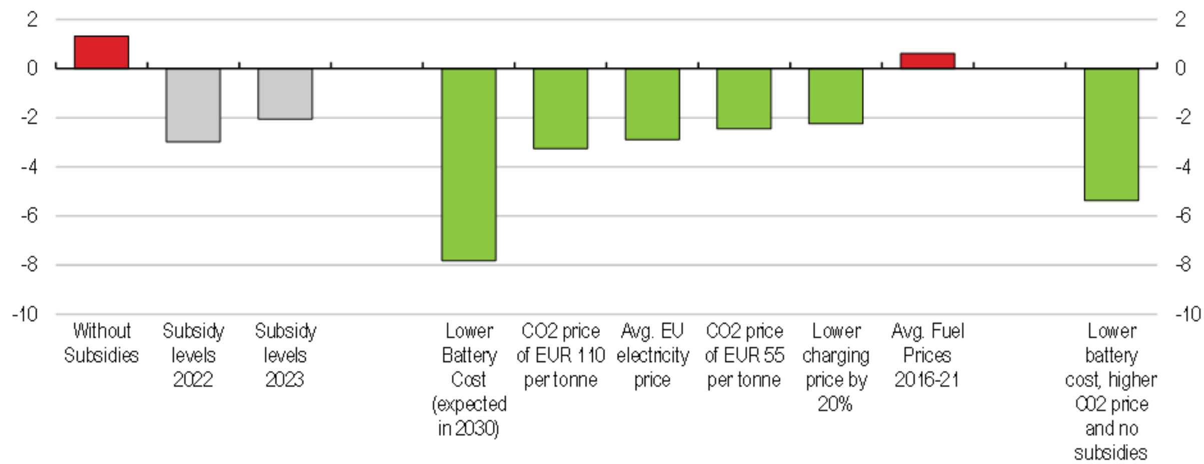
To better understand how changes in the relevant costs influence the motivation to shift to low-emissions vehicles, simulations considering several scenarios were conducted for this Survey (Figure 2.33). In each scenario, only one cost variable is changed, while the others remain constant (Table 2.7). Costs to buy an electric car are compared to the costs of buying a similar petrol car (see Note to Table 2.6).

Table 2.7. Main parameters affecting the decision to shift to driving low-carbon vehicles

Scenario	Description
A further decrease in battery cost	Over the last decade, the cost of a lithium-ion battery declined by around 85%. Rising material prices and soaring inflation have halted the decline in 2022. However, prices are expected to decline further from 2024 (BloombergNEF, 2022[129]). The battery cost of an electric vehicle can decrease by 50% until 2030, which corresponds to an estimated 21% decrease in car purchase costs (König et al., 2021[130]).
A lower household electricity price	Electricity prices are higher in Germany than in most European countries. In the second half of 2021, the EU average electricity price was 23.7 cents per kWh compared to 32.3 cents per kWh in Germany. A decrease in electricity prices to the EU average is considered in this case.
Higher carbon prices	In the beginning of 2021, Germany implemented a CO_2 price on transport fuels of EUR 25 per tonne, implying an increase of 7 cents per litre of petrol and around 8 cents per litre of diesel. In 2026, the CO_2 price will be EUR 55.A further increase in the carbon price to EUR 110 per tonne is considered.
Fuel prices return to their long-term average	Given the volatility of fuel prices, consumer expectations might be based on the long-term average rather than the current prices. The additional cost related to driving an electric vehicle is calculated according to the average fuel prices from 2016 to 2021 in that case.
Lower public charging prices	A reduction of 20% in both the slow- and fast-charging possibilities due to economies of scale, potential subsidies from the government, higher competitiveness in the market and technological developments is considered.

Figure 2.33. Incentives to buy an electric car are highly sensitive to changes in battery and fuel prices

Additional cost related to driving an electric vehicle (compared to a combustion engine car) under different policy scenarios, per 100 kilometres, in EUR



Source: Author's calculations.

StatLink https://stat.link/uzd34e

A more sustainable and socially equitable way to incentivize the shift to low-emission vehicles, especially in case carbon prices remain too low, would be to impose a registration tax for new cars, with tax levels varying based on CO_2 emissions. Germany is one of the only OECD countries that does not tax vehicle purchase or registration (see below). Along with the EU fleet-wide CO_2 emission reduction targets for new passenger cars and vans and the ban on the registration of new internal combustion cars by 2035, the introduction of a registration tax for petrol- and diesel-based vehicles would maintain a strong signal regarding the need to accelerate the shift to low-emission passenger cars. Speed limits on motorways would be another way to cut emissions per kilometre travelled on the road. According to the German Environment Agency, it would allow reductions of GHG emissions ranging between 1.9 and 5.4 million tonnes annually, depending on the limit imposed (UmweltBundesamt, 2020[131]).

Though freight vehicles represent a relatively small percentage of on-road vehicles, they account for 36% of transport emissions. The technological pathway towards zero-emission heavy goods vehicles is uncertain, but some mix of electric vehicles, technology that would allow vehicles to draw power from the grid while in use (route electrification) and fuel cell electric vehicles powered by hydrogen have the potential to eliminate emissions by the middle of the century (Lyons, Curry and Rohr, 2021[132]). Given technological uncertainties, the focus in the short term should be on supporting research and development by increasing funding dedicated to this field. This should be complemented by reducing the highway toll for low-emissions large goods vehicles for a limited period and supporting EU efforts in tightening the EU's CO_2 fleet target values for heavy vehicles.

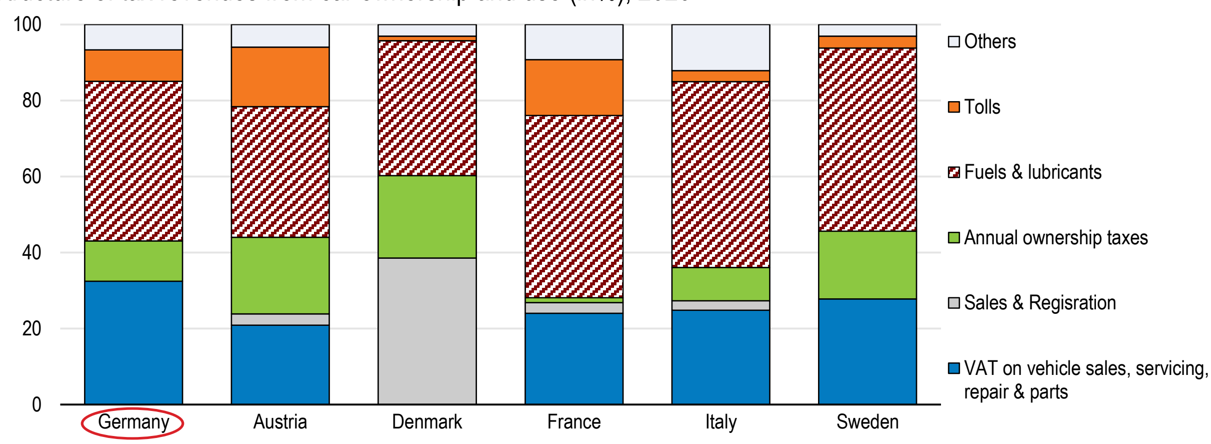
Cutting emissions by moving transport off the road

Public support for emission reductions is an opportunity to change the way people travel. The share of distance travelled by walking and cycling in cities in the Netherlands is more than twice higher than in Germany, for example, and the share of travel by car is eight percentage points lower (Eurostat, 2021[133]). Reducing private car use can help to lower emissions, but also improve health outcomes by reducing air pollution, congestion, and noise in urban areas. Strengthening urban planning, improving the quantity and quality of public transport, and modernising the tax system – e.g., abolishing environmentally harmful subsidies and tax expenditures and relying more on distance-based taxes – should be the main priorities.

The rising electrification of the vehicle fleet will undermine the tax base for fuel taxes and risks to increase negative externalities related to driving, such as congestion, which are currently not priced. Relying more heavily on tolls, consistent with the polluter-pays principle, would contribute to making mobility more sustainable and provide resources for investing in transport infrastructure and other needs (Frey et al., 2015[134]). Distance-based tolls for private vehicles that make it possible to set differentiated charges for infrastructure and internalise other external costs due to road traffic should be promoted as soon as possible to avoid increasing resistance as electric vehicles become more widespread. The collection mechanism could rely on lessons learned from the HGV tolling scheme that applies to heavy goods vehicles on motorways and federal roads, first introduced in 2005. An initial toll rate of about one cent per kilometre driven would yield a revenue of 6.6 billion euros, while a toll rate of 4.3 cents/km would fully finance the road infrastructure costs (based on 2018 car mileage in each case) (German Environment Agency, 2021[135]). Such revenues could largely offset the decline in energy tax revenues from 2030 on. Local externalities (such as noise and congestion) could be more effectively addressed through local measures such as congestion charges. In the short run, Germany has room to increase truck charges using existing charge mechanisms as well as purchase taxes, which are below the levels in France and Denmark (Figure 2.34). A recent government decision to raise truck charges is, therefore, welcome. However, instead of making the charges more dependent on carbon emissions, which would further increase heterogeneity in carbon pricing across sectors, the planned cap-and-trade system for Non-ETS sectors should be phased in earlier and its cap should be aligned with national emission reduction targets to harmonise carbon prices across sectors and reach emission targets more cost-effectively.

Figure 2.34. There is room to increase highway tolls and truck charges

Structure of tax revenues from car ownership and use (in%), 2020



Source: ACEA tax guide.

StatLink https://stat.link/w0lju6

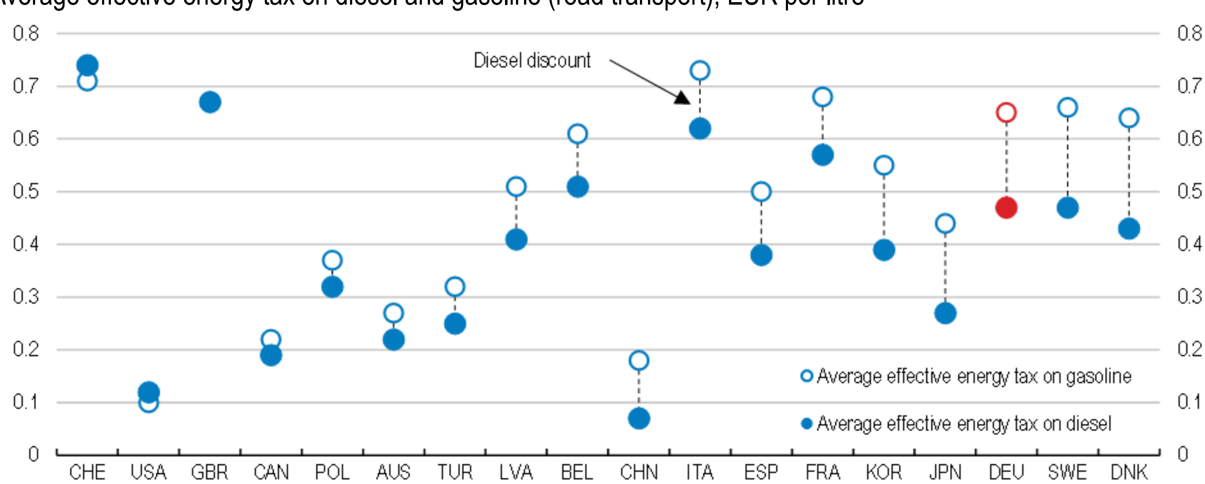
The current tax allowance for commuters – a tax deduction of EUR 30 cents per kilometre of traveling from home to work, regardless of means of transport, and 38 cents for distances of 21 kilometre or more – offers incentives to travel larger distances than necessary, jeopardising climate goals and encouraging urban sprawl and land use. Moreover, this EUR 6 billion tax allowance is regressive: high-income earners commute larger distances and pay higher marginal taxes, therefore enjoying a more substantial deduction. In several OECD countries (such as Australia, Italy, and the United Kingdom), commuting expenses are considered a personal non-deductible decision. In the OECD countries where the commuting deduction does exist, the deductible rate per kilometre is lower (Harding, 2014[136]). Abolishing the distance allowance is estimated to lower greenhouse gas emission by about 2 million tonnes in 2030, about 0.5% of the needed reduction according to the government's targets (Burger and Bretschneider, 2021[37]). Replacing this tax expenditure with a targeted support for employees who have high travel costs as a share of their income or to those who must accept long distance work for social or professional reasons could reduce emissions and inequalities.

Fossil fuel subsidies and tax expenditures weaken price incentives to reduce transport emissions. Diesel is taxed at significantly lower effective rates than gasoline, even though CO_2 emissions per litre of diesel are higher (Figure 2.35). Meant to encourage commercial road traffic, this tax expenditure was introduced when the share of diesel cars was low. Currently, diesel cars account for about 32% of all cars in Germany. As diesel vehicles are used especially by companies – which react more to change in prices – phasing out the lower taxation of diesel could have a substantial effect on behaviour and emissions (Zimmer and Koch, 2016[137]). It could reduce emissions by 3.7 million tonnes in 2030 (Burger and Bretschneider, 2021[37]). Other harmful tax expenditures include the exemption of agricultural vehicles from the vehicle road tax and the tax rebates farmers receive for their diesel consumption.

Furthermore, generous tax breaks for the private use of company cars – which represent about 60% of all new passenger cars in Germany – blur the price signals for those who get the benefit. This increases the number of cars in the economy and overall transport demand, incentivises buying larger and heavier cars as well as discourages energy-efficient driving (Metzler, Humpe and Gössling, 2019[138]). Where a vehicle is provided to an employee, the employer typically pays the annual registration and insurance costs as well as fuel and other operating expenses, regardless of whether they relate to personal or business use. Currently, the value of this fringe benefit, which is treated as taxable income, is mainly assessed based on the 1% rule, i.e., each month, 1% of the list price of the car (lower for cars with low CO_2 rating) is taxed according to the employee's income. In addition, there is a variable component based on the number of kilometres between the employee's home and workplace. Consequently, the tax benefits increase with the value of the car due to the untaxed capital component as well as the distances travelled privately, given the fixed level of taxation. Other countries use values above 1% of the list price to tax the fringe benefit. Thus, the tax benefit in Germany is high (Harding, 2014[136]). Unsurprisingly, company cars are driven almost twice as much as private cars, while company owners – who have higher incentives to save energy – drive less than employees (Metzler, Humpe and Gössling, 2019[138]). Companies favour car benefits as compensation because they only pay social security contributions on the 1% list price taxed, saving on costs that would arise should the full value of the company car be taxed. As for other fossil fuels subsidies, this beneficial tax treatment should be abolished. However, in the short run, reducing the generosity of the tax benefit only for cars with high CO_2 emissions could accelerate the shift to low-emissions vehicles.

Figure 2.35. Many fossil fuel subsidies jeopardise climate goals

Average effective energy tax on diesel and gasoline (road transport), EUR per litre



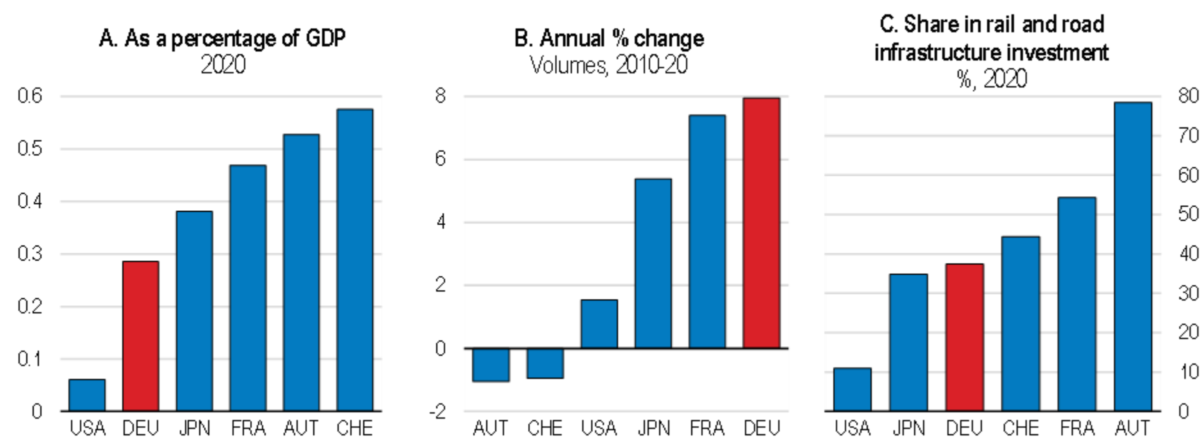
Source: OECD (2022), Pricing Greenhouse Gas Emissions: Turning Climate Targets into Climate Action, OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris, https://doi.org/10.1787/e9778969-en.

StatLink https://stat.link/2v1d9x

Rail accounts for only 9% of passenger traffic in Germany and 19% of freight transport (Bundesnetzagentur, 2021[139]). The quality of the rail services deteriorated in the last decade, with an increasing share of delayed trains and a shrinking network infrastructure. Consumer's satisfaction is lower than in the EU average, especially regarding punctuality, availability of Wi-Fi on trains and accessibility for persons with disabilities (European Commission, 2018[140]). Likewise, the electrification of the rail network has barely increased since 2015. The federal government aims to double rail passenger transport and increase the market share of rail freight transport to 25% by 2030, among others, to reduce the number of flights which have a high carbon footprint. It also aims to electrify 75% of the rail network by 2030 from a level of 62% in 2021. To reach these targets, investment in rail infrastructure needs to be prioritised and rise considerably. Rail investment has increased since 2010, but it is still far lower as a percentage of GDP than in leading countries like France and Switzerland, and lower than road infrastructure investment (Figure 2.36). In 2019, Bardt et al. (2020[141]) estimated that EUR 60 billion are needed over the following 10 years to overcome the investment backlog and improve supraregional rail infrastructure. This also requires simplifying and speeding up planning and approval procedures for rail infrastructure projects and addressing capacity constraints in the construction sector (see above) (BMDV, 2022[142]). A recent government decision to define key railway projects as an objective of national interest and, therefore, facilitate planning and approval procedures, has the potential to significantly accelerate rail infrastructure investments.

Figure 2.36. Investment in rail should increase further

Investment in rail infrastructure



Note: For the United States, 2019 data are used.
Source: The International Transport Forum (ITF) database.

StatLink https://stat.link/rqai41

Digitalisation can improve the quality of these investments and the attractiveness of the railway system. Accelerating the digitalisation of the control and signalling systems could improve safety and train connections, while helping rail companies to cope with scarce human resources (BMDV, 2022[142]). Lack of staff for operating the old signalling systems has recently restricted train services. Further simplifying the train ticketing system and reducing train tariffs proved to have a significant impact on public transport attractiveness (Box 2.9). Providing sales platforms with a non-discriminatory access to data would be necessary to protect competition in the market (Monopolies Commission, 2021[143]). Improving recruitment of specialists for planning and construction of rail infrastructure, e.g. through more flexibility in pay schedules, is key.

Box 2.9. Early lessons from the EUR 9 public transport ticket experiment

Simplifying the train ticketing system and reducing tariffs significantly impact public transport attractiveness, but the impact on environmental goals seems more limited. As part of the measures taken to mitigate the increase in energy prices due to Russia's war against Ukraine, the government introduced a EUR 9 ticket from June to August 2022: Citizens in Germany could travel nationwide on all local and regional buses and trains by using a monthly single ticket. About half of Germany's population (40 million people) purchased the ticket. Rail travel has grown considerably in the first month after the introduction. In June 2022, movements in rail transport were 42% higher than in June 2019, while in May 2022, they were only 3% higher than in May 2019. The change during weekends was significantly greater (Federal Statistical Office, 2022[144]). Nonetheless, the cost of this measure was high: The federal government provided the states with an additional 2.5 EUR billion (0.26% of the quarterly GDP) to compensate for the loss of ticket sales, excluding funds for added person capacity.

Research on the impacts of the reform is still ongoing. Initial findings show that shifting away from cars was limited: Around a quarter of the journeys made in public transport would not have been made without the ticket, and only about 3% of the users took public transport instead of driving. Nonetheless, a decrease in traffic jams was evidenced in 23 out of Germany's 26 major cities, and about 22% of the users said they used public transport for the first time due to the scheme (VOX, 2022[145]). However, a better balance between measures to improve service quality – in particular through more infrastructure investments – and reducing fares is needed. For enhancing public transport usage, quality-of-service improvements are at least as important as lowering fares (Graham, Crotte and Anderson, 2009[146]).

Following the popularity of the 9-euro ticket, a similar ticket at a monthly cost of 49 EUR will be available from spring 2023. Expenses are estimated to stand at EUR 3 billion annually and to be shared evenly between the federal government and the Laender.

Fostering competition in the railway market would improve the quality of rail services and lower prices. Although smaller competitors continued to gain market shares in recent years (mainly in freight transport), 96% of long-distance rail transport and 72% of regional and short-distance transport in 2019 were still conducted by the national rail company, Deutsche Bahn (DB), which is both a rail operator and infrastructure manager that provides services to other rail operators (Bundesnetzagentur, 2021[139]). A substantial equity injection in favour of DB during the COVID-19 crisis risks distorting competition in the market further as increasing borrowing costs for private firms hamper their ability to compete. To strengthen competition in the market, the federal government should demand more transparency regarding DB's investment decisions and set quality indicators to ensure investments are used sustainably (Monopolies Commission, 2021[143]). Likewise, the government can share some of the risks of new competitors by, for example, introducing a limited reimbursement mechanism for lost ticket sales. A vertical separation of the infrastructure from the operations within the DB group would be the first best solution to enhance competition in the long run (Monopolies Commission, 2021[143]). Currently, both the operation and infrastructure companies within DB group share management functions such as legal advisory, financial management, and corporate development. In addition, profits and losses are transferred between companies (within DB).

Coordinating policies on housing and transport can accelerate the transition

Households' use of private transport also depends on housing and work locations (OECD, 2021[147]). Since 1990, urban sprawl has considerably increased. About 20% of the urban population in 2014 resided in areas of very low population density, which the OECD defines as a density of 150-1 500 per km^2. This share rose by about three percentage points since 1990. It is difficult and costly to provide high quality public transport to low-density areas, explaining why public transport use is usually lower for residents in remote regions. Therefore, integrating land-use and transport planning, promoting densification, and encouraging public transport, cycling and walking is key to reduce distances travelled and emissions.

Local authorities play a crucial role in densification through their responsibility for transport system planning and regulation on land use and zoning. More compact urban development patterns and higher density combined with public transport planning would help to improve the competitiveness of sustainable modes of transport. However, this requires a shift in planning from the traditional “predict and provide” approach that expands transport infrastructures to meet inferred latent demand towards management of available road space according to strategic planning. To promote cycling, local authorities could set a standard speed of 30 km/h in certain built-up areas. In addition, planning procedures for cycling infrastructure (such as cycling lanes and parking) could be streamlined. The federal government can help by subsidising bicycles instead of cars. Sweden, for example, launched a subsidy for electric bikes of up to USD 1100 in 2017. About 100 000 people used the subsidy to purchase an electronic bike, and about two thirds of them would not have done this without the support. Each bicycle is estimated to have reduced lifetime carbon emissions by 1.3 tonnes (Anderson and Hong, 2022[148]). In the United Kingdom, a cycle-to-work scheme allows employers to buy or lease bicycles and related equipment for their employees and supports them with deductions of income tax and social security contributions. Employees can save up to 40% of the cost of a new bicycle. Over the past ten years, more than 1.6 million people participated in the scheme, including nearly 200 000 during the COVID-19 pandemic between March and September 2020 (OECD, 2022[149]).

Decarbonising buildings through energy efficiency improvements and renewable energy use

A combination of high per capita energy use and extensive reliance on fossil fuels puts Germany among the OECD countries with the highest emissions per capita from the residential sector (OECD, forthcoming[150]). Only 19% of the final energy use in the building sector is supplied by district heating and renewables; a share that is rising only slowly (Ministry For Economic Affairs and Climate Action, 2022[35]). The government now aims to reduce emissions in the sector by 42% until 2030, although a more flexible and decentralised approach relying on unified carbon pricing and allowing faster emission reductions in sectors with lower abatement costs would be preferable (see above).

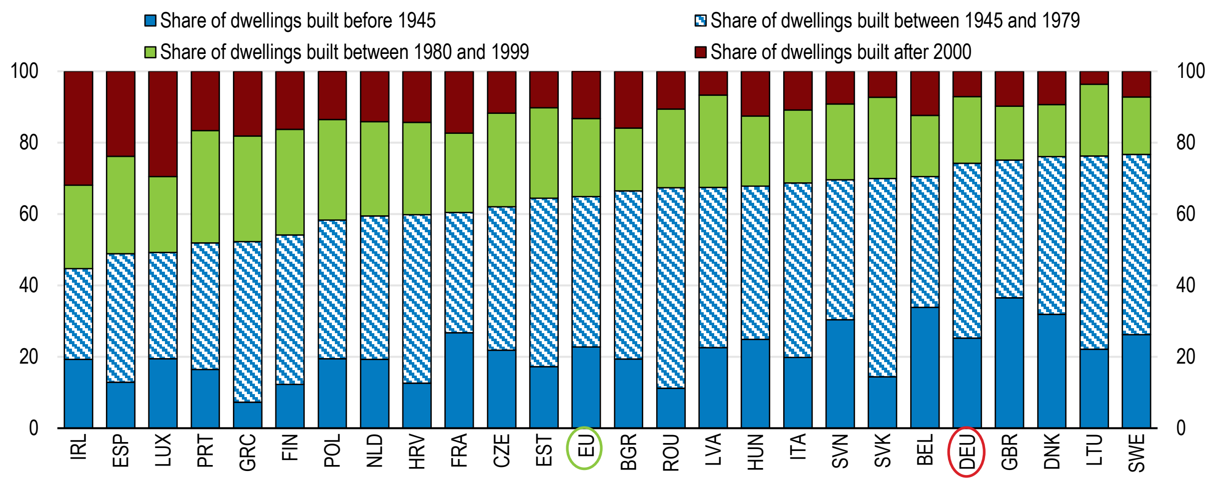
Accelerating building renovations and at the same time increasing energy efficiency standards are key priorities for faster decarbonisation. Fully refurbished buildings in Germany consume, on average, 22% less energy than un-refurbished buildings while new buildings have 39% lower energy consumption (Federal Ministry for the Environment, 2021[151]). However, only 12% of the building stock is classified as new (4%) or fully refurbished (8%). The main challenge is that the building stock is old and characterised by low annual renovation rates (Figure 2.37). Roofs in Germany, for instance, are replaced every 50 to 55 years (German Council of Economic Experts, 2021[10]).

The introduction of the national emissions trading scheme and the abolishment of the EEG surcharge (see above) as well as the higher energy prices due to the war in Ukraine create strong incentives for renovation and shifting to lower-emission heating systems. This is particularly true for industrial heat pumps, which additionally benefit from generous subsidies (IEA, 2022[152]). Nonetheless, the high abatement costs in the sector call for continued investments in innovative technologies and infrastructures, such as the expansion of the electricity distribution grid to support heat pumps in residential buildings (IEA, 2022[152]). Moreover, homeowners who are willing to renovate often struggle to find contractors (German Council of Economic Experts, 2021[10]). Already in 2018 it was estimated that around 100,000 additional skilled crafts workers were needed to achieve the climate targets set for the buildings sector (German Council of Economic Experts, 2021[10]). Since then, the targets have been raised and labour shortages have become more severe. Addressing skilled labour shortages requires raising productivity in the construction sector, for example by reducing occupational entry regulations and allowing for more competition from firms in other EU countries, and raising labour supply, for example by encouraging immigration of skilled workers (see

Chapter 1 and the 2020 Economic Survey of Germany). It also calls for careful prioritisation of government support programmes and better synchronising them with ambitious targets to increase the supply of new buildings.

Figure 2.37. The housing stock is old

Share of residential building by construction year, %



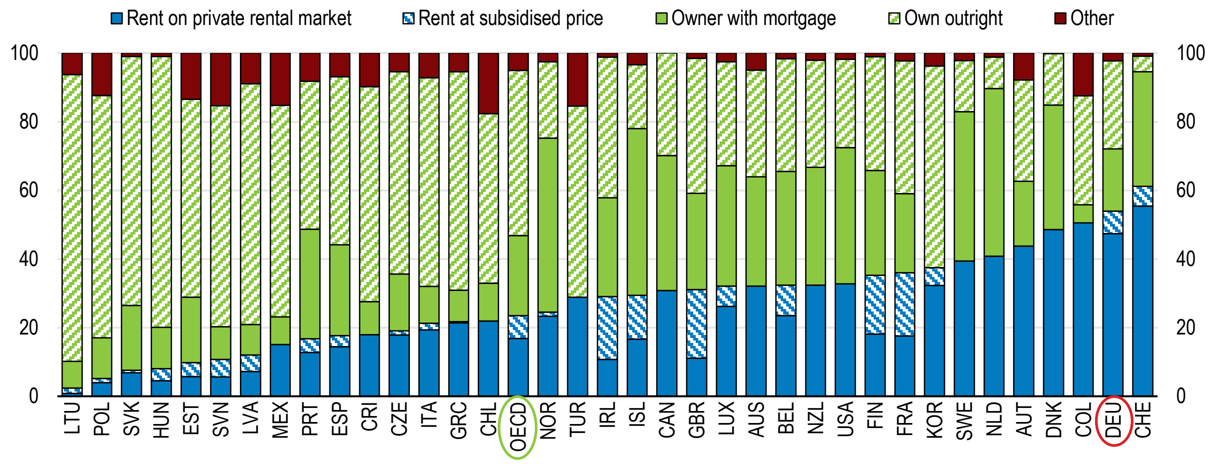
Source: European Commission, EU Building Stock Observatory database.

StatLink https://stat.link/v51ufm

The effect of lower electricity and higher CO_2 prices on building renovations and emission reductions is hindered by market failures. For instance, current tenants and property owners do not necessarily know how poorly insulated their homes are, as energy certificates are only mandatory when renting or selling a property and the quality of many older certificates is weak (OECD, forthcoming[150]). A particular problem in the rental sector is the split incentives problem: Tenants usually have limited options to react to higher energy costs, while property owners who have opportunities to invest in energy efficiency solutions have weak incentives to do so because they typically do not pay the energy bills. In Germany, about half of the households live in rented dwellings, amongst the highest shares in the OECD (Figure 2.38). To tackle this, the government decided to split the payment to the National Emission Trading System between tenants and landlords, depending on the building's emissions performance. Tenants in low-emission housing will bear most of the carbon price, while landlords will be liable for most of the additional price for carbon-intensive rental dwellings. Coordination issues also exist for buildings with several apartments, including those built and managed by non-profit housing associations. Changes to collective decision-making procedures might help, as two thirds of the owners currently need to approve retrofitting of multi-owner properties to enable full cost sharing among owners. Some OECD countries – like Belgium and Austria – have recently eased the voting rules for renovations of multi-owner properties (OECD, forthcoming[150]). Home-level market failures are only compounded at the city level due to the need to coordinate between an even more significant number of actors. Therefore, fast decarbonisation of the building sector requires a mix of regulations, subsidies, and consultancy services to tackle these coordination issues and complement the increase in energy and carbon prices.

Figure 2.38. A high share of Germans rent

Share of households in different tenure types, %, 2020 or latest available year



Source: OECD, Affordable Housing Database, https://www.oecd.org/housing/data/affordable-housing-database/

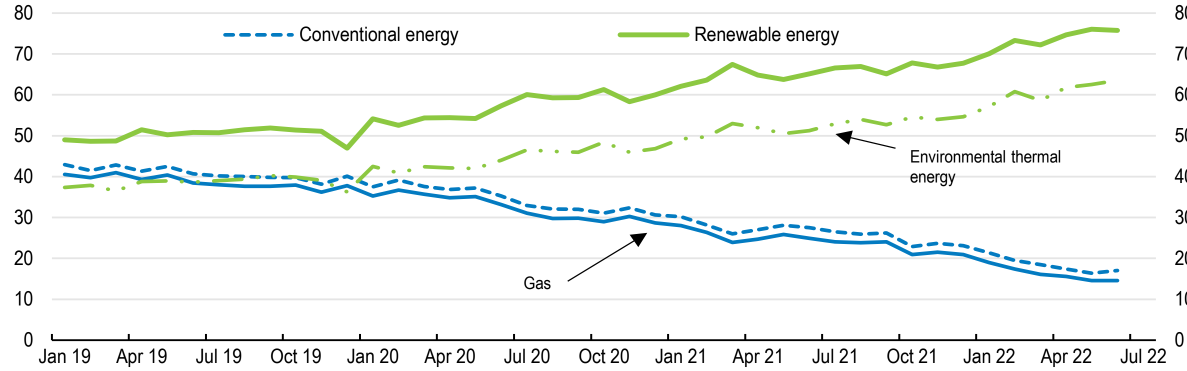
StatLink https://stat.link/2kprxg

A variety of policy instruments to support the transition of the buildings sector are already in place: Germany has a long tradition in providing low interest loans and government support for new buildings and for the renovation of existing buildings and heating systems. Independent consultancy services are provided by the National Consumer Agency and minimum energy efficiency standards for new buildings became stricter over time. These policy measures seem to bear fruits, with more and more Germans choosing to use renewables for heating their new homes (Figure 2.39). Nonetheless, until recently, the policy measures may have focused too much on new buildings rather than reducing energy consumption of the existing housing stock, which has the highest energy savings potential (Environmental Action Germany, 2021[153]). Moreover, subsidies to raise energy efficiency of new and old buildings have not been targeted at households, which face binding credit constraints for investing in energy-efficiency renovations, but also benefitted many large institutional investors. This has considerably reduced spending efficiency, as many retrofitting projects would have been undertaken without subsidies, due to rising energy prices and technology improvements (Egner, Klöckner and Pellegrini-Masini, 2021[154]).

Non-targeted building subsidies should be phased-out quickly, as high energy prices provide sufficient incentives for renovations, and should be replaced by subsidies targeting vulnerable and credit-constrained households. At the same time, energy-efficiency standards should be strengthened faster than planned. The efficiency standards in existing buildings have not been raised since 2009 and monitoring is weak (Environmental Action Germany, 2021[155]). In Scotland, for example, a sufficient level of energy performance is required for rented homes from 2022, when a tenancy contract changes, and for all properties from 2025 (Sunderland and Jahn, 2021[156]). Energy performance certification has become mandatory for all properties in the Netherlands recently and will become mandatory in France for multi-family properties (OECD, forthcoming[150]). The draft bill specifying that newly installed heating systems, whether in new or existing buildings, must be operated with at least 65% renewable energy from January 2024 is a step in the right direction. Still, the specific threshold should be reviewed regularly to make sure it stays relevant, given the fast increase in renewable use (Figure 2.39). Better targeting government subsidies to credit-constrained households living in the worst-performing buildings could accelerate decarbonisation and energy poverty alleviation. There is also a scope to support pilot projects to boost energy efficiency innovation in buildings.

Figure 2.39. More and more Germans use renewables to heat their new homes

Approved residential buildings to be newly constructed by primary heating energy, %



Source: Statistical Federal Office.

StatLink https://stat.link/yi8krz

Main findings	Recommendations
Implementing efficient mitigation policies across the economy	
Germany prices 90% of its GHG emissions, explicitly or implicitly, but levels are too low and differ substantially across sectors.	**Set an emissions cap for all sectors not covered by the EU ETS, which is in line with the national targets, until the European trading system for road transport and heating starts operating.**
Many fossil fuel subsidies and tax expenditures weaken price signals and can jeopardise climate goals.	**Gradually phase out fossil fuel subsidies and tax expenditures, replacing them with abatement subsidies or direct transfers to households if needed.**
Boosting green investment and innovation	
Carbon pricing makes solar and wind technologies price competitive. Renewable energy subsidies can help to reduce electricity prices, but they are costly and can lead to higher emissions in other EU countries.	**Gradually shift support from renewable energy subsidies towards more targeted subsidies for green R&D and the deployment of near-zero emission industrial technologies to reduce future abatement costs.**
There is substantial uncertainty about the future carbon prices in both ETS and non-ETS sectors, weighing on green investments, particularly in hard to abate sectors.	Set a floor for prices in the National Emissions Trading System from 2026. Gradually expand the use of Carbon Contract for Difference and allow for a higher strike price for less matured technologies.
Low carbon prices used in public procurement contradict the “economically most advantageous bid” concept, as negative external effects on emissions are not priced in. However, the administrative burden of including carbon shadow prices in procurement is high.	Until carbon prices are sufficiently high, use shadow carbon prices for procuring strategic products and services and negative lists for other items. Enable contractors to apply for a CO_2 performance ladder certificate, and consider this ladder in procurement decisions.
Protecting social cohesion and building strong public support for climate policy	
Displacement costs for workers in carbon-intensive sectors are high, in particular because their human capital is very specific. Many unemployed but also employed workers lack basic skills necessary for attending initial and continuing VET courses.	Expand the scope of Active Labour Market Programmes, focusing on re-training and basic skills acquisition, while improving adult education by introducing nationwide quality standards and better coordination and marketing of training supply across regions.
Negative employment effects of emission reductions are regionally concentrated making it more difficult to find a new job. Moving to other local labour markets helps to find better paid-jobs.	Facilitate job mobility by expanding mobility subsidies to the unemployed, improving coordination between public placement services and employers across regions, and lowering general barriers such as stringent occupational entry regulations.
Low-skilled workers are most exposed to changing skill requirements due to the green and digital transition, but participate less in training. Partial qualifications combined with recognition of informal prior-learning can facilitate training up take.	Make standardised partial qualifications available nationwide and better link them with recognition of prior-learning and career guidance services.
Germans are conscious of the need to act strongly to tackle climate change, but support for effective policies such as carbon taxes depend on understanding their impact and the use of carbon tax revenues.	Expand public information and education campaigns to explain how policies reduce emissions and clarify their distributional effects.
Addressing sector-specific context and challenges	
Solar and wind capacity installation needs to accelerate significantly but is hindered by conflicts with nature conservation objectives, and lengthy planning and approval procedures.	Streamline the permitting process by setting a single contact point for procedures, applying silence-is-consent rules where appropriate, improving capacity and specialisation of administrative and court staff, and adopting animal population-based approach to biodiversity protection.
Electricity generation from renewables is less stable over time. Price signals on the consumer side are weak due to static levies, taxes, and grid charges.	Introduce time-variable grid charges.
Smart meters can help to match electricity supply and demand, but their rollout is lagging considerably, mainly due to data protection issues.	Accelerate the deployment of smart meters, while strengthening data protection and cyber security.
Government subsidies strongly incentivise the purchase of electric and hybrid cars. But they encourage car-dependency, are regressive and have high fiscal costs. In contrast with most OECD countries, there is no purchase or registration tax on new vehicles.	End purchase subsidies for electric cars after 2024 and introduce a purchase tax for cars with high CO_2 emissions.
The limited supply of publicly available charging stations is slowing electric vehicles' uptake.	**Expand the deployment of charging capacity, while enhancing competition in and access to the market by targeting support at small players, standardizing pricing, and setting performance requirements.**

The electrification of the vehicle fleet will undermine the tax base for the fuel excise duty and risk to increase car-dependency and negative externalities related to driving, which are currently not taxed.	Introduce highway tolls for passenger vehicles and increase truck charges. Consider congestion charging at the local level.
A tax allowance for commuters and a favourable tax treatment for privately used company cars encourage urban sprawl and offer incentives to travel larger distances than necessary.	Abolish the tax allowance for commuters and the favourable tax treatment for privately used company cars, while considering targeted support for employees who must accept long distance work and have high travel costs as a share of their income.
The quality of the rail services deteriorated in the pre-pandemic years. Investment in rail is lower than in leading countries.	**Increase public investment in rail, subject to cost-benefit analysis, and accelerate the digitalisation of the control and signaling systems.**
The temporary introduction of a flat rate nationwide public transport ticket (the EUR 9 ticket) significantly raised public transport attractiveness.	Continue to simplify the train ticketing system and provide a sales platform with non-discriminatory access to data for all market participants.
96% of long-distance rail transport and 72% of regional and short-distance transport in 2019 were made by the national rail company Deutsche Bahn, which is both a rail operator and infrastructure manager that provides services to all other rail operators.	Demand more transparency regarding Deutsche Bahn's investment decisions and set quality indicators for its investment. Consider a vertical separation between Deutsche Bahn's infrastructure management and operations.
Higher energy and carbon prices as well as the abolishment of the EEG surcharge create strong incentives for renovation and shifting to lower-emission heating systems. Many large institutional investors benefited from subsidies for increasing energy efficiency of new and existing buildings.	Phase out non-targeted building subsidies and replace them by subsidies targeting vulnerable and credit constrained households.
Landlords have limited incentives to invest in energy-saving measures as tenants pay for energy costs. The efficiency standards in existing buildings have not been raised since 2009.	**Increase minimum efficiency standards and apply energy performance certification to all existing buildings.**

References

ACEA (2021), *Electric cars: 10 EU countries do not have a single charging point per 100km of road*. [125]

Acemoglu, D. et al. (2012), "The Environment and Directed Technical Change", *American Economic Review*, Vol. 102/1, pp. 131-66, https://doi.org/10.1257/AER.102.1.131. [46]

Agora Verkehrswende (2022), *The Bottom Line of Electric Cars: Comparing the Cost of Ownership of Electric and Combustion-Engine Vehicles*, http://www.agora-verkehrswende.de (accessed on 30 October 2022). [123]

Anderson, A. and H. Hong (2022), "Welfare Implications of Electric-Bike Subsidies: Evidence from Sweden", *Swedish House of Finance Research*. [148]

Andersson, J. (2019), "Carbon Taxes and CO2 Emissions: Sweden as a Case Study", *American Economic Journal: Economic Policy*, Vol. 11/4, pp. 1-30, https://doi.org/10.1257/pol.20170144. [32]

Autor, D. et al. (2014), "Trade Adjustment: Worker-Level Evidence *", *The Quarterly Journal of Economics*, Vol. 129/4, pp. 1799-1860, https://doi.org/10.1093/qje/qju026. [81]

Bachelet, M., M. Kalkuhl and N. Koch (2021), "What If Working from Home Will Stick? Distributional and Climate Impacts for Germany". [13]

Bardt, H. et al. (2020), *For a sound fiscal policy: Enabling public investment*, IW. [141]

Barreto, C., R. Grundke and Z. Krill (forthcoming), *The Social Cost of the Green Transition: Displacement Effects in Carbon Intensive Sectors*, OECD. [2]

Bechichi, N. et al. (2018), "Moving Between Jobs An Analysis of Occupation Distances and Skill Needs", *OECD Science, Technology and Innovation Policy Papers*, No. 52, OECD, Paris, http://www.oecd.org/going-digital (accessed on 27 September 2018). [82]

Bechichi, N. et al. (2019), "Occupational mobility, skills and training needs", http://www.oecd.org/going-digital. (accessed on 26 January 2020). [83]

Becker, S., K. Ekholm and M. Muendler (2013), "Offshoring and the onshore composition of tasks and skills", *Journal of International Economics*, Vol. 90/1, pp. 91-106, https://doi.org/10.1016/j.jinteco.2012.10.005. [76]

Bertheau, A. et al. (2022), "The Unequal Cost of Job Loss across Countries", https://doi.org/10.3386/W29727. [90]

Bickmann, M. et al. (forthcoming), "The economic and distributional consequences of carbon emission abatement for Germany – A computable general equilibrium analysis", *OECD Economics Department Working Papers*. [1]

Black, S. et al. (2021), *Scaling up Climate Mitigation Policy in Germany*. [52]

Blanchard, O. and J. Tirole (2021), *Major Future Economic Challenges*. [34]

BloombergNEF (2022), *Lithium-ion Battery Pack Prices Rise for First Time to an Average of $151/kWh*. [129]

BMBF (2022), *Fortschrittsbericht zur Umsetzung der Nationalen Wasserstoffstrategie*. [63]

BMDV (2022), *Beschleunigungskommission Schiene - Abschlussbericht*, Bundesministerium fuer Digitales und Verkehr. [142]

BMF (2022), *German Stability Programme*. [26]

BMWK (2022), *Germany's current climate action status*. [105]

Böhringer, C., A. Lange and T. Rutherford (2014), "Optimal emission pricing in the presence of international spillovers: Decomposing leakage and terms-of-trade motives", *Journal of Public Economics*, Vol. 110, pp. 101-111, https://doi.org/10.1016/J.JPUBECO.2013.11.011. [38]

Böhringer, C. and K. Rosendahl (2010), "Green promotes the dirtiest: on the interaction between black and green quotas in energy markets", *Journal of Regulatory Economics*, Vol. 37/3, pp. 316-325, https://doi.org/10.1007/s11149-010-9116-1. [48]

Brand, S. and D. Römer (2022), *Public investment required to achieve climate neutrality in Germany*. [25]

Brand, S., D. Römer and M. Schwarz (2021), *Investing EUR 5 trillion to reach climate neutrality – a surmountable challenge*. [24]

Brown, A. (2015), "Can hiring subsidies benefit the unemployed?", *IZA World of Labor*, https://doi.org/10.15185/IZAWOL.163. [98]

Brunner, E. and D. Schwegman (2022), "Commercial wind energy installations and local economic development: Evidence from U.S. counties", *Energy Policy*, Vol. 165, p. 112993, https://doi.org/10.1016/J.ENPOL.2022.112993. [109]

BSW solar (2022), , https://www.solarwirtschaft.de/2022/03/09/energiekrise-laesst-solarspeicher-boomen/. [110]

Bundesagentur für Arbeit (2022), *Arbeitsmarkt nach Qualifikationen - Deutschland, West/Ost und Länder (Jahreszahlen)*. [94]

Bundesnetzagentur (2023), *Recommendations for action to ensure security of supply with electricity*. [23]

Bundesnetzagentur (2021), *Market developments in 2020 under the constraints arising from the COVID-19 pandemic*. [139]

Burger, A. and W. Bretschneider (2021), *Environmentally harmful subsidies in Germany*. [37]

Caliendo, M., S. Künn and R. Mahlstedt (2017), "Mobility Assistance Programmes for Unemployed Workers, Job Search Behaviour and Labour Market Outcomes", *IZA Discussion Papers*. [97]

Cammeraat, E., A. Dechezleprêtre and G. Lalanne (2022), "Innovation and industrial policies for green hydrogen", *OECD Science, Technology and Industry Policy Papers*, No. 125, OECD Publishing, Paris, https://doi.org/10.1787/f0bb5d8c-en. [58]

Card, D., J. Kluve and A. Weber (2018), "What works? A meta analysis of recent active labor market program evaluations", *Journal of the European Economic Association*, Vol. 16/3, pp. 894-931, https://doi.org/10.1093/jeea/jvx028. [99]

Chancel, L. (2021), *Climate change and the global inequality of carbon emissions, 1990–2020*, World Inequality Lab. [20]

Climate Action Tracker (2022), *Germany - Country summary*, https://climateactiontracker.org/countries/germany/ (accessed on 28 July 2022). [22]

Cordonnier, J. and D. Saygin (2022), "Green hydrogen opportunities for emerging and developing economies: Identifying success factors for market development and building enabling conditions", *OECD Environment Working Papers*, No. 205, OECD Publishing, Paris, https://doi.org/10.1787/53ad9f22-en. [62]

Council of Economic Experts (2019), *Setting Out for a New Climate Policy*, https://www.sachverstaendigenrat-wirtschaft.de/en/special-report-2019.html. [19]

Council of Experts on Climate Issues (2021), *Report on the Estimate of German Greenhouse Gas Emissions for the Year 2020*. [12]

Cunliff, C. (2019), *Omission Innovation 2.0: Diagnosing the Global Clean Energy Innovation System*, https://www2.itif.org/2019-omission-innovation-2.pdf. [59]

D'Arcangelo, F. et al. (2022), "A Framework to Decarbonise the Economy", *Economic Policy Paper* 31. [30]

Dauth, W., S. Findeisen and J. Suedekum (2020), "Adjusting to Globalization in Germany", *Journal of Labor Economics*, pp. 000-000, https://doi.org/10.1086/707356. [80]

de Serres, A., F. Murtin and G. Nicoletti (2010), "A Framework for Assessing Green Growth Policies", *OECD Economics Department Working Papers*, No. 774, OECD Publishing, Paris, https://doi.org/10.1787/5kmfj2xvcmkf-en. [29]

Dechezleprêtre, A. et al. (2022), "Fighting climate change: International attitudes toward climate policies", *OECD Economics Department Working Papers*, No. 1714, OECD Publishing, Paris, https://doi.org/10.1787/3406f29a-en. [102]

Dechezleprêtre, A., T. Kruse and C. Berestycki (Forthcoming), "Measuring and Assessing the Effect of Environmental Policy Uncertainty", *Economics Department Working Paper*. [50]

Dechezleprêtre, A., D. Nachtigall and F. Venmans (2018), "The joint impact of the European Union emissions trading system on carbon emissions and economic performance", *OECD Economics Department Working Papers*, No. 1515, OECD Publishing, Paris, https://doi.org/10.1787/4819b016-en. [33]

Desiere, S., K. Langenbucher and L. Struyven (2019), "Statistical profiling in public employment services: An international comparison", *OECD Social, Employment and Migration Working Papers*, No. 224, OECD Publishing, Paris, https://doi.org/10.1787/b5e5f16e-en. [101]

Dix-Carneiro, R. and B. Kovak (2017), "Trade liberalization and regional dynamics", *American Economic Review*, Vol. 107/10, pp. 2908-2946, https://doi.org/10.1257/aer.20161214. [86]

Douenne, T. and A. Fabre (2022), "Yellow Vests, Pessimistic Beliefs, and Carbon Tax Aversion", *American Economic Journal: Economic Policy*, Vol. 14/1, pp. 81-110, https://doi.org/10.1257/POL.20200092. [103]

Dussaux, D. (2020), "The joint effects of energy prices and carbon taxes on environmental and economic performance: Evidence from the French manufacturing sector", *OECD Environment Working Papers*, No. 154, OECD Publishing, Paris, https://doi.org/10.1787/b84b1b7d-en. [68]

Edenhofer, O. et al. (2021), *A whole-economy carbon price for Europe and how to get there*. [39]

Egner, L., C. Klöckner and G. Pellegrini-Masini (2021), "Low free-riding at the cost of subsidizing the rich. Replicating Swiss energy retrofit subsidy findings in Norway", *Energy and Buildings*, Vol. 253, p. 111542, https://doi.org/10.1016/J.ENBUILD.2021.111542. [154]

Environmental Action Germany (2021), *Fact check: The state of energy renovation in Germany*, https://www.bmwi.de/Redak- (accessed on 28 October 2022). [153]

Environmental Action Germany (2021), *Fact check: The state of energy renovation in Germany*, https://www.bmwi.de/Redak- (accessed on 28 October 2022). [155]

European Commission (2020), *Benchmarking smart metering deployment in the EU-28*. [114]

European Commission (2019), *Handbook on the external costs of transport*. [121]

European Commission (2018), *European Construction Sector Observatory - Country profile Germany*. [27]

European Commission (2018), *Survey on passenger satisfaction with rail services*. [140]

European Environment Agency (2022), *Economic losses and fatalities from weather- and climate-related events in Europe.*. [5]

Eurostat (2021), *Average distance per person per day (kilometres)*, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Average_distance_per_person_per_day_(kilometres)_v3.png. [133]

Färber, G. and J. Wieland (2022), *Legal and administrative organizational possibilities for the implementation of a climate premium (in German)*. [73]

Federal Ministry for the Environment (2021), *Climate Action in Figures*. [151]

Federal Ministry for the Environment (2021), *Climate Action in Figures – Facts, Trends and Incentives for German Climate Policy*. [118]

Federal Ministry of Economic Affairs and Climate A (2022), *Germany's current climate action status Core messages*. [120]

Federal Ministry of Finance (2021), *28th Subsidy Report*. [128]

Federal Statistical Office (2022), *9-euro ticket: mobility markedly up at short distances in rail transport*, https://www.destatis.de/EN/Press/2022/07/PE22_284_12.html. [144]

Fraunhofer ISE (2022), *Integrated Photovoltaics – Areas for the Energy Transformation*. [111]

Frey, K. et al. (2015), "A road toll for Germany: Every kilometre counts The contribution of an HGV, coach and car toll to the environment-oriented financing of transport infrastructure". [134]

Fritz, W., C. Maurer and A. Jahn -Projektleitung (2021), "Zukünftige Anforderungen an eine energiewendegerechte Netzkostenallokation IMPULS". [113]

Funke, M. and R. Terasa (2022), *Temporary Super Depreciation Allowances for Green and Digital Investments*. [55]

G7 (2022), *Statement on Climate Club*. [45]

Gathmann, C., I. Helm and U. Schönberg (2018), "Spillover effects of mass layoffs", *Journal of the European Economic Association*, https://doi.org/10.1093/jeea/jvy045. [84]

German Council of Economic Experts (2022), *Coronavirus Crisis, Income Distribution And Educational Opportunities*. [100]

German Council of Economic Experts (2021), *Global Climate Protection: Policy Framework And Potential Courses Of Action*. [10]

German Environment Agency (2021), *Climate Impact and Risk Assessment 2021 for Germany - Summary*, Umweltbundesamt. [4]

German Environment Agency (2021), *Reshaping mobility: A tax and duty concept for climate-friendly and socially fair transport up to 2050*, http://www.umweltbundesamt.de (accessed on 30 October 2022). [135]

Graham, D., A. Crotte and R. Anderson (2009), "A dynamic panel analysis of urban metro demand", *Transportation Research Part E: Logistics and Transportation Review*, Vol. 45/5, pp. 787-794, https://doi.org/10.1016/J.TRE.2009.01.001. [146]

Grundke, R. and J. Arnold (2022), "Mastering the transition: A synthetic literature review of trade adaptation policies"*, OECD Economics Department Working Papers*, No. 1719, OECD Publishing, Paris, https://doi.org/10.1787/5fad3487-en. [71]

Hanny, L. et al. (2022), "On the progress in flexibility and grid charges in light of the energy transition: The case of Germany", *Energy Policy*, Vol. 165, p. 112882, https://doi.org/10.1016/J.ENPOL.2022.112882. [112]

Harding, M. (2014), "Personal Tax Treatment of Company Cars and Commuting Expenses: Estimating the Fiscal and Environmental Costs"*, OECD Taxation Working Papers*, No. 20, OECD Publishing, Paris, https://doi.org/10.1787/5jz14cg1s7vl-en. [136]

Harthan, R. et al. (2022), *Klimaschutzbeitrag verschiedener CO 2-Preispfade in den BEHG-Sektoren Verkehr, Gebäude und Industrie*. [51]

Helm, I. (2019), "National Industry Trade Shocks, Local Labour Markets, and Agglomeration Spillovers", *The Review of Economic Studies*, Vol. 87/3, pp. 1399-1431, https://doi.org/10.1093/restud/rdz056. [85]

House, C. and M. Shapiro (2008), "Temporary Investment Tax Incentives: Theory with Evidence from Bonus Depreciation", *American Economic Review*, Vol. 98/3, pp. 737-68, https://doi.org/10.1257/AER.98.3.737. [56]

Hummels, D. et al. (2012), "Offshoring, Transition, and Training: Evidence from Danish Matched Worker-Firm Data", *American Economic Review: Papers & Proceedings*, Vol. 102/3, pp. 424–428, https://doi.org/10.1257/aer.102.3.424. [75]

Hyman, B. (2018), "Can Displaced Labor Be Retrained? Evidence from Quasi-Random Assignment to Trade Adjustment Assistance", *SSRN network*. [74]

IEA (2022), *Achieving Net Zero Heavy Industry Sectors in G7 Members*. [49]

IEA (2022), *Policy brief on public charging infrastructure*, https://www.iea.org/reports/policy-brief-on-public-charging-infrastructure. [124]

IEA (2022), *The Future of Heat Pumps*. [152]

IEA (2021), *Net Zero by 2050 - A Roadmap for the Global Energy Sector*, http://www.iea.org/t&c/ (accessed on 23 June 2022). [57]

Immel, L. and A. Peichl (2020), "Regional Inequality in Germany: Where Do the Rich Live and Where Do the Poor Live?", *ifo Schnelldienst*, Vol. 73/05, pp. 43-47. [69]

Jacobson, L., R. Lalonde and D. Sullivan (1993), "Earnings Losses of Displaced Workers", *The American Economic Review*, Vol. 83/4, pp. 685-709. [77]

Journalism for the energy transition (2015), *The history of the Energiewende*. [15]

Knut, C. et al. (2009), "Green Serves the Dirtiest: On the Interaction between Black and Green Quotas", *At Cesifo Area Conference On Energy & Climate Economics*. [47]

König, A. et al. (2021), "An overview of parameter and cost for battery electric vehicles", *World Electric Vehicle Journal*, Vol. 12/1, pp. 1-29, https://doi.org/10.3390/WEVJ12010021. [130]

Kristine, L. (2019), "Lmp Interventions For The Long Term Unemployed In-Depth Evaluation". [91]

Löschel, A. and D. Schulze (2022), "Brauchen wir CO2-Schattenpreise für öffentliche Ausgaben?", *Wirtschaftsdienst 2022 102:1*, Vol. 102/1, pp. 41-46. [65]

Lyons, G., A. Curry and C. Rohr (2021), "Decarbonising UK Transport Final report and technology roadmaps". [132]

Marz, W. (2022), *Does more home office reduce emissions in transport? (In German)*. [14]

Metzler, D., A. Humpe and S. Gössling (2019), "Is it time to abolish company car benefits? An analysis of transport behaviour in Germany and implications for climate change", *Climate Policy*, Vol. 19/5, pp. 542-555, https://doi.org/10.1080/14693062.2018.1533446. [138]

Ministry For Economic Affairs and Climate Action (2022), *Annual Economic Report of the German Federal Government*. [35]

Miotti, M. et al. (2016), "Personal Vehicles Evaluated against Climate Change Mitigation Targets", *Environmental Science and Technology*, Vol. 50/20, pp. 10795-10804. [122]

Mohommad, A. (2021), *Employment Effects of Environmental Policies – Evidence From Firm-Level Data*. [67]

Monopolies Commission (2021), *8th Sector Report Railways: Competition on the rail!*. [143]

Monopolies Commission (2021), *Energie 2021: Wettbewerbschancen bei Strombörsen, E-Ladesäulen und Wasserstoff nutzen*. [127]

Nemet, G. (2019), *How Solar Energy Became Cheap: A Model for Low-Carbon Innovation*, Routledge. [17]

Nordhaus, W. (2015), “Climate Clubs: Overcoming Free-Riding in International Climate Policy”, *American Economic Review*, Vol. 105/4, pp. 1339-70, https://doi.org/10.1257/AER.15000001. [44]

OECD (2023), *Environmental Performance Reviews: Germany*, OECD Publishing, Paris. [157]

OECD (2022), *Career Guidance for Low-Qualified Workers in Germany*, Getting Skills Right, OECD Publishing, Paris, https://doi.org/10.1787/5e6af8da-en. [96]

OECD (2022), *OECD Environmental Performance Reviews: United Kingdom 2022*, OECD Environmental Performance Reviews, OECD Publishing, Paris, https://doi.org/10.1787/b6a2be87-en. [149]

OECD (2022), *OECD Reviews of Innovation Policy: Germany 2022: Building Agility for Successful Transitions*, OECD Reviews of Innovation Policy, OECD Publishing, Paris, https://doi.org/10.1787/50b32331-en. [61]

OECD (2022), *Pricing Greenhouse Gas Emissions: Turning Climate Targets into Climate Action*, OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris, https://doi.org/10.1787/e9778969-en. [41]

OECD (2021), *Assessing the Economic Impacts of Environmental Policies: Evidence from a Decade of OECD Research*, OECD Publishing, Paris, https://doi.org/10.1787/bf2fb156-en. [42]

OECD (2021), *Continuing Education and Training in Germany*, Getting Skills Right, OECD Publishing, Paris, https://doi.org/10.1787/1f552468-en. [95]

OECD (2021), *Effective Carbon Rates 2021: Pricing Carbon Emissions through Taxes and Emissions Trading*, OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris, https://doi.org/10.1787/0e8e24f5-en. [40]

OECD (2021), *Regional Outlook 2021 - Country notes: Germany*, https://www.oecd.org/regional/RO2021%20Germany.pdf. [70]

OECD (2021), *Transport Strategies for Net-Zero Systems by Design*, OECD Publishing, Paris, https://doi.org/10.1787/0a20f779-en. [147]

OECD (2020), *Climate Policy Leadership in an Interconnected World: What Role for Border Carbon Adjustments?*, OECD Publishing, Paris, https://doi.org/10.1787/8008e7f4-en. [43]

OECD (2020), *OECD Economic Surveys: Germany 2020*, OECD Publishing, Paris, https://doi.org/10.1787/91973c69-en. [87]

OECD (2019), *Public Procurement in Germany: Strategic Dimensions for Well-being and Growth*, OECD Public Governance Reviews, OECD Publishing, Paris, https://doi.org/10.1787/1db30826-en. [66]

OECD (2018), *OECD Product Market Regulation - How does Germany compare?*, https://issuu.com/oecd.publishing/docs/ger_country_note_-_final?fr=sMzM1NTkzNTk1MQ. [116]

OECD (2012), *Policy Priorities for International Trade and Jobs*, OECD Publishing, Paris, https://doi.org/10.1787/9789264180178-en. [88]

OECD (2005), *Trade and Structural Adjustment: Embracing Globalisation*, OECD Publishing, Paris, https://doi.org/10.1787/9789264010970-en. [89]

OECD (forthcoming), *Home, Green Home: Policies to Decarbonise Housing*. [150]

OECD (forthcoming), "OECD Environmental Performance Review Germany". [3]

Öko-Instituts e.V. (2015), *Umwelt- und Kostenentlastung durch eine umweltverträgliche Beschaffung*, http://www.oeko.de (accessed on 6 July 2022). [64]

Osberghaus, D. (2021), *Extreme Weather Events: State Aid or Private Provision – Who Bears the Costs?*, ifo Institute. [9]

Our World in Data (2022), *Germany: CO2 Country Profile*, https://ourworldindata.org/co2/country/germany (accessed on 28 July 2022). [28]

Pahle, M. et al. (2018), "Sequencing to ratchet up climate policy stringency", *Nature Climate Change 2018 8:10*, Vol. 8/10, pp. 861-867, https://doi.org/10.1038/s41558-018-0287-6. [18]

Pflugmann, F. et al. (2019), *Germany's energy transition at a crossroads*, McKinsey. [16]

Pisany-Ferry, J. (2021), "Climate policy is macroeconomic policy, and the implications will be significant", *Peterson Insitute for International Economics - Policy Brief* 21-20. [31]

Prognos (2022), *The damage of the July 2021 floods in Germany*. [7]

Prognos, IOW and GWS (2022), *Übersicht vergangener Extremwetterschäden in Deutschland Methodik und Erstellung einer Schadensübersicht*. [6]

PwC (2022), *The E-Mobility Check: How ready is Germany?*. [126]

Richstein, J. (2017), "Project-Based Carbon Contracts: A Way to Finance Innovative Low-Carbon Investments". [54]

Richstein, J. et al. (2021), *Carbon Contracts for Diference An assessment of selected socio-economic impacts for Germany*. [53]

Schleich, J. et al. (2001), "Greenhouse gas reductions in Germany—lucky strike or hard work?", *Climate Policy*, Vol. 1/3, pp. 363-380, https://doi.org/10.3763/cpol.2001.0136. [11]

Schmieder, J. et al. (2022), "The Costs of Job Displacement over the Business Cycle and Its Sources: Evidence from Germany", https://doi.org/10.3386/W30162. [78]

Stede, J. and N. May (2020), "Way Off: The Effect of Minimum Distance Regulation on the Deployment of Wind Power", http://www.diw.de/discussionpapers (accessed on 21 September 2022). [106]

Stern, L. (2022), *Rewarding countries for public spending on clean energy research: Optimal mechanisms under exogenous budgets*. [60]

Sunderland, L. and A. Jahn (2021), *Considering minimum energy performance standards for Germany*, https://www.raponline.org/knowledge-center/minimum-energy-efficiency-standards-for- (accessed on 30 October 2022). [156]

SVR (2019), *Aufbruch zu einer neuen Klimapolitik*, Sachverstaendigenrat zur Begutachtung der Gesamtwirtschaftlichen Lage. [72]

The Monopolies Commission (2022), *Wettbewerbsverhältnisse im Bereich der Erzeugung elektrischer Energie 2021*. [115]

The Monopolies Commission (2021), *Competition between electricity exchanges in Germany*. [117]

Thieken, A. et al. (2022), *Performance of the flood warning system in Germany in July 2021 – insights from affected residents*, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2022-244. [8]

UmweltBundesamt (2022), *Climate protection in transport (in German)*. [119]

UmweltBundesamt (2020), *Speed limits on motorways clearly cut down CO2 emissions*. [131]

Umweltbundesamt (2022), *National projections of anthropogenic greenhouse gas emissions*. [21]

Utar, H. (2018), "Workers beneath the Floodgates: Low-Wage Import Competition and Workers' Adjustment", *The Review of Economics and Statistics*, Vol. 100/4, pp. 631-647, https://doi.org/10.1162/rest_a_00727. [79]

van den Berg, G., A. Uhlendorff and J. Wolff (2021), "The Impact of Sanctions for Young Welfare Recipients on Transitions to Work and Wages, and on Dropping Out", *Economica*, Vol. 89/353, pp. 1-28, https://doi.org/10.1111/ecca.12392. [92]

Vandyck, T. et al. (2021), *Baseline GECO 2021*, European Commission, Joint Research Centre. [36]

VOX (2022), *Public transit for nine bucks a month? Germany tried it*. [145]

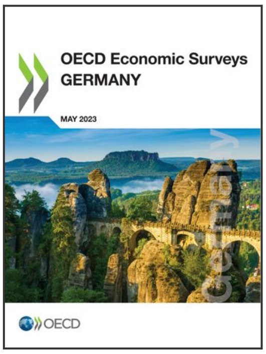
Wind Europe (2022), *How to simplify permitting*, https://windeurope.org/intelligence-platform/product/how-to-simplify-permitting/. [107]

Wolff, J. (2021), *Schneller ist nicht immer besser: Sanktionen können sich längerfristig auf die Beschäftigungsqualität auswirken*, Institut fuer Arbeitsmarkt und Berufsforschung. [93]

Wolsink, M. (2000), "Wind power and the NIMBY-myth: institutional capacity and the limited significance of public support", *Renewable Energy*, Vol. 21/1, pp. 49-64, https://doi.org/10.1016/S0960-1481(99)00130-5. [108]

World Bank (2020), *DataBank*, https://databank.worldbank.org/reports.aspx?source=3001&series=IC.ELC.SAID.XD.DB1619. [104]

Zimmer, A. and N. Koch (2016), "Fuel Consumption Dynamics in Europe - Implications of Fuel Tax Reforms for Air Pollution and Carbon Emissions from Road Transport", *SSRN Electronic Journal*, https://doi.org/10.2139/SSRN.2813534. [137]



From:

OECD Economic Surveys: Germany 2023

Access the complete publication at:
https://doi.org/10.1787/9642a3f5-en

Please cite this chapter as:

Krill, Zeev, Robert Grundke and Marius Bickmann (2023), “Reaching net zero while safeguarding competitiveness and social cohesion”, in OECD, *OECD Economic Surveys: Germany 2023*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/62ec319f-en