04

CLIMATE PROTECTION AS AN INDUSTRIAL POLICY OPPORTUNITY

This is a translated version of the original German-language chapter "Klimaschutz als industriepolitische Chance", which is the sole authoritative text. Please cite the original German-language chapter if any reference is made to this text.

KEY MESSAGES

- Commitments worldwide to reduce greenhouse gas emissions make structural change inevitable. This will create significant industrial policy opportunities.
- The reduction of distorting incentives through an energy price reform with simultaneous strengthening of carbon emissions pricing could increase the coordination function of the market.
- Complementary measures can address obstacles that delay the penetration of lower emission technologies, by increasing the steering effect of the pricing of carbon emissions.

SUMMARY

The commitments undertaken both worldwide and within the European Union (EU) to cut greenhouse gas emissions make **structural change** towards a carbon-neutral economy in Germany unavoidable. A number of political initiatives have therefore been launched in recent years with the aim of accelerating this transformation. The target of achieving carbon neutrality by 2050 has put the close connection between climate policy and the competitive position of German industry in the focus of attention. The necessary sector coupling, which will involve various sectors, will transform value chains extensively. German industry possesses considerable expertise in many relevant technologies that enable it to take a position as a leading provider of carbon-neutral applications and products in these areas both in Germany and internationally. At the same time, however, the forthcoming transformation poses significant challenges for established firms.

In order to meet the challenge of structural change and make use of the potential for competitiveness, firms need **market-based incentives** to invest, drive innovation and develop new markets. The **national emissions trading scheme** beginning in 2021 should therefore be consistently executed and integrated into the European emissions trading system (EU ETS) as soon as possible. In addition, the incentives should be strengthened even further by reducing government-imposed, distorting levies and surcharges as far as possible. This will increase the appeal of sector coupling in particular. The possibilities for product certification should be improved in order to make products' carbon footprint easier to retrace internationally. Furthermore, labelling economic activities according to their sustai-nability could reduce the information asymmetry in the capital markets and thereby mobilise private capital in future.

In addition to an energy price reform, the introduction of an emissions trading scheme as well as the creation of the right conditions for investments and green financial products by means of certification many other measures are currently being discussed. In the areas of research funding, workforce training and infrastructure investments the use of government funding can accelerate the establishment of new technologies and help resolve 'chicken-and-egg' dilemmas. The support for electric vehicles and the production of green hydrogen by means of bonuses or contracts for difference should be done moderately and should take into account the need to become economically viable.

Tackling climate change is a global problem. National and European efforts must therefore always be evaluated in a **global context**. Europe and Germany can benefit from smart energy and climate policies which they can use to achieve their own climate targets as cost-effectively as possible. To this end, key industries should be supported in their efforts to develop new business areas, and forward-looking partnerships should be forged and encouraged if they make it more likely that global climate targets will be met.

I. MOTIVATION

352. The commitments undertaken both worldwide and within the European Union (EU) to cut greenhouse gas emissions make **structural change** in German industry unavoidable. National, European and global climate targets require a transition to be made towards a sustainable energy supply, production processes and products. In recent years a number of political initiatives have therefore been launched with the aim of accelerating this transformation and creating **opportunities for industrial policy**. The areas in which action needs to be taken include the development of carbon-neutral solutions around hydrogen and solid fuels, the use of electricity to decarbonise the heating, mobility and industrial sectors (sector coupling) and the digitalisation of energy systems. German firms possess considerable expertise in what are likely to be the key technology fields and can enter new markets. ↘ ITEMS 358 FF. At the same time, however, the forthcoming transformation poses significant challenges for established firms.

353. In order to **exploit the opportunities available**, it will be necessary to substantially modify existing value chains and put new ones in place. This creates, however, coordination problems that can prevent technologies and products from establishing in the economy. Hydrogen technologies, for example, involve complex value chains. The task is to configure market conditions in such a way that the coordination issues arising from the transformation process can be resolved. This can take the form of **market-based incentives** by strengthening the steering effect of the relative prices of goods and services. Network effects and other market imperfections can delay this technology transformation, and careful thought should therefore be given as to how to address them.

354. The coordination problems arising from the transformation process when putting new value chains in place strengthen the arguments in favour of a **cross-sectoral emissions trading scheme** as a **guiding instrument of climate policy** (Stiglitz et al., 2017; Edenhofer and Schmidt, 2018), as discussed by the German Council of Economic Experts in its special report entitled ‘Setting out for a new climate policy’ (GCEE Special Report 2019). The **abolition** of government-imposed, **distorting levies and surcharges** could provide additional and timely support for the coordinating function of the market (acatech et al., 2017). If fuels are taxed on a cross-sectoral and cross-border basis in proportion to their carbon footprint, firms will invest, drive innovation and enter new markets. A reliable market environment can significantly reduce the need for fragmented support measures and accelerate the transformation process. Households will benefit from these innovations, which will make it easier for them to cut their emissions. The GCEE will provide a detailed analysis of the impact of such energy price reform on households and firms. ↘ ITEMS 391 FF.

355. The far-reaching transformation taking place in the industrial and energy sectors requires substantial **private-sector investments** Despite the attractive financial returns potentially available, however, asymmetric information on the climate-relevant properties of economic activity could prevent the mobilisation of

private capital and investment in the real economy. The possibilities for **certifying products and processes** should therefore be improved. The EU's taxonomy as a system for classifying sustainable investments in the financial markets is making a valuable contribution to ensuring that climate risks can be assessed more effectively. ↘ ITEMS 419 FF.

356. In addition to introducing carbon pricing, the Climate Action Programme 2030 intends to implement many **fragmented, individual measures** in future (BMU, 2019a). ↘ ITEMS 362 FF. Consistent carbon-based energy price reforms would obviate the need for many of these regulatory measures, which would otherwise raise the transformation costs for the economy as a whole. **Complementary measures** might, however, be appropriate given the existence of market imperfections such as knowledge externalities, information asymmetry and network effects. They could assist the markets so as to support their functionality and **mitigate undesirable distribution effects** (GCEE Special Report 2019 items 245 ff.). In the following, mobility and the hydrogen strategy are used as examples to illustrate some of these measures. ↘ ITEMS 433 FF.

A carbon price ensures that economic actors internalise the social cost of their greenhouse gas emissions in their decisions. Carbon pricing can be used to reduce emissions wherever this is the most cost-effective – irrespective of location, technology and sector (GCEE Special Report 2019 items 107 ff.). However, the report of the High-Level Commission on Carbon Pricing flags up obstacles that restrict the functionality of carbon pricing or jeopardise the political support for this instrument. This could raise the transformation costs (Stiglitz et al., 2017). Consequently, appropriate measures should be taken to address issues such as distribution effects as well as coordination problems and path dependencies, which delay the diffusion of new, lower-emission technologies (Edenhofer et al., 2019a). This can make it easier to cut carbon emissions and can enhance the appeal of new markets (GCEE Special Report 2019 items 245 ff.).

357. Tackling climate change and transforming industry are **global challenges**. National and European efforts must therefore always be embedded within a global context. Europe and Germany can benefit from smart energy and climate policies which they can use to achieve their own climate targets as cost effectively as possible, help key industries to develop new business areas, and forge and encourage forward-looking partnerships which make it more likely that climate targets around the world will be met (GCEE Special Report 2019 item 6).

Coordinating these initiatives at various political levels poses a particular challenge. The EU and Germany's national and regional governments should coordinate their initiatives in order to reap synergies and avoid any inefficient duplication.

II. CLIMATE POLICY INITIATIVES AND THEIR OPPORTUNITIES

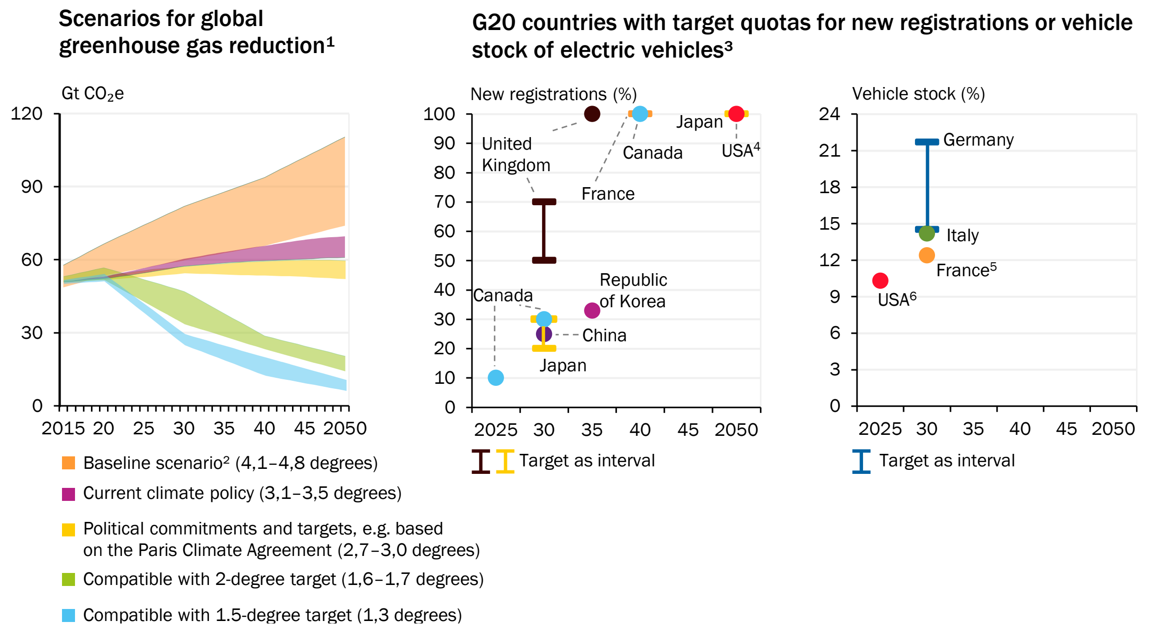
1. Meeting global climate targets will open up new markets

358. The **need for low-emission technologies** will steadily increase not just in the EU. If the commitments made in the Paris Climate Agreement are implemented and addressed in the form of appropriate political initiatives, the demand for technical solutions as a way of cutting carbon emissions is likely to grow worldwide. ↘ CHART 58 LEFT This presents a number of **opportunities** for established and new firms alike.

Climate targets and market opportunities **influence one another**: the more ambitious the global climate targets are, the more comprehensively and swiftly adjustments need to be made to business models and firms, which may be associated with considerable costs and challenges for competitiveness. At the same time, this increases the incentives for firms to develop low-emission production processes and products. As new technologies become increasingly available, this will, in turn, lower the cost of cutting emissions. Politically this will probably make it

↘ CHART 58

Industrial policy opportunities as a result of global emissions reduction targets and national initiatives



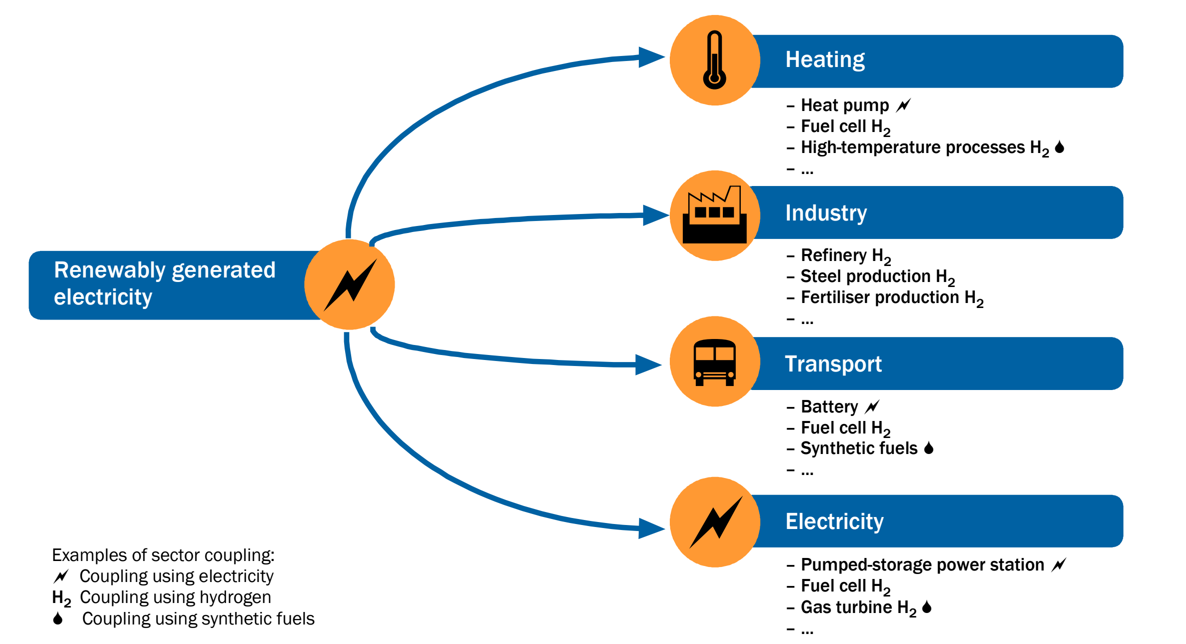
1 – The chart shows annual emissions reduction quantities based on the warming scenarios of the Climate Action Tracker (CAT). The analysis shows carbon emission-equivalent greenhouse gas emissions in gigatonnes (Gt CO_2e). 2 – The baseline scenario assumes that no political initiatives of any kind are introduced. 3 – Selected countries have specified targets for the cumulative number of registered electric vehicles. The absolute targets for electric vehicles are shown as a proportion of the vehicle stock in 2015. The G20 countries not listed have not specified any targets. 4 – For eleven countries. 5 – Value for 2028. 6 – For ten countries. Target as a proportion of the vehicle stock in 2019.

Sources: CAT, IEA (2020), OICA, U.S. Department of Public Transportation possible to set the sort of **more ambitious global emissions reduction targets** needed to meet the 1.5-degree or 2.0-degree target. ↘ CHART 58 LEFT If German firms manage to make these technical solutions available, this could raise the country's value added, employment and prosperity while at the same time making a valuable contribution to combatting climate change.

359. Potential solutions to the issue of **sector coupling** in particular cover a wide range of new business models. ↘ CHART 59 Technologies that enable renewably generated electricity to be used in all sectors are, as far as we know today, essential for achieving carbon neutrality (UBA, 2014; acatech et al., 2017; Ram et al., 2018; Runkel, 2018; Agora Energiewende and the Wuppertal Institute, 2019; IRENA, 2020; Sterchele et al., 2020). In addition to direct electrification, the conversion of electricity into hydrogen and synthetic fuels will play an important role. **Hydrogen applications** could be used, for example, to enable renewable energy to be transported and stored without an electricity grid. Countries that have plentiful supplies of sun or wind could thus become energy exporters (Pfennig et al., 2017; Heuser et al., 2019; Timmerberg and Kaltschmitt, 2019; Grimm, 2020; Runge et al., 2020).

360. Nonetheless, the climate targets pose significant challenges for incumbent firms. The electrification of transport, for example, is likely to increase over the coming years – not least owing to the political targets set for newly registered vehicles (IEA, 2020). ↘ CHART 58 RIGHT **New providers** such as Tesla, BYD and BAIC are entering this market. At the same time, the **value added** in the production of vehicles is changing. Electric engines are less complex than internal combustion engines, and battery production will account for a significant proportion of the value added. Jobs in the manufacture of internal combustion engines in Germany

↘ CHART 59
Sector coupling



Sources: H2.B (2020), own presentation

might be lost (Falck et al., 2017; Bauer et al., 2018; Mönning et al., 2018). Hydrogen mobility has yet to become established in the market. German firms have considerable expertise in the relevant technology fields. Carmakers and supplies need to adapt accordingly over the coming years to ensure that they remain competitive.

361. If and when firms enter new markets depends on the **benefits and drawbacks of deciding to adopt a technology at an early stage** (Hoppe, 2002). On the one hand, the investment risk decreases over time (**wait-and-see approach**). The market conditions for the new technology could eventually become more certain, and the expected gradual decline in costs as well as economies of scale and learning effects are likely to lower the cost of investment (Dixit and Pindyck, 1994). On the other hand, however, firms might lose their **first-mover advantage** of developing competencies at an early stage and, by participating in international standardisation processes, improving their market position. By deciding not to enter the market at an early stage they might lose out on higher profit margins and greater market reach.

This is the dilemma potential business start-ups and established firms alike are facing, which have to decide whether to enter new market segments. In the field of hydrogen technologies, in particular, incumbent firms can build on their technology expertise – in areas such as materials research, plant engineering and gas logistics – and, in doing so, profit from new markets. The complexity of the emerging value chains in the production, distribution and use of hydrogen provides many firms with attractive business models and makes it less likely that individual production stages will be offshored than in the manufacture of solar cells or batteries. The **public sector has a significant influence** on whether firms decide to leave or enter markets. Climate policy initiatives are already setting today the course for the future.

2. New initiatives at several levels

European initiatives

362. In December 2019 the European Commission presented the **European Green Deal**, which defines its key target as carbon neutrality for the EU by 2050. This is also likely to modify the EU's climate targets for 2030. In October 2020 a majority in the European Parliament voted to expand the emission reduction targets. Emissions are to be cut by 60 % by 2030 compared with their 1990 levels. The previous target was 40 %. The Green Deal contains proposed measures to cut emissions in various areas such as agriculture, mobility, building refurbishment, sustainable finance, energy systems, or research and development (European Commission, 2019a). An action plan specifies the drafting of appropriate strategies and proposed legislation by 2021.

The key instruments contained in the proposal include cross-sectoral **carbon pricing**, a **carbon border tax adjustment system** for various sectors, **research funding** for climate-friendly technologies, and a revision of the carbon emissions standards for passenger cars.

363. In the summer of 2020 the EU also presented two further strategies of relevance to climate policy. The **EU's hydrogen strategy** is intended to increase the use of hydrogen-based technologies (European Commission, 2020a). The EU Commission regards that hydrogen applications potentially offer considerable value added for the industry. Its strategy is aimed at creating the necessary regulatory framework, launching global energy partnerships and providing incentives to produce hydrogen.

At the same time the EU Commission presented a **strategy for an integrated energy system**, which mainly focuses on sector coupling. The envisaged measures call on member states to abolish high taxes on electricity compared with other energy sources as well as subsidies for fossil fuels. In addition, the Commission announced a proposal to **extend the European emissions trading system (EU ETS)** by 2021 to include sectors not currently covered by the scheme (European Commission, 2020b).

364. In March 2018 the EU Commission published an **action plan for a sustainable financial system**. ↘ ITEMS 419 FF. Essentially, the EU action plan calls for the drafting of a binding legal framework (EU taxonomy), which defines uniform criteria for sustainable investments (European Commission, 2018; EU TEG, 2020). The action plan also proposes various disclosure requirements for financial market participants in the context of sustainable investments and sustainability risks. The Taxonomy Regulation came into force in July 2020.

National initiatives

365. In the autumn of 2019 the political process in Germany resulted in the **Climate Action Programme 2030**. This catalogue of measures comprises the key points designed to ensure that the Climate Action Plan 2050 is achieved (BMU, 2019a). This includes investment funds of €54 billion that the German government has committed to spend by 2023 (BMF, 2019). This programme will be implemented in stages in the form of legislation and support programmes. One of the cornerstones of this programme is the **Federal Climate Change Act (KSG)**, which defines the emission reduction targets. It commits Germany to reducing its greenhouse gas emissions by at least 55 % by 2030 compared with 1990 levels (section 3 (1) KSG). Over the long term the German government aims to achieve the target of greenhouse gas neutrality at the national level by 2050 (section 1 KSG). The KSG also defines **sector-specific targets** for 2030 and requires the climate targets to be continually reviewed, imposing clearly defined responsibilities on the individual sectors and specifying binding adjustment measures if there is any deviation from the target path.

366. A national emissions trading scheme is to be set up in the non-EU ETS sectors of heating and transport starting in 2021 under the **German Fuel Emissions**

Trading Act (BEHG). Emissions certificates will be issued at an annually rising fixed price – initially without any cap – as part of the **national emissions trading system (nEHS)**. Germany's national and regional governments reached agreement on the Mediation Committee that the carbon price should initially be fixed at €25 per tonne of CO_2 starting in January 2021. The price will then gradually rise in stages to €55 in 2025. In 2026 the **fixed-price system** will be converted into a **market-based system with minimum and maximum prices** of €55 and €65 respectively. The relevant legislation is due to be evaluated in 2025. It will then be decided whether minimum and maximum prices are still considered to be sensible and necessary for the period from 2027 onwards. An annual cap on the certificates available will be fixed from 2027 onwards.

367. Some of the revenue from the national emissions trading scheme is to be used as a form of **social equalisation** to fund a gradual **reduction in the EEG surcharge** in line with the Climate Action Programme 2030. The amount of this redistribution is likely to vary from year to year depending on the level of revenue actually received under the BEHG (BMU, 2019a).

The EEG surcharge amounted to roughly 6.76 cents per kWh in 2020. Despite the BEHG revenue being used to reduce the EEG surcharge, the economic slump resulting from the **coronavirus pandemic** would have caused the EEG surcharge to rise sharply in 2021: the economic situation in Germany has reduced electricity demand ↘ ITEM 32 and, consequently, the market price of electricity. This automatically gives rise to increasing payment obligations for the feed-in tariff and, therefore, a higher EEG surcharge next year (Wagner et al., 2020). In order to limit the additional financial costs for households and firms and to create planning certainty for the coming years, the economic stimulus package launched in June 2020 fixed the **amount of the EEG surcharge** at 6.5 cents per kWh for 2021 and at 6.0 cents per kWh for 2022 (BMWi, 2020a; Coalition Committee, 2020). ↘ ITEM 161 The necessary federal government subsidy, which will total €10.8 billion in 2021, will be partly covered by the revenue from the BEHG, which was intended to be used to reduce the EEG surcharge anyway.

368. The Climate Action Programme contains further **sector-specific measures** in addition to the national emissions trading scheme. Some of these have already been implemented (raising the tax on air travel, tax incentives for the refurbishment of buildings, cutting value added tax on train tickets for long-distance journeys). The decision has also been taken to pay a supplementary allowance for housing benefit from 2021 onwards in order to reduce the financial cost resulting from the national emissions trading scheme, and it has been decided to adopt a **master plan for the electric-vehicle charging infrastructure**, which aims to electrify the transport sector more swiftly (German government, 2020). In addition to providing direct financial support for public and private electric-vehicle charging posts and filling stations for fuel-cell vehicles, this concept proposes various legislative initiatives that are designed to accelerate the expansion of the electric-vehicle charging infrastructure.

369. By launching its **national hydrogen strategy**, which was presented in the summer of 2020, the German government is strengthening its ambition to step up the

production, import, transportation and application of carbon-neutral hydrogen and derivative synthetic fuels in Germany. This approach is intended, firstly, to facilitate the full decarbonisation of industry, transport and heating. And, secondly, Germany's Federal Ministry for Economic Affairs and Energy (BMWi, 2020b) intends to provide German firms with new market opportunities. The strategy contains various instruments designed to enable **hydrogen to become established more quickly in the market.** ↘ ITEMS 461 FF. The hydrogen strategy is contained in a forward-looking package that forms part of the **economic stimulus package designed to mitigate the consequences of the coronavirus pandemic**. The funding required here is estimated to be around €9 billion (Coalition Committee, 2020).

370. The **economic stimulus package** approved in the summer of 2020 contains further measures of relevance to climate policy. The forward-looking component of the economic stimulus package, for example, includes raising the bonus for purchases of **electric vehicles** from €3,000 to €6,000. Together with tax relief on the personal use of electric vehicles as company cars, total funding of €2.2 billion is to be made available. In addition, **fleet replacement programmes** are to be launched and investment in the automotive industry will be stimulated. There are also plans to subsidise lower-emission technologies in the shipping and aviation industries, expand the building refurbishment programme and facilitate the greater use of renewable energy (Coalition Committee, 2020).

III. STRENGTHENING MARKET-BASED MECHANISMS

371. **Considerable investment** will be needed to meet the European climate targets. The EU Commission reckons that additional private and public investment of around €2.6 trillion will be required over the period from 2021 to 2030, which would equate to roughly 184 % of the investment spent between 2010 and 2019 (European Commission, 2019a, 2020c).

372. Cross-sectoral **carbon pricing as a guiding instrument of energy and climate policy** is central for coordinating the transformation effectively and mobilising private-sector capital on the path towards a lower-emission economy. A steep price path in the national emissions trading scheme will be required in order to meet the climate targets at national level by 2030. ↘ ITEMS 376 FF. However, distorting levies and surcharges on electricity are currently hindering the technology transformation from fossil fuels to electricity-based technologies in transport, heating and industry. ↘ ITEMS 382 FF. Only by **designing cross-sectoral market conditions** will it be possible to exploit the full benefits of market-based coordination. This includes carbon pricing and the consistent abolition of existing distorting levies and surcharges on energy prices. An Energy price reform that mitigates the distorting elements of electricity pricing could make it easier to meet the climate targets by 2030 and might strengthen the incentives for firms to invest

earlier in innovative business models in the field of sector coupling. ↘ ITEMS 391 FF. Beyond the energy sector it is necessary to question rules and regulations that directly or indirectly subsidise fossil fuels and, consequently, increase the cost of combatting climate change, such as the commuting mileage allowance and the preferential tax treatment of company cars (GCEE Annual Report 2011 items 358, 360; GCEE Annual Report 2012 item 365; GCEE Special Report 2019 item 105). ↘ ITEM 405

373. **Strengthening market-based instruments** and **abolishing direct and indirect subsidies** of fossil fuels would ensure reliable political guiding principles and lower the risks for investors. This would reduce the need for fragmented support measures for climate policy. Lastly, the right market conditions can create incentives for domestic firms to engage in standardisation processes as part of a forward-looking approach, thereby securing and enhancing their international competitiveness. Reconfiguring market conditions accordingly will result in both lower and additional government revenues as well as lower government spending. If all of the available options are fully utilised so as to compensate for the lower revenues arising from abolished taxes and levies, it is possible to implement major reforms without having an adverse impact on the public finances. ↘ ITEMS 396 FF.

374. **German climate policy** must increasingly be embedded within the **European context** over the medium term (GCEE Special Report 2019 items 117 ff.) in order to further strengthen markets' coordinating function. At the same time, Europe-wide uniform labelling of economic activities according to their sustainability can reduce the information asymmetry – which can hinder green investment – in capital markets. ↘ ITEMS 419 FF. Additionally, measures can be discussed which, when carbon prices are rising, would be suited to securing European firms' competitiveness in future. ↘ ITEMS 424 FF.

375. The appeal of new technologies will in future be largely determined by their product-specific carbon footprint. If the **climate-relevant properties of goods and services** were documented in a transparent, understandable and legally secure way, firms could make the climate-relevant benefits of their production processes recognisable. Whereas solutions at the firm level are already offered in the form of the Greenhouse Gas Protocol and the DIN EN ISO 14064 industrial standard, **certification systems** at product level within the EU are currently only available for selected goods such as wood and fuel (Dobson, 2018). No such certification is available in industry, where sector coupling will cause various production processes to be comprehensively transformed ↘ ITEM 359. Answers are being sought throughout Europe (European Commission, 2020d) and should be applicable globally.

1. Impact of the envisaged carbon price paths

376. The price path fixed in the national emissions trading scheme sends out a credible and binding signal and offers planning certainty for investors and households. The predictable rise in the carbon price enables households and firms to adjust to increasing costs. When the fixed-price system is converted into a **market-based**

system with a price corridor, the risk of a sharp price rise and a growing burden for firms and households will be limited by a maximum price. A minimum price, on the other hand, ensures that households faced with long investment cycles can already now plan their investments in lower-emission technologies (Edenhofer et al., 2019b; Board of Academic Advisors at the BMWi, 2019a; GCEE Special Report 2019 items 141 ff.).

The planning certainty resulting from a fixed price path or a narrow price corridor does not exist in the EU ETS. Firms requiring certificates can, however, use **futures contracts** to hedge the prices of the quantities of energy that they are likely to need. This enables the actors concerned to mitigate the uncertainty of the price path and to plan their investments accordingly.

377. **Price elasticities in the heating and transport sectors** determine how strongly the demand for energy sources and the associated carbon emissions react to the price changes induced by the national emissions trading scheme. On this basis, and in line with Bach et al. (2019a), it is possible to calculate what impact the **price path in the national emissions trading scheme** could have on **emissions in the heating and transport sectors**. It is assumed here that firms can pass on the full cost of the carbon price to households. However, substitution and evasion reactions between various energy sources cannot be taken into account. The quantitative statements are therefore subject to uncertainty.

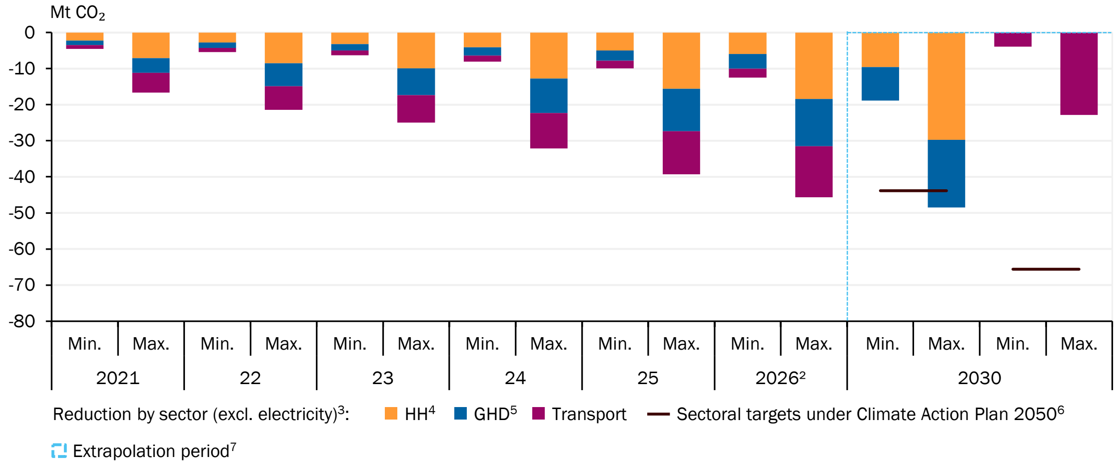
378. Various studies distinguish between **short-term and long-term own-price elasticities** for households and for trade, commerce and services. ↘ TABLE 17 APPENDIX These distinctions are, however, not totally clear. Whereas short-term price elasticities relate to immediately implementable demand responses, long-term price elasticities may reflect investments in long-lived assets such as purchases of vehicles, heating systems or, in the case of firms, production processes. Demand responses tend to be more modest in the short term than over the long term. This gives rise to a range of potential emissions reductions. ↘ CHART 60 Whereas households could significantly cut their emissions without any change of equipment, in the transport sector it is only the long-term elasticities associated with changes of equipment that bring about significant emissions reductions.

379. The introduction of a carbon price of €25 per tonne in 2021 is likely to achieve a **short-term reduction of roughly 4.6 million tonnes of CO2 compared with emissions levels in 2018**. ↘ CHART 60 Households will account for approximately 2.2 million tonnes of this reduction. The trade, commerce and services sector and the transport sector are both likely to cut their emissions by around 1.2 million tonnes of CO2 each. Higher prices along the price path up to 2026 will result in correspondingly larger reductions. In 2026, when the maximum price of €65 per tonne applies, a reduction of up to 77 million tonnes of CO2 could then be achieved compared with emissions levels in 2018.

380. The Climate Action Plan 2050 requires emissions in the heating and transport sectors to be cut by between 66 % and 67 % and by between 40 % and 42 % respectively by 2030 compared with emissions levels in 1990 (BMU, 2019b). This means that a maximum of 72 million tonnes and 98 million tonnes of CO2 respectively is still likely to be emitted in 2030. **In order to meet these targets**, the

↘ CHART 60

Emissions reductions through national carbon pricing compared with 2018[1]



1 – The minimum values for the emissions reductions are based on short-term price elasticities, while the maximum values are based on long-term price elasticities. 2 – It is assumed that the planned maximum price of €65 per tonne of CO_2 will materialise in 2026. 3 – The total reduction in the heating sector corresponds to the total reduction achieved by households and the trade, commerce and services sector. The Climate Action Programme uses the term 'buildings sector'. 4 – Private Households. 5 – Trade, commerce and services. 6 – The targets plotted here start from 2018's emissions levels and show the emissions reductions that still need to be achieved by 2030 in order to meet the targets defined in the Climate Action Plan 2050. 7 – Extrapolation assumes a carbon price of €65 per tonne from 2027 onwards.

Sources: Bach et al. (2019b), Eurostat, Federal Statistical Office, German Environment Agency, Working Group on Energy Balances, own calculations

necessary carbon price is likely – in the absence of any complementary measures – to **be much higher** than permitted by the price corridor in the national emissions trading scheme. Emissions in the heating sector (transport sector) would need to be cut by roughly 44 million tonnes (66 million tonnes) of CO2 respectively by 2030 compared with emissions levels in 2018.

If the maximum price of €65 per tonne of CO2 is extrapolated from 2026 onwards, these targets – especially those in the transport sector – are unlikely to be met by means of the carbon price alone. A price of €65 per tonne of CO2 in the transport sector will probably save a maximum of 20 million tonnes of CO2 by 2030. In the heating sector, changes in the form of appropriate investments – such as the replacement of a heating system – which are captured in the long-term price elasticities, could achieve a reduction of roughly 50 million tonnes of CO2. If this were the case, the target in the heating sector could be met. In order to achieve the emissions targets in both sectors with a uniform price – given the existing price path and historically average behavioural adjustments up to 2026 – a **price of €110 per tonne of CO2 would be needed from 2027 onwards**. According to calculations by Edenhofer et al. (2019b), the price needed in 2030 in order to meet the national climate targets by 2030 amounts to between €70 per tonne of CO2 in the best-case scenario and €350 per tonne of CO2 in the worst-case scenario. The price needed in 2030 under the medium scenario amounts to €130 per tonne of CO2 (Edenhofer et al., 2020).

381. Carbon pricing has a regressive effect unless appropriate complementary redistribution measures are taken (Preuss et al., 2019). A carbon price that would ensure that the pertinent targets are met in 2030 is therefore relevant in terms of its dis-

tribution effects (GCEE Special Report 2019 items 220 ff.). Even if these were addressed by means of appropriate redistribution, risk aversion and loss aversion, for example, could lead that individuals would be sceptical about carbon pricing (Stiglitz, 2019). Firms might be concerned about maintaining their **international competitiveness** (GCEE Special Report 2019 items 181 ff.). These difficulties need to be addressed. ↘ ITEMS 446 FF.

2. Distorting levies and surcharges need to be questioned

382. The profitability of business models in the field of sector coupling is partly determined by **changes in the price of electricity in relation to the price of fossil fuels**. This relationship is currently being distorted by a number of energy-related taxes, levies and surcharges. Fossil **fuels** such as heating oil, gas, petrol and diesel in particular are **taxed unsystematically** with respect to their carbon footprint (GCEE Special Report 2019 item 98). The electricity sector already forms part of the EU ETS. The price of electricity therefore already includes some of the consequential costs incurred by carbon emissions but, in addition to that, is also taxed in the form of national levies and surcharges.

Taxation of energy sources

383. The **widely varying levels of taxation from one energy source to another** create incentives to invest more in technologies based on less heavily taxed energy sources. This makes it less attractive to use new technologies that are already based on the use of electricity from renewable sources to decarbonise the other sectors.

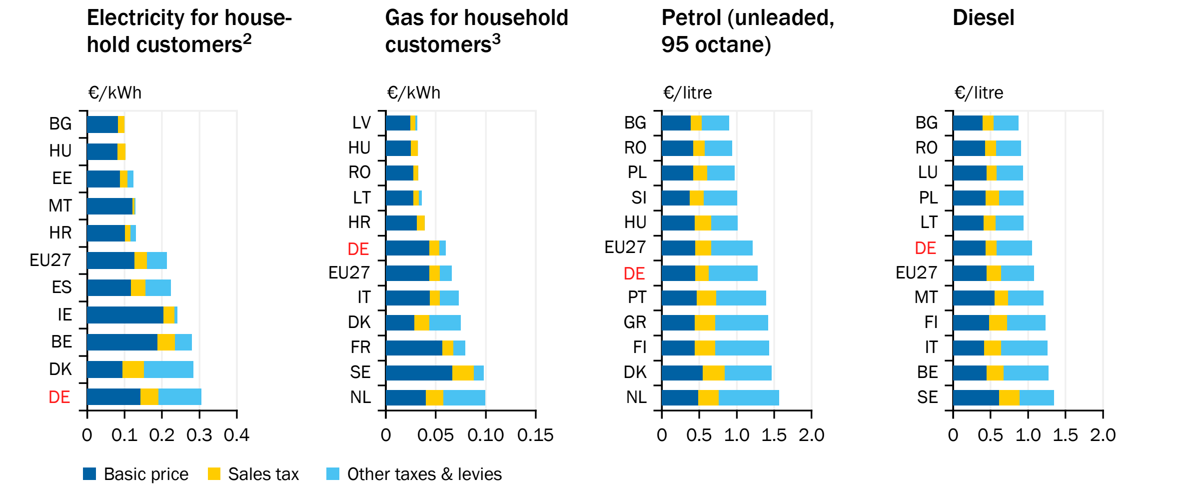
The price of electricity for end customers varies widely across Europe. Germany currently has the highest electricity prices in the EU. These differences are mainly attributable to the **varying levels of taxation of energy sources across the member states**. The taxes levied on electricity in Germany are very high compared with other European countries. ↘ CHART 61 In terms of its taxation of fossil fuels, on the other hand, Germany is on a par with the EU average.

384. In addition to the sectoral specification of emissions targets, the **varying taxation and regulation** of the individual energy sources hampers attempts to ensure that the **energy system evolves on an integrated, cross-sectoral basis**. This poses a risk that avoidance of emissions will in future not happen where it would be especially cost-effectively feasible. The taxation of energy consumption is not the only tax preventing the efficient reduction of emissions. A fundamental reconfiguration of climate policies requires the prospect of **reforms of the taxes and levies on electricity** and other energy sources (GCEE Special Report 2019 item 126). In addition, the entire tax system contains elements that prevent the climate targets from being met. ↘ ITEM 405 Desirable would be a single consistent regulatory framework for fossil fuels and renewable energy as well as for the electricity, heating and transport sectors to eliminate price distortions between all energy sources and technologies.

↘ CHART 61

Basic prices and tax burden on various energy sources in 2020[1]

The five cheapest and the five most expensive member states compared with the EU and Germany



1 – Data as at 25.10.2020. BE-Belgium, BG-Bulgaria, DE-Germany, DK-Denmark, EE-Estonia, ES-Spain, EU27-European Union, FI-Finland, FR-France, GR-Greece, HR-Croatia, HU-Hungary, IE-Ireland, IT-Italy, LT-Lithuania, LU-Luxembourg, LV-Latvia, MT-Malta, NL-Netherlands, PL-Poland, PT-Portugal, RO-Romania, SE-Sweden, SI-Slovenia. 2 – Consumption of more than 2,500 kWh and less than 5,000 kWh. 3 – Consumption of more than 20 GJ and less than 200 GJ.

Sources: European Commission, Eurostat , own calculations

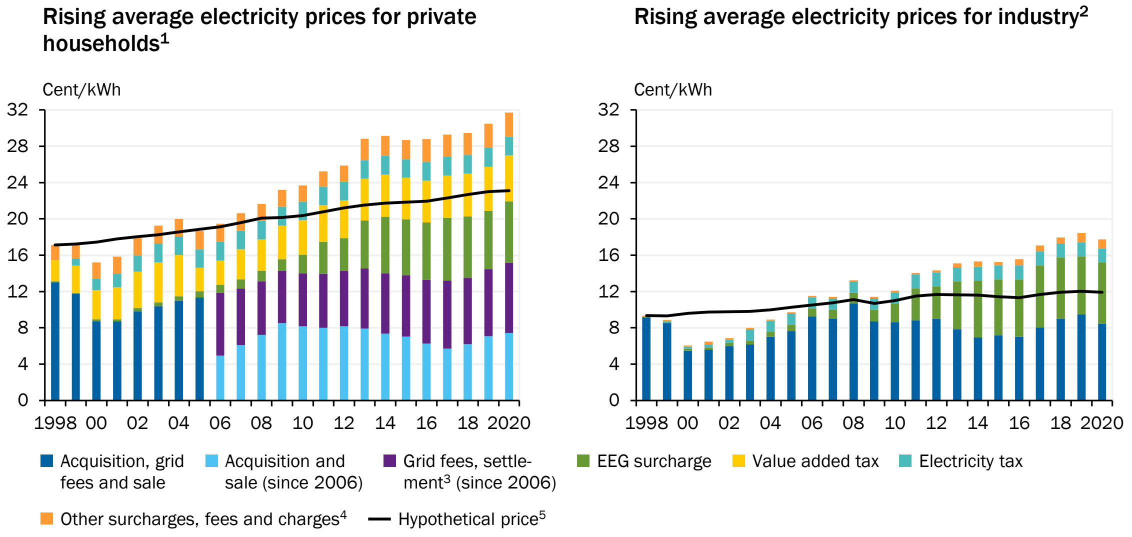
385. If a sector, such as the electricity sector, is already integrated into an emissions trading scheme with a cap, a lowering of taxes and levies will not increase total emissions. If, however, a **trading system with fixed certificate quantities** has not yet been established – as in the heating and transport sectors, for example – then a quantity reaction to a lowering of taxes and levies can increase carbon emissions overall. If, therefore, existing distortions in the electricity price are addressed, where the relative tax burden is already fairly high ↘ CHART 61, this can create a considerable leverage effect which, owing to the cap in the EU ETS, is not likely to be accompanied by a corresponding impact on total emissions. In addition, reducing the burden of electricity levies and surcharges on households can more than compensate for the negative distribution effects of carbon pricing for the lower income deciles. ↘ ITEM 413

386. The taxation of fuel has been partly justified by the need to **finance the transport infrastructure**. Although the appropriation of these funds for this specific purpose is not legally binding, any future transport system based largely on electricity would logically have to resort to alternative sources of funding. It might, for example, be considered funding road infrastructure in future not by taxing energy sources but by taxing road use in the form of road pricing (SRU, 2017; Cramton et al., 2018, 2019; Board of Academic Advisors at the BMWi, 2019b). Local externalities such as road congestion could then be addressed more effectively by imposing local levies such as congestion charging (Löschel et al., 2019; GCEE Special Report 2019 item 127).

Electricity prices and their components for households and industry

387. The **electricity prices charged to household customers** comprise three basic components: the price for the procurement and supply of the electricity, the

↘ CHART 62
Electricity prices and their components for households and industrial customers



1 – As at July 2020. For an annual consumption of 3,500 kWh. The reduced sales tax rate of 16 %, which applies for a limited period until 31 December 2020, gives rise to a gross price of 30.91 cents per kWh for 2020. 2 – As at July 2020. Medium-voltage supply: for annual consumptions of between 160,000 kWh and 20 million kWh. 3 – Including metering and meter operation. 4 – Concession fee, surcharge for the Combined Heat and Power Act (KWKG), surcharge under section 19 of the Electricity Grid Fee Ordinance (StromNEV), offshore grid surcharge (offshore liability surcharge until 2018) and surcharge for interruptible loads. 5 – For private households: 1998's electricity price updated in line with increases in the consumer price index (as at October 2020). For industry: 1998's electricity price updated in line with increases in producer prices of commercial products excluding electricity, gas and district heating (as at September 2020).

Sources: Federal Statistical Office, German Association of Energy and Water Industries (BDEW), own calculations

fees for use of the grid, as well as taxes and levies. ↘ CHART 62 LEFT The average electricity price charged to households in 2020 has been 31.71 cents per kWh (BDEW, 2020). Of this price per kWh charged in 2020, 2.05 cents is attributable to electricity tax and roughly 6.76 cents goes on the EEG surcharge. Further charges payable here are a concession fee, a surcharge for the Combined Heat and Power Act (KWKG), a surcharge under section 19 of the Electricity Grid Fee Ordinance (StromNEV), an offshore grid surcharge and a surcharge for interruptible loads. Together they have increased the electricity price by 2.67 cents per kWh in 2020. In addition, sales tax is charged at the regular rate, which has been cut in the second half of 2020. Taxes, levies and surcharges account for an average of around 53 % of households' total spending on electricity.

388. **Firms** have paid an average electricity price of 17.75 cents per kWh in 2020. ↘ CHART 62 RIGHT Taxes, levies and surcharges account for an average of around 50 % of this price (BDEW, 2020). The levels of **taxes and levies paid by firms for electricity** vary widely. Manufacturing industry and the agricultural and forestry sector pay a reduced tax rate of roughly 1.54 cents per kWh. Further allowances are granted in the form of peak balancing and tax relief on electricity consumption for certain energy-intensive processes and procedures. Consequently, taxes and levies account for a much smaller proportion of end-consumer prices in the manufacturing sector. Firms engaged in trade, commerce and services, on the other hand, bear the full cost of these taxes and levies. In addition, manufacturing firms paid grid fees of 2.33 cents per kWh last year, which was significantly less than the grid fees of 7.22 cents per kWh and 6.31 cents per kWh paid by households and small businesses respectively (German Bundestag, 2020a).

389. **Taxes, levies and surcharges** as a **proportion of the electricity price** paid by households and industry have **risen continually** since 1998. ↘ CHART 62 The largest rise is attributable to the EEG surcharge, which rose in absolute terms until 2017 and has since fallen slightly. This is related to the transition towards calls for tenders under the German Renewable Energy Sources Act (EEG) 2017 (EEG 2017; GCEE Annual Report 2016 items 891 ff.), which specifies that the level of funding granted to plant operators is determined by the Bundesnetzagentur (federal network agency) as part of an auction process, which has replaced the previously legally enshrined entitlement to funding.

390. The cost of the electricity grid is currently divided among the electricity customers living in the grid region of the relevant operator. The current system of **paying fees to use the electricity grids** is coming under growing pressure as a result of the transformation of Germany's energy sector (RAP, 2014; dena, 2018a). The average grid fees for all consumer groups have tended to rise since 2011. ↘ CHART 62 This increase has not, however, been equally distributed. Rather, inherent benefits enjoyed by individual user groups are increasingly being claimed at the expense of other user groups. This is giving rise to an ever wider range of financial costs for individual households and competitive disadvantages for individual industrial locations (RAP, 2014). Although the German government's coalition agreement stated the need to reform the system of grid fees, this has yet to be done (German Bundestag, 2020b)

3. Effects of an energy price reform

391. A decisive step towards strengthening market-based guidance of decision-making in energy markets could consist of a far-reaching energy price reform that reduces the burden for consumers through quantity-based levies and surcharges on electricity. In order to achieve the maximum leverage effect, such an **energy price reform** might **abolish the EEG surcharge**. In addition, the **electricity tax could be cut to the minimum European rate** of 0.01 cents per kWh for households and 0.05 cents for firms.

392. An across-the-board cut in surcharges and levies with the aim of establishing electricity as the main source of energy reduces the regulatory risk and creates **planning certainty** for market participants. This would provide **incentives** for firms to start investing more in technologies that use electricity from among a growing proportion of renewable energies to decarbonise the heating and transport sectors as well as industry. It would also encourage households to use electricity-based technologies and products in order to meet their mobility and heating needs. Cutting taxes that distort climate-policy incentives thus removes the need to support specific technologies in places where carbon-neutral business models can compete on their own merits. Reducing electricity prices also acts as a **counterweight to carbon pricing** for low-income households in particular**, which has a regressive effect**.

393. The distribution effects induced by climate policy should not be ignored from a political and societal perspective. The revenue received from carbon pricing could

be used to ensure social equilibrium. Various forms of redistribution would be feasible (Preuss et al., 2019; GCEE Special Report 2019 items 220 ff.).

The **Climate Action Programme 2030** specifies that revenues from the national emissions trading scheme should be used to reduce the EEG surcharge. ↘ ITEM 367 According to the latest plans, however, not all of the **revenues from the national emissions trading scheme** are to be used to **cut the EEG surcharge** (Pittel and Schmitt, 2020). Under the arrangements in the German government's economic stimulus package the EEG surcharge will be set at 6.5 cents per kWh in 2021. This represents a year-on-year reduction of 0.25 cents per kWh in the EEG surcharge. Because the EEG surcharge would otherwise have been expected to rise sharply as a result of the coronavirus crisis (Wagner et al., 2020), the revenues from the national emissions trading scheme as well as a federal government subsidy will be used next year to stabilise electricity prices at their pre-crisis levels.

394. If, as intended by the Climate Action Programme 2030, the amount of redistribution in future varies from year to year depending on the level of revenue received under the BEHG, the government-determined components of future electricity prices will remain insufficiently anticipatable for market participants. This will therefore continue to offer **little planning certainty for investors and households**. This may cause investors' and households' adoption of new technologies to be significantly delayed. More significant cuts in surcharges are likely to create a correspondingly **stronger steering effect with respect to the transition to electricity-based technologies**. The total abolition of price-distorting aspects of electricity prices can make a necessary and market-neutral contribution to **ensuring economic efficiency and competitiveness** for individual sector-coupling technologies as opposed to a less ambitious approach (Winkler et al., 2020). The efficiency benefits associated with the abolition of price-distorting factors are likely to have an additional positive impact. **Lowering the EEG surcharge to zero** can also **cut bureaucracy** and reduce complexity for actors such as transmission and distribution grid operators, electricity suppliers, self-suppliers and electricity-intensive firms (dena, 2020).

395. Using public funds to reduce the EEG surcharge is of **relevance under EU state aid rules**. From a legal procedural perspective, an action of this kind would need to be notified owing to the state-aid nature of the EEG surcharge and, in this way, would need to be approved by the European Commission. Given that the objective of this action is combatting climate change, the Commission might, nonetheless, approve this initiative (Büdenbender, 2019; Kahles and Müller, 2020). From a forward-looking perspective, on the other hand, the effects of this shift from a surcharge to budget finance would be considerably more far-reaching. In purely formal terms, and with respect to the relevant legislative processes, every material change to the EEG would then in future – before coming into force – have to be notified to the European Commission and approved by it. Such cases are examined for compliance with EU state aid rules and the guidelines on state aid for environmental protection and the energy sector, although these are to be replaced by new guidelines by the end of this year. In terms of their substance therefore, it

remains to be seen what criteria are applied to such approvals in future (dena, 2020).

Funding of an energy price reform

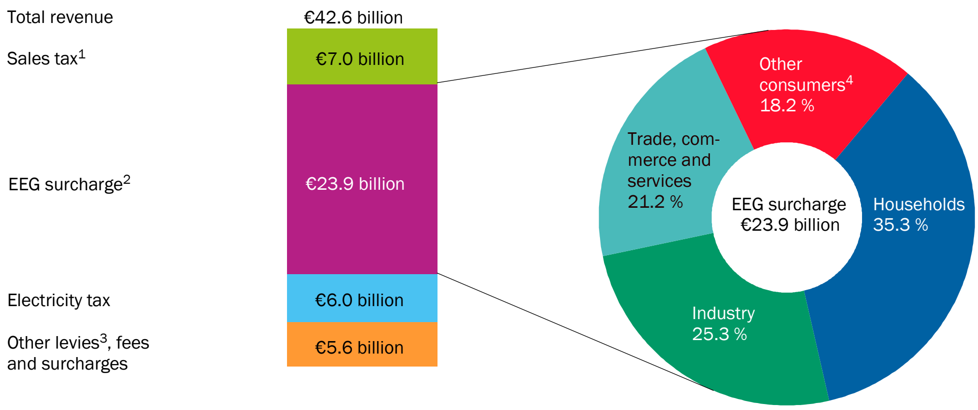
396. **Changes in the levels of the EEG surcharge and the electricity tax over time** need to be simulated in order to estimate how the discussed energy price reforms will **impact on the public finances** over the coming years. Forecasts of this kind are dependent on various factors, such as the market price of electricity, electricity consumption and the exemptions for industry and self-suppliers and therefore involve a degree of uncertainty.

397. The EEG surcharge will impose a burden of €23.9 billion on households and firms in 2020 (BDEW, 2020). Given the decisions taken as part of the government's climate-protection and economic stimulus package, the direct amounts appropriated to **fund the shares for renewable energy are likely to decline from 2021 onwards** (Agora Energiewende, 2020; dena, 2020). ↘ ITEM 367 The costs still borne by consumers in 2026 are likely to amount to roughly €18.5 billion.

The German government will receive revenue of €6 billion from the electricity tax in 2020. A forecast of electricity consumption over the coming year is necessary in order to estimate the future **levels of electricity tax revenues**. A forecast by the German Energy Agency (dena, 2018b), which already factors in trends in the fields of electric mobility and heat pumps, predicts levels of gross electricity demand over time that would cause the revenue received from the electricity tax to rise linearly until 2030. This revenue is likely to amount to approximately €8 billion in 2026. ↘ CHART 63

398. An energy price reform that reduces the EEG surcharge to zero and cuts the electricity tax to the European minimum for households and firms would thus incur

↘ CHART 63
Revenue expected from taxes and surcharges in 2020



1 – Excluding the temporary cut in sales tax as part of the economic stimulus package. 2 – Costs borne by consumers (amount of surcharge in 2020 plus revenue from privileged final consumption) for the EEG surcharge in 2020. Based on the BDEW's forecast of the EEG surcharge for 2020 dated 15.10.2019 and the medium-term forecast of Germany's nationwide electricity levy on final consumers dated 07.10.2019. 3 – Surcharge for the Combined Heat and Power Act (KWKG), concession fees, surcharge under §19 of the Electricity Grid Fee Ordinance (StromNEV), offshore grid surcharge and surcharge for interruptible loads. 4 – Agriculture, public institutions, transport.

Sources: BDEW, own calculations

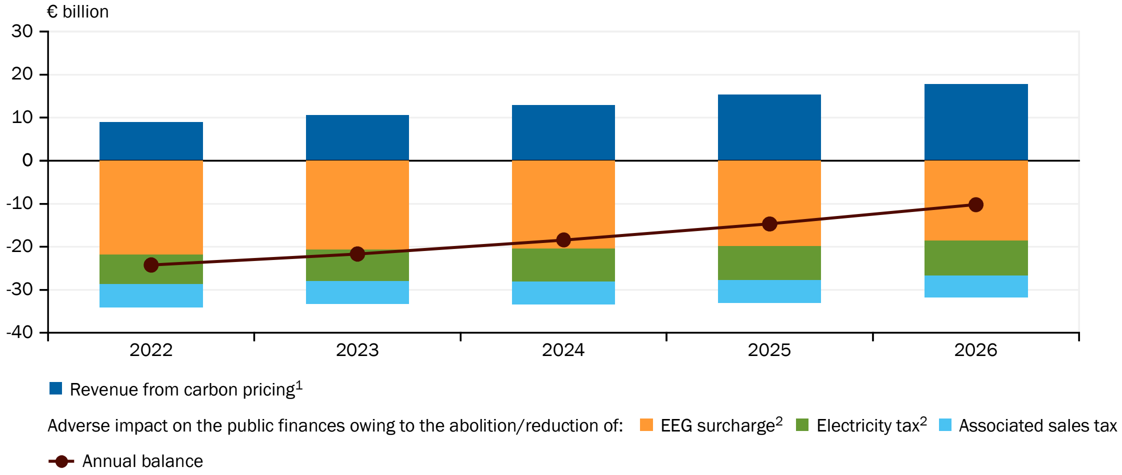
a **financial expense of around €29 billion in 2022** based on the forecast trends for both levies. This cost would fall to around €27 billion by 2026. ↘ CHART 64 In addition, annual sales tax revenues of between €5 billion and €6 billion would be lost. Reform proposals that do not cut all levies to zero cause the cost to fall linearly.

399. The main instrument used to fund the transformation of Germany's energy sector and the country's climate change initiatives is its **Energy and Climate Fund (EKF).** ↘ TABLE 16 The Climate Action Programme 2030 made €38.9 billion available to the EKF. The economic stimulus package launched in July 2020 approved a further €26 billion (BMF, 2020). The main source of income for the EKF is currently the revenue received from the EU ETS. A federal government subsidy of roughly the same amount will also be available over the coming years. In addition, from 2021 onwards the EKF will receive all of the revenue derived from the national emissions trading scheme, from the reforms of motor vehicle tax, from the carbon differentiation of truck tolls and from the increase in air traffic tax. Over the coming years this revenue will be used to fund various programme measures such as promoting electric mobility, encouraging the energy-efficient refurbishment of buildings, cutting value added tax (VAT) on train tickets and supporting local public transport. Total programme spending of €26.8 billion is planned for 2021. Roughly €30 billion has been earmarked for cutting electricity prices during the period up to 2024 (German Bundesrat, 2020).

400. The extent to which the discussed **energy price reforms** – which would totally abolish the EEG surcharge and cut the electricity tax to the minimum rate – could be **funded by the revenue derived from the national emissions trading scheme** depends largely on the level of the carbon price. Because this price will rise annually over the coming years, the revenue generated is likely to increase

↘ CHART 64

Overall fiscal impact of national carbon pricing and energy price reform



1 –According to the draft of the German government's budget projections for the period from 2022 to 2024. The figures for 2025 and 2026 have been calculated under the assumption that revenue will continue to grow at the rate at which it grew in 2023 and 2024. It is assumed that the planned maximum price of €65 per tonne of CO_2 will materialise in 2026. 2 –Based on a German Energy Agency (dena) simulation of the future levels of the EEG surcharge and electricity tax.

Sources: Federal Ministry of Finance, dena (2020), own calculation steadily in the first few years. The German Federal Ministry of Finance (BMF, 2020) expects the revenue generated by the national carbon pricing scheme to amount to €7.4 billion next year, rising to €12.9 billion by 2024. ↘ TABLE 16 If the revenue received from the carbon pricing scheme continues to rise at a similar rate in subsequent years, in 2025 we are likely to see revenue of €15.4 billion and in 2026 – assuming a maximum price of €65 per tonne of CO_2 – revenue of €17.8 billion generated. On the whole, however, the amount of revenue received – especially over the medium to long term – is likely to depend heavily on how the total level of emissions evolves up to then.

401. The **revenue received from the national emissions trading scheme** could be used to partly fund the energy price reforms. This might even send out a positive signal: the appropriation of these funds for this purpose would show that the carbon price is not intended to generate revenue but is directly redistributed (GCEE Special Report 2019 item 219). Various factors need to be considered here.

↘ TABLE 16
"Energy and Climate Fund" special asset[1]
€ million

	2020 target[2]	2021 draft	Budget projections		
			2022	2023	2024
Total revenue	**35,024**	**42,669**	**30,878**	**22,058**	**20,854**
of which Revenue from EU ETS	2,264	2,745	2,692	2,788	3,824
Revenue from national carbon pricing	–	7,413	8,971	10,540	12,938
Federal government subsidies	26,523	2,454	3,306	3,012	2,639
Withdrawal from reserve	6,237	30,057	15,910	5,718	1,453
Total expenditure	**35,024**	**42,669**	**30,878**	**22,058**	**20,854**
of which Buildings sector	3,549	6,007	5,611	5,210	4,659
Transport sector	1,856	5,544	6,426	5,756	5,253
Industrial sector	804	1,172	1,559	1,604	1,404
Energy sector	696	1,251	1,274	956	788
Agricultural and forestry sector	70	180	192	216	215
Research and innovation sector	156	196	236	241	241
National climate change initiative and other measures on national climate protection	375	431	396	396	396
Energy efficiency cross-cutting function	281	272	370	425	347
Electricity price compensation (Industry)	567	878	957	972	988
Electricity price reduction (EEG)	–	10,800	8,070	4,770	6,523
Other	30	30	70	60	40
Transfer to reserve	26,643	15,910	5,718	1,453	–

1 – Draft of the German government's budget projections for the period from 2022 to 2024. Totals contain rounding-related dicrepancies.
2 – Figures for 2020 include supplementary budgets.

Source: German Bundesrat (2020)

Some of the revenue received from the national carbon pricing scheme, for example, has already been set aside for other measures in the EKF. The electricity price reduction currently planned under the EEG, on the other hand, would directly help to fund the energy price reform. ↘ TABLE 16

Over the coming years, however, the revenue generated by the national carbon pricing scheme can only partly fund the discussed energy price reform. Even if all of the revenue received from the national carbon pricing scheme were used to fund this reform, there would still be a deficit of roughly €24 billion in 2022 if the carbon price were €30 per tonne of CO2. This deficit represents the **difference between** the **revenue received from the carbon pricing scheme**, on the one hand, and the electricity tax and EEG surcharge revenue lost as a result of the **energy price reform** as well as the sales tax revenue lost owing to the abolition of the electricity levies and surcharges, on the other. Although this deficit would decrease over the coming years because of the envisaged carbon price path and an EEG surcharge that would probably fall over time, there would nonetheless always be a deficit to report in the coming years that would either need to be covered by other sources or would have to be accepted. ↘ CHART 64 If the revenue received from the national carbon pricing scheme should be used to cover the entire deficit resulting from the abolished levies and surcharges, a carbon price of €90 per tonne of CO2 would probably be needed in the national emissions trading scheme. This price level would, under the current plans, not be possible until at least 2027.

402. One option as a contribution to funding might be a **national minimum carbon price in the EU ETS**. Based on the model used by the United Kingdom, a minimum price could be fixed for several years and the difference between the certificate price and the minimum price could be charged as a climate change levy (Hirst and Keep, 2018; GCEE Special Report 2019 item 146). Provided that legal concerns can be allayed (Büdenbender, 2019), a minimum price could offset the difference in carbon prices between the EU ETS and the national emissions trading scheme. It is true that a minimum price in the EU ETS is likely to raise the price of electricity, thus weakening the discussed energy price reform's impact on the appeal of sector coupling. However, the distorting aspects of two parallel market systems could be mitigated at an early stage, thereby making it easier to establish cross-sectoral carbon pricing at a later date. Although, given the potential **waterbed effect** (Edenhofer et al., 2019a), a minimum price is unlikely to have any impact on total emissions within the EU, it might improve the efficiency of German climate policy.

403. It would, in principle, be possible to deviate from the approved price path in the national emissions trading scheme in order to reach a carbon price more quickly that would enable **far-reaching energy price reforms to be better funded**. This would burden households and firms to a greater extent than previously planned in the areas of transport and heating. ↘ ITEMS 408 FF. AND 415 FF. In addition, the steeper price path would present actors with the challenge of switching to electricity-based technologies more quickly in order to avoid the higher prices of fossil fuels and to benefit from low electricity prices. Despite the price reductions introduced by the energy price reform, this financial burden might be perceived as being socially unbalanced. It is expected, however, that stronger market incentives

will lead to a situation where climate-friendly forms of behaviour will be available to households and firms sooner as the relevant business models become attractive more quickly.

In political terms, therefore, any **raising of the carbon price path** poses a **challenge** for which the various consequences and opportunities need to be weighed up against each other. It is thus also worth considering other ways of funding an energy price reform.

404. Another way of helping to fund the energy price reform would be to reduce the EKF's spending in various places. The energy price reform might make **fragmented individual measures** in various sectors **superfluous**. For example, such a reform is likely to enhance the appeal of electric vehicles. Other support measures designed to make electric vehicles cheaper could be scaled back accordingly without slowing down the electrification of transport. ↘ ITEM 451 This would offer the chance to replace fragmented national climate policy measures with market-based mechanisms wherever these appear to be more promising. This could therefore cut the overall cost of meeting climate targets.

405. Another feasible way of funding part of the discussed energy price reform would be to **abolish** regulations that are problematic from a climate policy perspective. A report compiled by Köder and Burger (2017) for the German Environment Agency lists subsidies totalling approximately €57 billion in 2012 that they classify as harmful to the environment. It might be worth considering reducing these subsidies. The **commuting mileage allowance**, for example, creates a dubious incentive to increase the distance between one's place of residence and place of work (GCEE Annual Report 2011 item 360; GCEE Annual Report 2012 item 365; GCEE Special Report 2019 item 105). At the same time, it reduced income tax revenue by around €5.1 billion in 2012 (Köder and Burger, 2017). The Climate Action Programme 2030 has even extended the scope of this allowance further to compensate commuters for the rising price of fuel. In addition, **personal use of company cars** continues to enjoy preferential tax treatment compared with privately owned cars (GCEE Annual Report 2011 item 358). Köder and Burger (2017) estimate the cumulative benefit of this preferential tax treatment of company cars to be at least €3.1 billion in 2012.

406. To a small extent, the energy price reform could fund itself. The starting point for this consideration is the **growing demand for electricity** that would be triggered by the reform. ↘ ITEMS 476 FF. APPENDIX Firstly, this would probably mean that demand for certificates in the EU ETS would rise. The resultant price effect on the certificates is likely to **increase the level of government revenue**, which would then be available to the EKF. And, secondly, the growing demand for electricity will probably cause the market price of electricity to rise. This, in turn, is likely to reduce the payment obligations for the feed-in tariff and, consequently, lower the EEG surcharge. It is, however, unclear how significant these two effects could be in the short term. Moreover, growing demand for electricity can have a countervailing effect on funding: the more fossil fuels in the transport and heating sectors are replaced by electricity, the lower the revenue from the national emissions trading scheme will be that could potentially be used for funding purposes.

407. If the aforementioned funding options are exploited to the fullest possible extent but they are still unable to provide all of the funding needed, the **energy price reform** could be implemented **in stages over time** in order to reduce the amount of funding required. It should be noted that cutting the EEG surcharge to zero would save a substantial administrative cost, which is why this surcharge should be the initial focus of attention. In addition, the available funds could be granted as a **federal government subsidy to the EEG account** each year so that the EEG surcharge for consumers could be gradually reduced. Furthermore, a reliable path should be indicated at the earliest opportunity in order to increase planning certainty for firms and households and create the strongest possible incentives.

Impact on households

408. In order to **estimate the impact that carbon pricing has** on households, consumption data from the sample survey of household income and expenditure (EVS) for 2018 as well as carbon emissions factors for fossil fuels in 2018 from the German Environment Agency are used. The starting point here is the assumption that households' spending on fuel and heating energy is made more expensive by the prevailing carbon price in line with their level of carbon emissions. Owing to the data, however, the calculated charges involve a degree of uncertainty (GCEE Special Report 2019 box 3).

The **national emissions trading scheme** is likely to have a direct **impact on consumer prices** with respect to heating energy and fuel (Nöh et al., 2020). However, the following calculations neglect carbon pricing's indirect effects on consumer goods, which can result from inputs of intermediate goods. The financial burden imposed on households by carbon pricing is therefore likely to be underestimated.

409. **Assuming** a price of €25 per tonne of CO2 and that **costs are passed on in full to consumers**, price increases of, for example, about 6 cents per litre for petrol and 7 cents per litre for heating oil can be expected for 2021 compared with 2018. Based on a price of €65 per tonne of CO2, which corresponds to the fixed maximum price in 2026, the price effects compared with 2018 could be as much as 15.5 cents per litre (17 cents per litre) for petrol (heating oil).

410. The introduction of carbon pricing in the transport and heating sectors is likely to impose a financial burden particularly on those households that are currently especially heavy users of fossil fuels. ↘ CHART 65 LEFT Households will be able to reduce their **individual financial burden** by adjusting their behaviour accordingly. This will especially be the case if the price path is transparent for households and they therefore have medium-term planning certainty. This could strongly influence decisions to **invest in durable goods** that use electricity rather than fossil fuels as their energy source.

411. In estimating the cost reductions enjoyed by households as a result of the abolition of the EEG surcharge and the cutting of the electricity tax to the minimum rate permitted, the following calculations take account of the **direct financial**

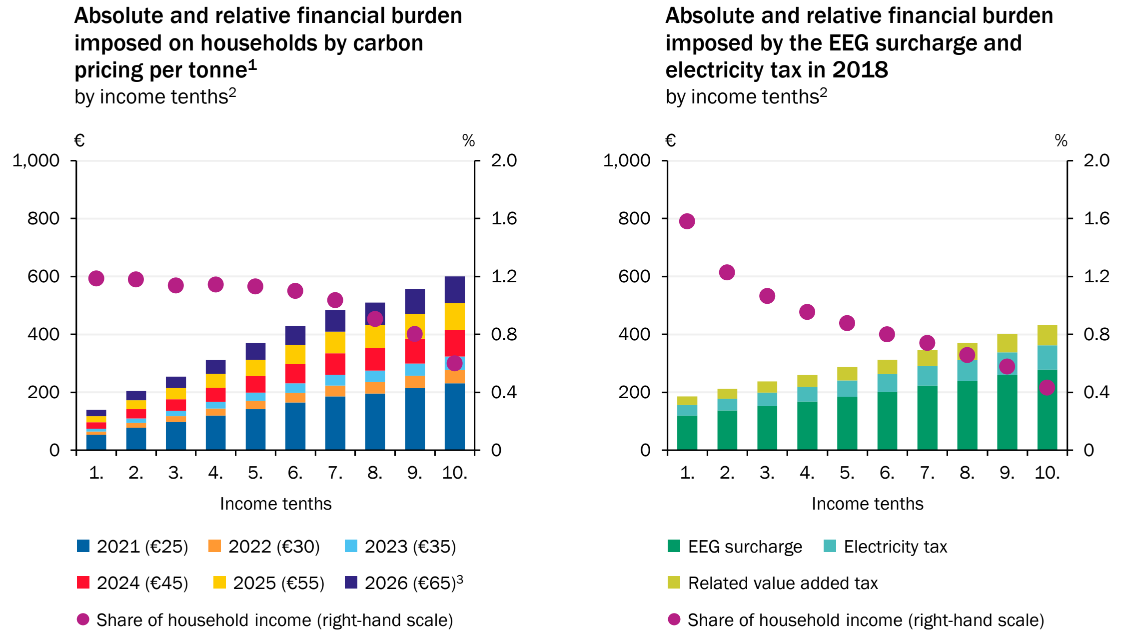
discharge for households in the form of lower electricity prices. However, these calculations neglect the **indirect financial discharge** accruing to households in the form of lower consumer goods prices arising from the lower electricity prices paid by firms. The financial discharge enjoyed by households as a result of the energy price reforms are therefore likely to be underestimated.

The **financial burden that levies impose** on households **is heterogeneous** (GCEE Special Report 2019 items 222 ff.). Because households in higher income groups have a higher electricity consumption, their burden is higher in absolute terms. Relative to equivalised household incomes, however, the financial burden on households in higher income deciles decreases as the proportion of other consumption categories in a basket of goods increases. Energy taxes therefore have a **regressive** effect. ↘ CHART 65 RIGHT

412. The distribution effects of climate policy measures can usually only be quantified with a great deal of uncertainty. In order to fully assess the energy price reforms and their distribution effect on households, the reforms would have to be compared with the **distribution effects of their funding measures**. However, the large number of individual measures does not allow any comprehensive distribution calculations to be carried out. The national system of carbon pricing is therefore used as an example to model this funding in full below. Furthermore,

↘ CHART 65

Financial burden and discharge for households as a result of the national emissions trading scheme and the energy price reform



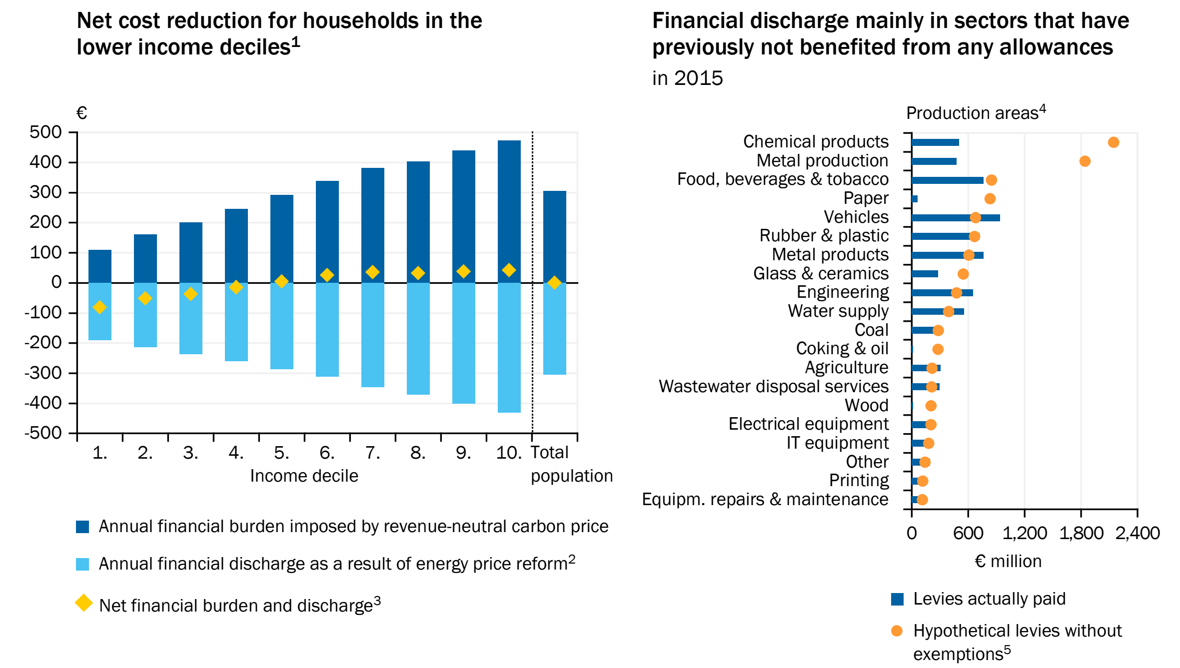
1 – Calculations are based on households' spending on fuel and heating energy in the sample survey of household income and expenditure (EVS) for 2018. The figures for 2021 show the price effect compared with this baseline year. The figures for the years from 2022 onwards show the financial burden imposed in each case compared with the previous year. 2 – The EVS only provides the absolute figures for spending on electricity. It is assumed that all households paid 29.47 cents per kWh in 2018 regardless of their annual consumption. According to the Bundesnetzagentur (federal network agency), this is the average price of electricity for annual consumptions of between 2,500 kWh and 5,000 kWh as at 1 April. The EEG surcharge amounted to 6.79 cents per kWh in 2018. 3 – It is assumed that the planned maximum price of €65 per tonne of CO_2 will materialise in 2026. This therefore constitutes the upper limit of the additional cost burden.

Sources: RDC of the Federal Statistical Office and Statistical Offices of the Länder, Einkommens- und Verbrauchsstichprobe 2018 Grundfile 5 (HB), own calculations firms' additional financial burden and discharge have been omitted owing to the inadequate database. ↘ ITEMS 415 F. This means that the indirect effects of firms passing on their additional costs and cost reductions to households are not taken into account. Given these assumptions, households' additional financial burden and discharge for various income deciles can at least be roughly estimated.

413. A sample calculation ↘ CHART 66 LEFT analyses, on the one hand, the financial discharge accruing to households as a result of changes to their electricity prices owing to the **abolition of the EEG surcharge and the cut in electricity tax**. And, on the other hand, the calculation shows the **additional costs** borne by households **as a result of carbon pricing**. It is assumed here that households' spending on fuel and heating energy is made more expensive by the prevailing carbon price in line with their level of carbon emissions. Potential indirect effects of firms' changing production costs on the prices of other goods and services are, on the other hand, neglected. ↘ ITEMS 415 F. Given these assumptions, a carbon price of €51 per tonne of CO2 would impose an aggregate additional financial burden of around €12 billion per year on households. This represents the fiscal costs that would be incurred if the electricity tax and the EEG surcharge as well as the sales tax payable thereon were abolished for households only. The total revenue received from the national emissions trading scheme at a price of €51 per tonne of

↘ CHART 66

Net financial burden and discharge as a result of energy price reform at a price of €51 per tonne of CO_2



1 – Revenue neutrality for households is reached at a price of €51 per tonne of CO_2. 2 – Based on electricity spending in the EVS in 2018 and on an EEG surcharge of 6.79 cents per kWh in the same year. 3 – This shows the difference between the absolute Financial discharge as a result of energy price reform – which abolishes the EEG surcharge and cuts electricity tax to the minimum rate – and the absolute additional cost imposed by a price of €51 per tonne of CO_2. 4 – According to the Classification of Products by Activity, edition 2008 (CPA 2008). 5 – Under the hypothetical scenario the EEG costs are charged on the full amount of electricity consumption, including self-generated electricity and the consumption currently exempted by the special compensation arrangement. The resultant hypothetical EEG surcharge rate then amounts to 4.37 cents per kWh. The hypothetical costs of a production area are the product of the hypothetical EEG surcharge rate and the total electricity consumption of the production area.

Sources: BMWi, Federal Statistical Office, German Environment Agency, RDC of the Federal Statistical Office and Statistical Offices of the Länder, Einkommens- und Verbrauchsstichprobe 2018 Grundfile 5 (HB), own calculations

CO_2 is likely to be much higher because more of firms' emissions would be subject to carbon pricing.

A carbon price of €51 per tonne of CO_2 is likely to impose additional costs of roughly €300 per year on the average household. The average cost reduction is likely to be of a similar amount. Right across the income distribution, however, the discussed **energy price reforms would counteract the regressive distribution effect of carbon pricing.** This would mean, for example, that households in the lowest four income deciles would benefit from net financial discharges overall, while households on higher equivalised incomes would bear a net burden. ↘ CHART 66 LEFT The findings suggest that energy price reforms that are funded on a revenue-neutral basis for households by means of national carbon pricing can be implemented in a socially balanced way. Complementary measures would be appropriate in cases where households bearing a particularly substantial net burden required additional support (GCEE Special Report 2019 items 245 ff.).

414. The energy price reforms would also discharge firms. ↘ ITEM 416 This discharge would be partly offset by revenue from the national emissions trading scheme which arises from the pricing of further emissions caused by firms. ↘ ITEM 415 This additional revenue would not, however, be sufficient to fund the **financial discharge for firms** in full. If the full cost of the energy price reforms is to be funded by carbon pricing alone, a carbon price of €90 per tonne of CO_2 is likely to be needed in the national emissions trading scheme. ↘ ITEM 401

The rising cost of levies imposed by carbon pricing is likely to raise prices. Against this backdrop it might be beneficial not to fund the energy price reform solely by means of the revenue received from carbon pricing but, instead, to look for alternative sources of funding by, for example, **abolishing** regulations that are problematic from a climate policy perspective. ↘ ITEM 405 When exploiting such sources of funding it is important to ensure that they do not have any undesirable distribution effects.

Impact on firms

415. The **pricing of carbon under the BEHG** in principle includes all types of fuel that are brought into circulation. Because the purpose of the BEHG is to price those emissions that are not covered by the EU ETS, double taxation by the BEHG and the EU ETS is to be avoided in accordance with section 7 BEHG. Consequently, no additional costs are imposed on the industrial plants covered by the EU ETS. As roughly 124 million tonnes out of the 184 million tonnes of carbon emissions caused by industry in 2018 was covered by the EU ETS, industry would incur additional costs of around €1.5 billion if the price of carbon emissions were €25 per tonne of CO_2. Trade, commerce and services firms, which caused carbon emissions of approximately 120 million tonnes in 2018, would incur additional costs of just under €3.0 billion. Assuming that the quantity of emissions remains constant, the revenue expected to come from these sectors in 2021 would therefore amount to roughly €4.5 billion, and then in 2026 – with carbon priced at €65 per tonne of CO_2 – would be approximately €11.6 billion.

416. Reducing the **EEG surcharge** and **electricity tax** will substantially lower firms' costs. In 2020, roughly 25 % (just under €6 billion) of the EEG surcharge has been paid by industry and around 21 % (approximately €5 billion) has been borne by trade, commerce and services firms (BDEW, 2020). ↘ CHART 63 This means that the EEG surcharge has imposed total costs of around €11 billion on firms. In addition, firms contributed roughly €4.3 billion of the total electricity tax revenues of €6.9 billion in 2018. An energy price reform that cuts the electricity tax to the European minimum of 0.05 cents per kWh for firms and abolishes all aforementioned levies would therefore reduce firms' total costs by around €15 billion per year.

417. **Comprehensive exemptions** from the EEG surcharge apply to **large-scale industrial consumers with high electricity costs** and to **self-generators** (sections 60a ff. EEG 2017). Large-scale consumers with an annual consumption of more than one gigawatt-hour and total electricity costs that account for more than 14 % of their gross value added pay a reduced EEG surcharge under the special compensation arrangement (besondere Ausgleichsregelung). In addition, self-consumed self-generated electricity is exempt from the EEG surcharge for many industrial plants. These exemptions mean that industries with high electricity costs pay comparatively low charges in relation to their electricity consumption. This is illustrated by comparing the actual charges paid by individual industries with the hypothetical charges if all **exemptions** were abolished. ↘ CHART 66 RIGHT Under this scenario the EEG surcharge would be divided equally among all electricity consumers – firms and households – so the surcharge per kWh would decrease by roughly 29 %. Consumers that are not privileged at present would pay lower charges. However, the exemptions granted to energy-intensive firms must be seen and judged within the context of their international **competitiveness**. ↘ ITEM 424

418. **Significant exemptions** from the **electricity tax** are also available to firms in the manufacturing industry and the agricultural and forestry sector (sections 9 ff. German Electricity Tax Act, StromStG). The category of electricity-intensive firms that enjoy privileges under this law is more broadly defined than in the case of the EEG surcharge. Electricity tax is reduced by 25 % for firms that have an electricity consumption of around 50 MWh or more. In addition, certain electricity-intensive processes are exempt from electricity tax. Firms with a high electricity consumption also benefit from cost reductions in the form of peak balancing (section 10 StromStG). The German government's report on subsidies states that these allowances totalled roughly €3.3 billion in 2017.

4. Green finance

419. The transformation towards a lower-emission economy will require significant private and public investment. The financial sector will play a key role in helping to **fund the global investment needs** within the framework of international climate policies and attempts to **direct capital flows towards sustainable investments**. The prospect of earning financial returns offers the decisive incentive for private investors. These prospects are affected in various ways by the con-

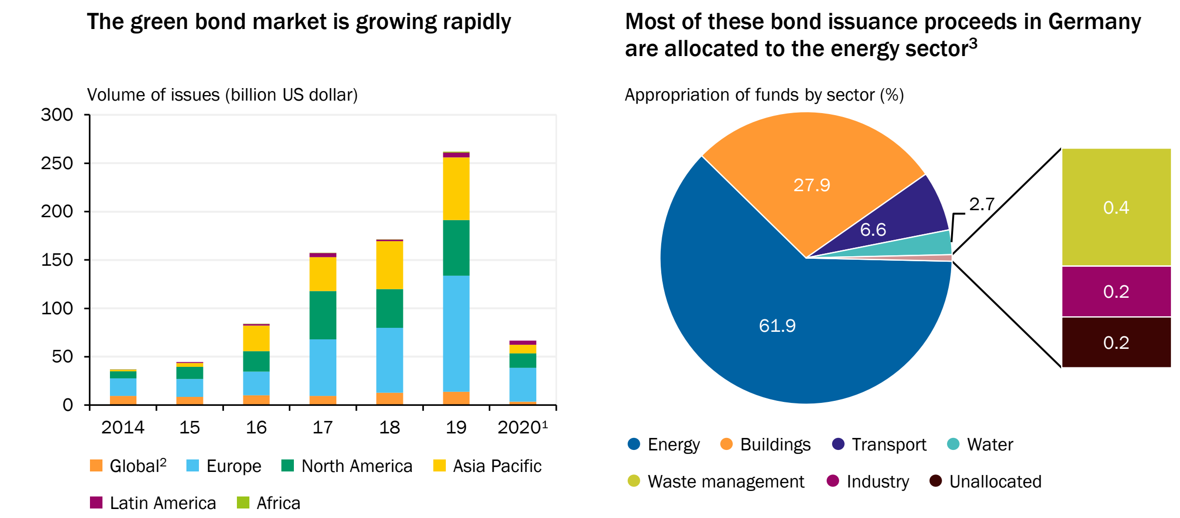
sequences of climate change and by climate policy decisions such as the introduction of carbon pricing. A further issue here can be information asymmetries, which act as a barrier to channelling sufficient amounts of capital into sustainable projects because they can prevent risks from being correctly priced (Batten et al., 2016; Addoum et al., 2019; Hong et al., 2019; Liebich et al., 2020).

420. The supply of and demand for sustainable investments have grown significantly in recent years. In Germany the **market for sustainable financial assets** amounts to €269.3 billion (FNG, 2020), which is roughly 5.4 % of the total investment fund market. Green bonds are bonds, the proceeds of which are earmarked specifically for the implementation of environmental and climate-change projects. They can be issued by either governments or companies. It is unclear, however, how governments in particular can ensure that the proceeds are used for the intended purposes (Liebich et al., 2020). Although they do not necessarily yield excess returns compared to those achieved by conventional forms of investment, (Ibikunle and Steffen, 2017; Silva and Cortez, 2016), **new bond issues are often heavily oversubscribed**. The total volume of bond issuance worldwide grew to 90 billion US dollars in 2019. This represented an increase of 53 % compared with 2018. ↘ CHART 67 LEFT Nonetheless, green bonds are still regarded as a niche product in the global bond market. Europe accounted for the largest share of such new bond issues in 2019.

Germany's largest issuer of green bonds is the KfW Banking Group. In September 2020 Germany issued its first ever green government bond for a total of €6.5 billion (German Finance Agency, 2020). **Most of the proceeds (62 %) earned from green bonds in Germany are allocated to the energy sector** (Liebich et al., 2020). ↘ CHART 67 RIGHT The buildings sector receives roughly 28 % of these funds. Only a small proportion of these proceeds are invested in Germany's transport sector (6.6 %).

↘ CHART 67

Issuance of green bonds[1]



1 – As at May 2020. 2 – Supranational organisations. 3 – Period from January 2013 to May 2020.

Sources: Climate Bonds Initiative, own calculations

421. The EU's taxonomy as a system for classifying sustainable investments came into force in July 2020. ↘ ITEM 364 The **European Commission's action plan on financing sustainable growth** recommends that standards and labels for green financial products should build on this taxonomy in future. This approach is intended to protect the integrity of sustainable financial markets and reduce information asymmetries, thus making it easier for investors to access these products. The EU Taxonomy Regulation divides economic activities into three categories and in future will **define uniformly throughout Europe which economic activities meet the relevant sustainability criteria**. Issuers of all financial products will be required to disclose to what extent these products meet the taxonomy criteria. This means that issuers will in future have to declare whether or not their financial products are sustainable according to the taxonomy definition, even for products that they do not claim to be sustainable.

Economic activity defined as sustainable according to the taxonomy should make a material contribution to at least one of the six environmental objectives defined in the taxonomy while at the same time not significantly impairing any of these objectives. The taxonomy's design therefore makes it **only partly suited** to **clearly certifying** economic activities as being directly beneficial to achieving the key climate policy objectives of the EU and its member states, namely **cutting carbon emissions**.

422. The taxonomy could potentially raise the cost of funding for firms whose economic activities are defined as unsustainable by the classification system if demand for green investments increases because, for example, climate change criteria are expected to be tightened. This might, in turn, strengthen the incentives for firms to make their processes and business models more sustainable. García et al. (2020) reckon that German firms are not yet adequately prepared for the taxonomy. Because detailed resolutions on the implementation of the EU taxonomy will be only gradually adopted, this legal framework will probably **not be fully functional until 2022** (EU TEG, 2020).

423. The action plan on financing sustainable growth also specifies various **disclosure requirements** for financial market participants in the context of sustainable investments and sustainability risks. The relevant information is viewed as being material to the correct pricing of climate risks – especially by rating agencies (Liebich et al., 2020).

5. Border carbon adjustment

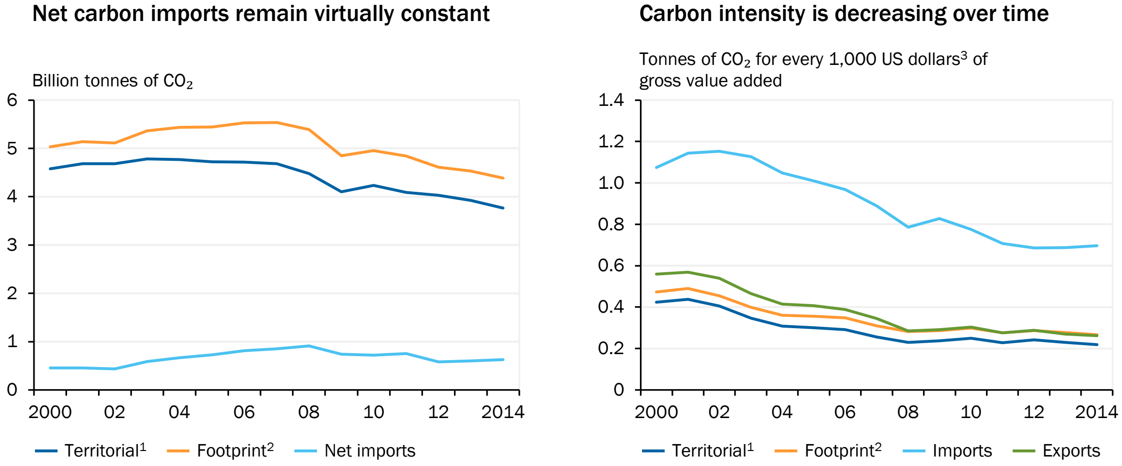
424. Carbon emissions caused by production at European industrial facilities are priced as part of the EU ETS. This means, for example, that power plant operators and manufacturers of chemicals have to purchase certificates for the carbon emissions measured at their production facilities. This **production-side approach to carbon pricing** raises the costs of European industrial firms relative to foreign firms not affected by the EU ETS. This **loss of competitiveness** could cause production and, consequently, emissions to be relocated outside the scope

of the EU ETS (**carbon leakage**), especially in emissions-intensive industries whose products are traded globally (GCEE Special Report 2019 items 183 ff.).

425. Carbon leakage can be estimated at the aggregate level from the variations in territorial carbon emissions and carbon footprint over time. ↘ CHART 68 LEFT The **carbon footprint** of the EU ETS comprises the carbon emissions caused by the production of goods consumed within the scope of the EU ETS throughout the entire value chain. The **territorial emissions** comprise the carbon emitted by production processes on the territory of the EU ETS member states. The difference between these two measures is referred to as the net carbon import. Overall, the member states of the EU ETS have always achieved positive net carbon imports.

426. Whereas the emissions caused within the scope of the EU ETS have consistently fallen since the EU ETS was introduced in 2005, **net carbon imports have not declined**. This might be interpreted as evidence of carbon leakage. Over the same period, however, the carbon intensity of imports – in line with the carbon intensity of industry in the EU ETS – has fallen. ↘ CHART 68 RIGHT The constant level of net carbon imports can therefore be primarily attributed to **increased trade volumes**. Irrespective of the introduction of the EU ETS, the growth in trade volumes is likely to reflect changes in trade policy, such as China's accession to the WTO in 2002. Garnadt et al. (2020) use econometric analysis at industry level to show that carbon imports from countries without an emissions trading scheme to countries with an emissions trading scheme are 3 % higher than carbon imports between countries with the same systems. Identical analysis carried out on value-added imports shows that these have fallen by 6 %. The lower levels of value-added imports might indicate that the **carbon leakage protection system currently being implemented in the EU ETS** by means of the free allocation of certificates to emissions-intensive firms and to firms engaged in international competition has **worked well so far**.

↘ CHART 68
EU ETS territorial carbon emissions and carbon footprint



1 – Carbon emissions caused by the production of goods in EU ETS member states as well as households' direct emissions. 2 – Carbon emissions caused by the production of goods finally used in EU ETS member states as well as households' direct emissions. 3 – At 2015 prices and exchange rates.

Sources: EU Commission, World Input-Output Database, own calculations

427. **Certificates** are currently **freely allocated** to production plants in certain industries (Directive 2003/87/EC; GCEE Special Report 2019 items 185 ff.). A large proportion of these certificates is allocated to the aviation sector and to the combustion of fuels. A large proportion of the certificates allocated in the manufacturing sector go to the production of pig iron and steel, to coking plants and oil processing and to the production of cement, which in Germany together account for 2.4 % of gross value added at factor cost and 1.5 % of employment in the manufacturing sector. In addition, the chemical industry, which accounts for 7.4 % of gross value added at factor cost and 5.1 % of employment in the manufacturing sector, receives a substantial proportion of the freely allocated certificates. ↘ CHART 69 LEFT

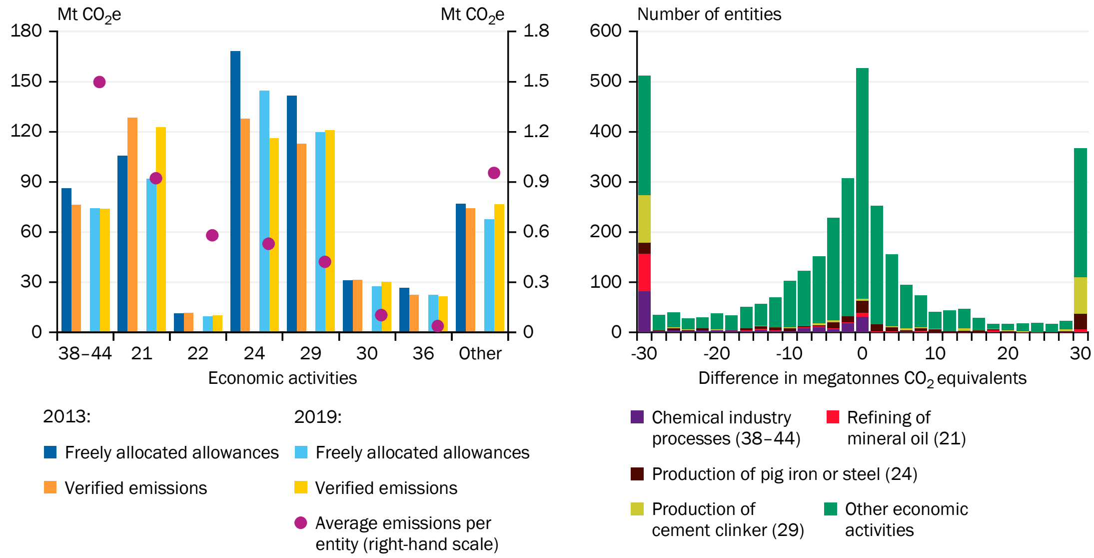
The number of freely allocated certificates is based on a benchmarking system, which means that some installations receive more freely allocated certificates than they need in a given year. ↘ CHART 69 RIGHT In the aggregate this applies particularly to the steel sector. Member states also have the option of partly compensating electricity-intensive firms for rising electricity prices (GCEE Special Report 2019 item 189). There are, however, concerns that the current **carbon leakage protection** system might no longer be adequate as the quantity of certificates declines and certificate prices are expected to rise. Moreover, the proportion of freely allocated certificates and the proportion of industries on the carbon leakage list for the fourth EU ETS trading period covering the years from 2021 to 2030 have

↘ CHART 69

Freely allocated allowances and verified emissions of the manufacturing sector in the EU ETS

Freely allocated allowances and verified emissions in 2013 and 2019[1]
Megatonnes CO_2 equivalents

Difference between freely allocated allowances and verified emissions in 2019[2]



1 – The only economic activities included are those that have received freely allocated allowances and – under the classification of activities applicable since 2013 – belong to the manufacturing sector. 38–44-Production of nitric acid, adipic acid, glyoxal and glyoxylic acid, ammonia, bulk chemicals, hydrogen and synthesis gas, soda ash and sodium bicarbonate, 21-Refining of mineral oil, 22-Production of coke, 24-Production of pig iron or steel, 29-Production of cement clinker, 30-Production of lime, or calcination of dolomite/magnesite, 36-Production of paper or cardboard, Other-Production of glass, ceramics, primary aluminium, pulp, mineral wool, carbon black, gypsum or plasterboard, secondary aluminium, production or processing of ferrous metals and non-ferrous metals, metal ore roasting or sintering; other activity opted-in under Art. 24 Directive 2003/87/EC. 2 – Entities that have been assigned to the categories presented in the data set according to the old classification prior to 2013 have been assigned to categories as presented by the European Environment Agency for emissions from 2017.

Sources: European Commission, European Environment Agency, own calculations been reduced (GCEE Special Report 2019 item 186). At the same time, it is possible to cut industry's carbon emissions more quickly by taking complementary measures. ↘ ITEM 433

428. In the summer of 2020 the political process to design a **carbon border adjustment mechanism** was launched at the initiative of the German and French governments in order to prevent carbon leakage. In the European Council agreement of July 2020 this border tax adjustment is also mentioned as a potential future source of revenue for the EU budget. A carbon border adjustment requires importers to purchase a quantity of certificates corresponding to the **carbon footprint** of the **goods being imported**. Exporters receive a quantity of certificates corresponding to the carbon footprint of the **goods being exported**. If the carbon footprint of all goods could be accurately measured, this mechanism would constitute a transition from production-side pricing to consumption-side pricing of the carbon footprint of the goods consumed within the scope of the EU ETS. As with a value added tax, such a mechanism would prevent competition between producers in the EU ETS and those outside the EU ETS from being distorted. A transition to consumption-side pricing could also be achieved by **taxing the carbon footprint** of all goods while at the same time expanding the free allocation of certificates. If the right tax rates and allocation quantities are chosen, this provides a theoretically equivalent alternative to the carbon border adjustment (Böhringer et al., 2017).

429. **However**, such a transition to **consumption-side pricing poses problems** both in the case of a carbon border adjustment and with respect to taxing the carbon footprint while at the same time subsidising domestic producers. **Measuring the carbon footprint** of individual goods poses considerable challenges for both of these measures because all of the carbon emissions caused throughout the product's entire value chain have to be counted. The use of benchmarks is also problematic (Droege and Fischer, 2020). For most products, for example, it is not possible to apply the benchmarks used for the current production-side adjustment mechanism of free allocation. This is because these benchmarks only measure the direct carbon emissions caused during the production process, which can differ substantially from the carbon footprint of the products themselves. In addition, a full carbon border adjustment entails a considerable amount of bureaucracy. If the introduction of a carbon border adjustment is being considered for the future, it would therefore be preferable to restrict it to emissions-intensive and trade-intensive industries.

430. There would also be **further challenges specific to each measure**. Taxation of the carbon footprint would require an EU-wide or harmonised European tax to be introduced. Moreover, the tax would have to be regularly adjusted to keep it consistent with the declining quantity of certificates. The introduction of, and each adjustment to, such a tax would require all member states to adopt a unanimous resolution to this effect.

431. A carbon border adjustment which introduces ad-valorem levies that are based on products' carbon content per euro and vary according to country and product might also be problematic from a commercial-law perspective because these levies

could contravene the most-favoured-nation principle. Using a border carbon adjustment to compensate for competitive disadvantages caused by carbon pricing is unlikely to comply with WTO rules, whereas the motivation of combatting climate change might present opportunities to price emissions (Dröge et al., 2018). Even if the most-favoured-nation principle is not contravened, **trading partners might interpret** any unilaterally introduced **border carbon adjustment as a protectionist measure** and therefore take retaliatory action. When in 2017 the United States discussed the introduction of a general border tax adjustment in connection with the destination-based cash flow tax, there were media reports that the EU and other trading partners were already preparing to take legal action before the WTO (Donnan et al., 2017). Germany, as an export-led country, could find that any trade conflict – especially one with the United States as a key export market – would involve a significant loss of value added. The harm inflicted by a unilaterally introduced border tax adjustment could therefore exceed its benefits. Consequently, the risk of losing value added as a result of trade barriers needs to be balanced against the risk of losing value added as a result of carbon leakage.

432. The risk of trade conflicts depends largely on the relevant mechanisms' design and on global political developments. Whereas the risk of retaliatory trade policy measures is likely to be high if the EU takes unilateral action, this risk could be significantly mitigated if the EU were to adopt a **coordinated multilateral approach by working together with key trading partners**. Many countries around the world – including China, Japan, Canada, Mexico and South Korea as well as some US states – have already established a carbon price or have started to introduce one, albeit in some cases at a lower level than the EU ETS (World Bank, 2020). Provided that the main trading partners agree to adopt a joint approach and that emissions prices already paid by both sides in the country of origin are taken into account, **mutually coordinated carbon border adjustment systems** could be used to **realise** the idea of a **climate club** (Nordhaus, 2015; GCEE Special Report 2019 item 43) which enables progress to be made towards worldwide emissions pricing. The revenue received from the carbon border adjustment would not necessarily have to be paid to the member states but, instead, could be used as transfer payments for newly industrialising countries in order to make it more appealing for them to join the climate club and to make it easier for them to achieve the transition to carbon neutrality.

IV. COMPLEMENTARY MEASURES

433. A **uniform carbon price** is **preferable** to a fragmented approach that tries to achieve success by taking **individual measures**. For various reasons, however, it is probably not possible to raise the carbon price swiftly to the level that would be needed to meet the emissions targets. Even in an optimal carbon pricing system the unknown price path can act as a barrier to investment. Minimum prices in carbon trading can address this uncertainty in the short term. Over a long time

horizon, however, which is the decisive factor in firms' strategic planning, a minimum price does not always send sufficient signals. Market imperfections are likely to restrict the carbon price's effectiveness in playing a coordinating role and thus in reducing emissions. Complementary measures may therefore be needed to ensure that carbon neutrality is efficiently achieved (Stiglitz et al., 2017; Edenhofer et al., 2019a; Stiglitz, 2019; GCEE Special Report 2019 items 245 ff.).

434. **Complementary measures** can strengthen research incentives and facilitate the diffusion of new technologies. This can increase the **options for substitution** from carbon-intensive to low-carbon goods. A rise in the carbon price would then result in a stronger adjustment response (Mattauch et al., 2015). Public investment, for example in transport infrastructure, can lead to a technology decision. This avoids inefficient duplication and can reduce uncertainty about the technology path for households, firms and investors. At the same time there is a risk that politicians encourage an inferior technology.

435. The effectiveness of complementary measures is largely determined by their design. These measures should always be evaluated in terms of their effectiveness and efficiency. Only this can ensure that macroeconomic cost of achieving the climate targets is as low as possible. Although the European emissions mitigation targets must be the yardstick for assessing climate policies (GCEE Special Report 2019 item 54), sector-specific targets can help to operationalise climate policies during the transition to cross-sectoral carbon pricing. ↘ ITEM 365 Such targets should not, however, be used as justification for implementing particularly resource-intensive or costly measures.

1. Structures aimed at encouraging research and skilled workers

436. Although the carbon price creates incentives for the private sector to invest in the research and development of lower-carbon technologies, without any government support the level of research is likely to be inefficiently low because of positive knowledge externalities. ↘ ITEMS 491 FF.

Basic research in Europe and Germany already benefits from very comprehensive support (GCEE Annual Report 2019 items 291 ff.). The particular importance of achieving greenhouse gas neutrality might justify **focusing more** research funding on sustainable technologies as part of a mission-oriented industrial policy (GCEE Annual Report 2019 items 298 ff.). Because, as part of sector coupling, the generation of energy from renewable sources and its efficient use in a wide variety of application fields are likely to play a key role in achieving greenhouse gas neutrality, an especially strong focus can be placed on research into technologies aimed at achieving carbon neutrality. In order to organise this research efficiently, technology-neutral and regularly evaluated research structures should be ensured within this research spectrum (GCEE Annual Report 2019 item 251).

Research structures

437. There are currently a **large number of funding structures** at German and European level. Germany's funding of energy research is mainly coordinated by the German government's energy research programme. The funding provided by the German government's **seventh energy research programme** for the period from 2018 to 2022 amounts to just under €1.3 billion per year and is made available both in the form of direct project funding and as institutional funding from the Helmholtz Association. Direct project funding is allocated by Germany's Federal Ministry of Education and Research (BMBF) for basic research and is made available by the BMWi and the Federal Ministry of Food and Agriculture (BMEL) for applied research. Although funding applications are examined and administered by various project sponsors according to the research field involved, the actual decision to grant funds is made by the relevant federal government departments.

438. A new feature of the seventh energy research programme is **real-world laboratories**, which have been set up as **time-limited and spatially separate experimentation spaces** under the BMWi's real-world laboratory strategy from 2018 (BMWi, 2018, 2019; GCEE Annual Report 2019 item 358). Real-world laboratories are to be used for energy research purposes especially in order to test the interaction between various new technologies from the perspective of energy producers and energy consumers under reality-like conditions. These tests will also examine new regulatory options and collect information on relevant experiences. At the same time, the risk to society will remain limited owing to the spatial separation of the experimentation space. However, real-world laboratories only offer promising prospects if the terms and conditions governing them enable their projects to be continued on a profitable basis once the relevant experimentation clauses have expired. Real-world laboratories are sometimes used as an instrument of regional policy. For example, at least one real-world laboratory for the transformation of Germany's energy sector has been approved in each lignite-mining region of the country.

439. Given the general-purpose nature of energy technologies, **research clusters – which link actors throughout the value chain** with each other – provide one potential form of application-related research funding (GCEE Annual Report 2019 items 345 ff.). The funding of clusters aims to create agglomeration externalities and is intended to help attract innovative firms and highly skilled workers. Government funding of clusters can provide stimulus, especially during the initial phase of the production ramp-up of technologies, for example with the coordination of actors (EFI, 2015). After this initial funding, however, successful clusters should be able to survive without further government support. Evaluations of government cluster initiatives in Germany have temporarily been able to demonstrate a modest positive impact on the innovation activities of related firms. So far, however, there is no evidence of any long-term positive effects beyond the period of **cluster funding** (Brenner et al., 2013; Engel et al., 2013). As with other industrial policy measures, effective cluster funding policies rely on an technologically neutral, competitive process in the choice of clusters as well as regular evaluation

of the funding. In addition, clusters should build on existing strengths and transformation opportunities.

440. Considerable importance is attached to energy research at the **European level** as part of the 'Horizon 2020' and 'Horizon Europe' research strategies as well as the European Green Deal. 35 % of the funding allocated via 'Horizon Europe' is used for projects that are intended to help meet the climate targets. A key funding instrument is available in the form of **important projects of common European interest (IPCEI)**, which are state aid rules that enable projects making a valuable contribution to the EU's objectives to be funded by governments (European Commission, 2014). This allows, in particular, the funding of application-related projects that make a contribution to the European strategy on key technologies, the European energy strategy or the digital agenda for Europe.

Two IPCEIs have been approved to date. Further IPCEIs – some relating to hydrogen – are currently in the pipeline. Both SMEs and large firms are involved in the existing IPCEIs. The proportion of firms set up in the past ten years is, however, fairly small. A greater involvement of young firms would be desirable, especially in terms of achieving the goal of encouraging innovation.

441. One barrier facing young firms when they apply for funding appears to be the **assessment of their credit history** which, in the case of research funding applications, is carried out by the project sponsor. Such assessments intend to reduce the asymmetry of information between firms and project sponsors. If these assessments erect **excessive barriers**, however, valuable potential can be lost. The application processes should be as transparent as possible. Standardising these processes throughout Germany could also reduce costs for firms and project sponsors alike.

Demand for skilled workers is changing

442. New technologies **demand different qualifications** and skills on the part of workers. In order to meet the **need for a skilled workforce in sustainable technologies** over the long term, it is therefore essential to promote education and training and to put the respective research structures in place at an early stage. Establishing new courses of study requires a considerable lead time. Researchers have to be recruited and degree courses need to be designed. It is also important to **modernise the training occupations** and to overhaul training curricula so that the necessary skills can be taught.

Continuing professional development can also give workers the opportunity to add new technologies to their skill set. This can help to accelerate the growth of sustainable technologies. Provision of information and guidance available as part of training courses can be used to provide information on new technologies and applications, thus raising professions' awareness of the future role of innovation in their field of application. ↘ ITEM 214

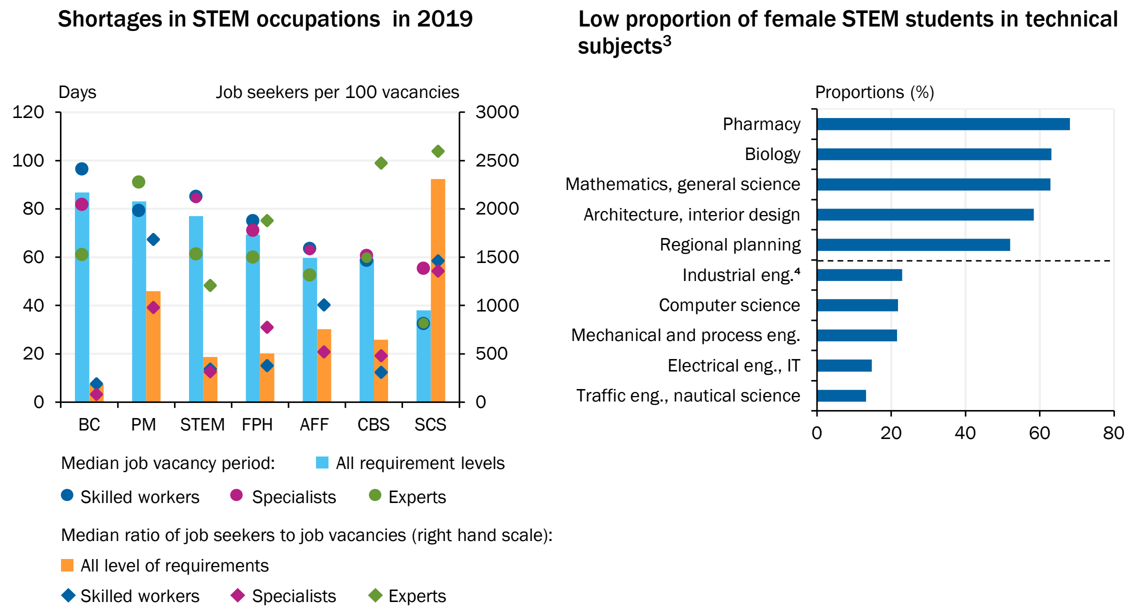
443. Last year a shortage of skilled workers in the STEM (science, technology, engineering and mathematics) professions could already be established. According to

Germany's Federal Employment Agency (BA), the median ratio of unemployed people to job vacancies in the STEM professions in 2019 was approximately 467 unemployed individuals for every 100 officially reported jobs subject to social security contributions, which is a low figure compared with other types of professions. ↘ CHART 70 LEFT This shortage indicator also suggests that there is a particular **shortage of experts in STEM professions**. Compared with specialists and experts, skilled workers in STEM professions accounted for the longest median job vacancy period (around 85 days), which is defined as the time between the preferred and actual recruitment dates. Relative to other professions such as building construction above and below ground there is also stronger demand for specialists in STEM professions. ↘ CHART 70 LEFT The STEM professions account for 41 of the 47 professions identified as having a shortage of specialists. Similarly, the STEM professions account for 22 of the 40 professions reported as suffering from a shortage of experts.

444. Targeted measures as early as school age to encourage **women to study STEM subjects** could help to meet the demand for skilled workers in future. The proportion of female students studying subjects such as computer science, mechanical engineering and process engineering in the winter semester of 2019/20 was a modest 22 %. ↘ CHART 70 RIGHT Empirical studies on **choices of academic subjects** show that gender stereotypes at school can have a long-term impact on **women's** career choices and their inclination to **study STEM subjects** at uni-

↘ CHART 70

Shortage indicators according to occupational group[1] and female students in STEM subjects[2]



1 – Completed median vacancy period in days and median ratio of jobseekers to vacancies. BC-occupations in building construction above and below ground, PM-occupations in product design, artisan craftwork, fine arts and the making of musical instruments; STEM-STEM professions, FPH-Food production and hospitality professions, AFF-Occupations in agriculture, forestry and farming; CBS-occupations in commercial and business-related services; SCS-Social work and cultural service occupations. 2 – The figure shows the five largest and the five smallest percentages of female students as a proportion of the total number of students in the 2019/2020 winter semester by subject group. 3 – eng.-Engineering, IT-information technology. 4 – With a focus on engineering.

Sources: Federal Employment Agency, Federal Statistical Office versity (Lavy, 2008; Alan et al., 2018; Lavy and Sand, 2018; Carlana, 2019). Attempts to improve women's and girls' access to STEM subjects should start as early as school age to **promote equal opportunities in the education system** and reduce any stereotypes in these subjects. This process should already begin during teacher training courses by providing information on the effects of gender stereotyping. Building on this approach, such courses should teach the skills and ability to question this kind of behaviour so that new gender-sensitive methods and teaching theories can be applied.

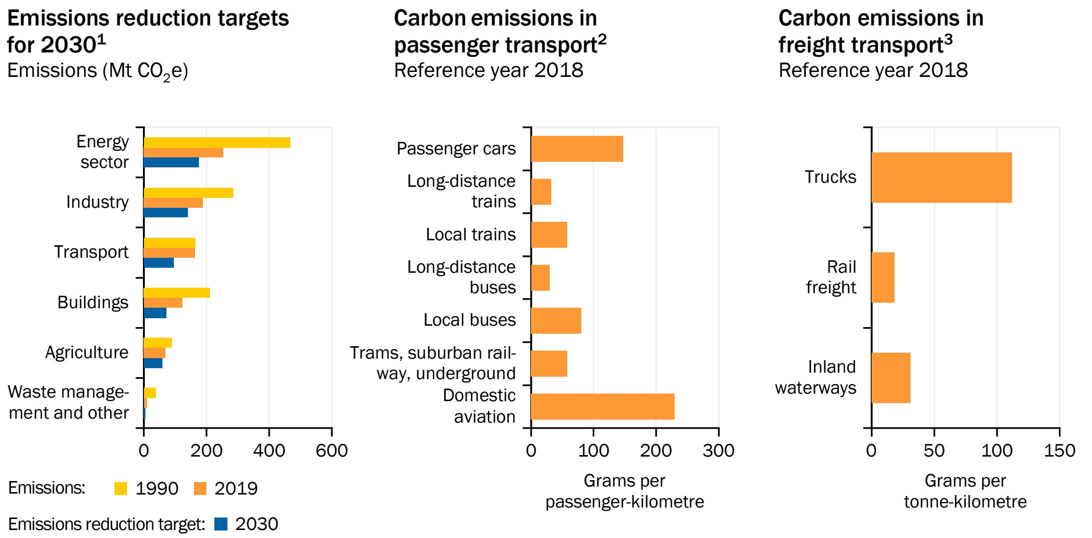
445. **Immigration of skilled workers** from EU member states and from non-EU countries can help to mitigate the shortage of skilled labour. Managed economic migration has the potential to attract especially highly demanded workers. The **German Immigration Act for Skilled Workers (FEG)**, which came into force in March 2020 and is designed to attract economic migrants from non-EU countries, could play an important role here. Its consistent combination of simplified labour market access with less arduous recognition and visa application procedures is key to being able to **compete for talent globally**. Administrative hurdles that make migration unnecessarily difficult need to be examined (Baczak et al., 2020; GCEE Annual Report 2019 items 357 ff.). The protectionist tendencies and restrictions on immigration currently being observed in countries such as the United States, the United Kingdom and Hong Kong might offer opportunities for Germany in this context.

2. Sector-specific measures illustrated by the example of the mobility sector

446. The mobility sector is responsible for around 19 % and 22 % of all annual greenhouse gas emissions in Germany and Europe respectively. While the EU ETS, for instance, has helped to cut emissions significantly in other sectors, emissions in the mobility sector remained virtually unchanged between 1990 and 2019. ↘ CHART 71 LEFT Despite considerable efficiency improvements in individual transport, which have resulted in declining carbon emissions per unit of traffic (passenger-kilometres or tonne-kilometres), the **growth in traffic volumes** has almost totally offset the reductions in emissions (German Environment Agency, 2020). The National Platform Future of Mobility (NPM) expects demand for mobility to continue to grow in future (NPM, 2019a). Although it remains to be seen to what extent the coronavirus pandemic will act as a catalyst in ensuring that people commute less, work from home more and that business travel is replaced by online conferences, Germany's target of cutting emissions in the transport sector by between 40 % and 42 % by 2030 compared with 1990's levels seems particularly ambitious.

While the sectoral target for 2030 in itself should not justify complementary measures, various market imperfections in the field of transport can make it more difficult for households and firms to **cut their carbon emissions**. A closer inspection of the mobility sector can therefore serve as an example of the kind of obstacles that can impair the functionality of a carbon price.

↘ CHART 71
Sector-specific emissions targets and emissions caused by transport



1 – Megatonnes expressed in CO_2 equivalents. 2 – Average emissions expressed in CO_2 equivalents. Alternative modes of transport for domestic transport are analysed here. 3 – Average emissions expressed in CO_2 equivalents.

Sources: BMU, UBA

Potential ways of cutting emissions in the transport sector

447. There are **three channels** through which the desired reduction in emissions can be **achieved**. Firstly, emissions can be cut as a result of further **efficiency improvements** in vehicles with internal combustion engines. Secondly, transport can be **electrified**. The corresponding emissions would then be counted as part of the energy sector, which is already integrated into the EU ETS. And, thirdly, **journeys** can be either **avoided altogether or switched to other means of transport**. Households can achieve this by using public transport more or by commuting to work less. Freight could be transported more on inland waterways and by rail (SRU, 2017; EASAC, 2019). ↘ CHART 71 CENTRE AND RIGHT

Because of the way in which the national emissions trading scheme works, the public sector does not have to specify by how much it intends to cut emissions and though which channel it plans to do so. Due to the **price incentives** economic actors decide themselves which channel they prefer. The carbon price impacts on customer demand, which sends out signals to carmakers. Product portfolios are adjusted and efficiency improvements are made to internal combustion engines in order to meet the modified demand and exploit new profit opportunities. Consumers' ability to react to price signals presupposes that sufficient alternative options are available. These include, for example, an adequate public transport supply and the necessary infrastructure for electric mobility. This enables consumers to plan what durable goods they wish to purchase in order to avoid carbon emissions.

448. Since public transport causes much lower emissions than passenger cars, the national emissions trading scheme increase the costs of individual motorised transport more strongly than those of local public transport. ↘ CHART 71 CENTRE AND

RIGHT **Demand for public transport** is therefore likely to grow (Balcombe et al., 2004). If this additional demand is not met by a corresponding supply and households are unable to switch their means of transport, rising carbon prices could impose a considerable financial burden which, owing to its regressive structure, might be perceived as being socially unbalanced (Edenhofer et al., 2019a). Because the necessary planning processes are complex, however, municipal transport firms can only increase their capacity over the medium term. In addition, bottlenecks in local authorities and in the construction sector could delay an expansion (GCEE Annual Report 2019 items 545 ff.). In order to meet the growing demand on time, it might be necessary to increase investment into public transport already today. In this respect, the Climate Action Programme 2030 has earmarked – aside additional funding for Deutsche Bahn – further funds for the expansion of regional public transport (BMU, 2019a).

449. **Various options** are available for **electrifying** the mobility sector. In case of battery-powered vehicles a distinction can be drawn between fully battery-powered vehicles (BEVs) and plug-in hybrids (PHEVs). Fuel-cell vehicles (FCEVs) use fuel cells to generate electricity for an electric engine. Although they are currently more expensive than battery-powered vehicles, their advantage is that they require only brief filling times and have larger ranges. With respect to the heavy-goods transport vehicles powered by fuel cells or synthetic fuels can make a valuable contribution for decarbonising the transport sector (Hebling et al., 2019; Löschel et al., 2019). However, carbon-neutral mobility, which also includes transportation, makes it necessary to expand a charging infrastructure for battery-powered vehicles and a hydrogen filling-station infrastructure.

Against this background it is **not necessary to focus on encouraging certain types of vehicles** such as BEVs, PHEVs or FCEVs for individual passenger transport. If the charging and filling-station infrastructure exists, it should be left to users to decide whether they wish to buy a purely battery-powered vehicle, a hybrid vehicle or a fuel-cell vehicle.

The production of battery cells is very energy-intensive. Correspondingly, a high level of greenhouse gas emissions is caused during the manufacturing of vehicles (Romare and Dahllöf, 2017; Emilsson and Dahllöf, 2019). If battery vehicles canhelp tocan reduce emissions overall, they must offset this drawback over their life cycle. The debate over the extent to which electric vehicles can reduce emissions more than internal combustion engines is very wide-ranging, and the estimates produce very different findings (Agora Verkehrswende, 2019; Buchal et al., 2019; IEA, 2019a; Volkswagen, 2019; Wietschel et al., 2019; Thielmann et al., 2020; Wietschel, 2020). The reason for these widely divergent findings is ultimately the varying assumptions about battery capacity, the weight of the car, the emissions caused during battery cell production, and the electricity mix used to charge the vehicle (Hall and Lutsey, 2018; Kelly et al., 2020).

450. The decision to purchase an electric vehicle is contingent on sufficient charging and filling-station facilities being available to meet individuals' mobility needs. Whereas private charging facilities enable firms and households to ensure their mobility within small ranges, an **extensive network of publicly accessible**

charging posts and hydrogen filling stations is needed in order to establish electric vehicles as a substitute for vehicles with internal combustion engines over larger distances.

451. In addition to the lack of a charging and filling-station infrastructure, the cost of electric vehicles could be a further reason why it is taking so long for them to become established in the market. The cost of manufacturing a **BEV or PHEV** is currently **not competitive** with vehicles that have internal combustion engines. Batteries continue to be a major cost factor in the production of BEVs and PHEVs, even though their manufacturing costs have fallen sharply in recent years (IEA, 2020). As these batteries become more established in the market, **learning effects and economies of scale in the production of battery cells** could lower their cost further and enhance their appeal (Wu et al., 2015; Kasten, 2018; Van Velzen et al., 2019).

A large number of measures are currently being taken to facilitate the deployment of electric vehicles (Preuss, 2020). The fragmented approach being adopted here is, however, inefficient. ↘ BOX 14 Especially in the field of mobility the incentives of **emissions pricing** can make a valuable contribution. Through carbon pricing the negative externalities of internal combustion engines are internalised as well as the emissions caused by the electricity demand for electric vehicles. The national emissions trading scheme and the EU ETS should therefore play an increasingly significant role and become the key instrument in transforming mobility over the medium term. **Local externalities** such as emissions of nitrogen, particulate matter and noise, however, remain unpriced. Congestion charging could help to internalise these externalities and would also partially reduce the cost advantage that internal combustion engines enjoy over BEVs (GCEE Annual Report 2018 items 30 ff.).

↘ BOX 14

Fragmented approach to encouraging electric mobility

Several instruments are used in Germany to **encourage purchases of electric vehicles** (Preuss, 2020). The main one is the federal government's purchase bonus, which was introduced back in 2016, increased for the first time in November 2019 and then raised for a second time as part of the economic stimulus package launched in 2020. This bonus is supplemented by fleet replacement programmes at federal, regional and local level. Support is also provided for the erection of private charging posts. In principle these measures lower the costs of electric vehicles, thereby mitigating the fact that they are currently more expensive in production than cars with internal combustion engines. As a result, electric vehicles' market share could grow faster. The efficiency of these measures is, however, questionable. Purchase subsidies are likely to give rise to substantial deadweight effects (Chandra et al., 2010; Edenhofer et al., 2020). In addition to unclear distribution effects there is also a risk that these subsidies merely result in price effects.

Further measures reduce the cost of running an electric vehicle. The **preferential tax treatment of company cars** driven for personal use was questionable with respect to climate policy even before the reforms. Now, the recently introduced preferential tax treatment of electric vehicles driven as company cars for personal use will have an additional distorting effect. The exemption of electric vehicles from motor vehicle tax will have a similar effect. Instead of using motor vehicle tax to address carbon emissions properly, electric vehicles are fully exempted from this tax. Although this exemption from motor vehicle tax and the extension of the preferential tax treatment of company cars are likely to encourage the electrification of the mobility sector, they – as well as the commuting mileage allowance – discourage the option of either avoiding journeys altogether or switching to other means of transport.

The fleet-wide average emission targets at European level indirectly encourage electric vehicles. From 2021 onwards they could have an additional impact on the price difference between powertrains. Although fleet targets have already existed for several years, the specifications for average fleet-wide emissions – for German carmakers, at least – are likely to be binding from 2021 onwards. For each gram of CO_2 per 100 kilometres that a manufacturer's fleet exceeds the new limits of 95 grams of CO_2 per 100 kilometres on a weighted average, a penalty of €95 is payable for each car sold. However, these fuel economy standards are inefficient (Anderson et al., 2011; Gillingham, 2013; Anderson and Sallee, 2016). Although they create an incentive to develop and sell lower-emission cars, once these have been purchased their drivers have no incentive to **restrict their mileage**. Their greater efficiency reduces their running costs, which can ultimately even increase their mileage and thereby the overall emissions (**rebound effect**). In addition, fleet economy standards can lead to a situation whereby new vehicles with internal combustion engines become more expensive and, consequently, older. In consequence, inefficient vehicles are used for longer. This could mean that more carbon emissions are caused cumulatively (**Gruenspecht effect**).

452. In addition to pricing carbon, the public sector should ensure that economic actors have all the information they need when deciding what to buy. Households underestimate the actual cost of running a car (Andor et al., 2020). Better information could also help to allay unjustified misgivings about electric vehicles with respect to their ranges and charging times (Coffman et al., 2017; Cui et al., 2020). **Publicly available information offerings** that disclose the cost of different types of vehicle and explain the impact of carbon pricing could be effective. This includes establishing a labelling system that provides an accurate and reliable picture of the emissions caused.

The legal priority given to electric vehicles on the roads, which is, for instance, implemented in Norway, could have a positive impact on people's purchasing decisions. The waiving of the high toll payable in Norway is claimed to be an important factor to buy an electric vehicle (Figenbaum and Kolbenstvedt, 2016). The German Electric Mobility Act (Elektromobilitätsgesetz), which came into force back in 2015, created the legal basis for **giving legal priority to electric vehicles**. Local authorities decide how this legislation should ultimately be implemented (Deutsches Dialog Institut and Noerr, 2018). Experience in Norway shows, however, that electric vehicles are often used as second cars. They could therefore be used not only as a substitute for cars with internal combustion engines but also to replace bicycles and public transport (Figenbaum and Kolbenstvedt, 2016).

453. There are several reasons why converting the **public vehicle fleet** to electric vehicles could have a beneficial impact on the electrification of private transport. This conversion would involve building an appropriate charging and filling-station infrastructure that could also be made available to private vehicles. An electrified public vehicle fleet can also send out a positive signal by proving that electric vehicles can be used in day-to-day life (Coffman et al., 2017). Electrification

can aim to cover public transport, official cars and commercial vehicles such as refuse-collection vehicles and road-sweeping machines. The federal government plans to electrify its entire vehicle fleet by 2030 (BMU, 2019a).

Funding of charging and filling-station infrastructure

454. The funding of publicly accessible charging and filling-station infrastructure can help to address **network externalities** and, consequently, reduce the carbon prices needed in order to gradually convert the vehicle fleet to carbon-neutral technologies. In the past Germany has made it a priority to expand its charging infrastructure for battery-powered vehicles (NPM, 2019b). Germany's network of hydrogen filling stations has also been expanded. They are, however, still fairly small in number (IEA, 2019b).

The public funding of Germany's charging and filling-station infrastructure is currently organised by NOW GmbH. Based on its calls for tenders, **subsidies are made available for the erection of public charging posts**. The level of funding is determined by the charging capacity and the need to modernise the power line. In addition, the subsidy varies according to local need. Subsidies are also used to fund hydrogen filling stations.

455. The publicly accessible charging and hydrogen filling-station infrastructure should continue to be swiftly expanded. The economic viability of hydrogen filling stations and charging posts at transport hubs is likely to steadily improve as electric vehicles' market share grows. An appropriate involvement of private investors can help to identify these locations and swiftly expand the network of charging and filling-stations. A **roadmap** can be used to clearly define **expansion targets**. This can send out market signals to further potential investors.

456. The funding of operating costs is problematic in terms of state aid rules. **Public funding** is therefore primarily **restricted to investment costs**. In anticipation of future revenues operating cost deficits are often already borne by the private operators at this early stage. On the one hand, the current funding practice increases the risk that inefficiently large amounts of funding are disbursed to highly frequented locations. On the other hand, the expansion of less attractive locations can fail to materialise because – despite the funding – the investment risk is too high. Although the information asymmetry between investors and the public sector could be mitigated by an appropriate disclosure requirement, the inefficiency of such funding cannot be totally avoided.

Aside to the lack of economic viability (Hall and Lutsey, 2017; NPM, 2019b) further factors could prevent the infrastructure from being expanded. The legislation on **approvals and public procurement** can, for example, delay the expansion. Furthermore, filling-stations and charging posts must meet **technical standards**. If, however, technical standards are expected to change in future and upgrades may get necessary, investment could be delayed. It is therefore crucial to make the relevant requirements transparent and clearly identifiable at an early stage. Funding should in any case be restricted to the initial phase during which this infrastructure becomes established in the market.

The expansion of the charging and filling-station infrastructure is ultimately a European issue. A full transition to electric mobility is only likely to be viable as a replacement for vehicles with internal combustion engines if the right infrastructure is available across national borders and is internationally compatible. The EU already recognised this need for coordination back in 2014 when it adopted the **Alternative Fuels Infrastructure Directive (AFID)**. This directive committed member states to drafting and implementing a national strategy. The directive is due to be revised in 2021.

457. The **erection of private charging posts** requires the right legal framework to be put in place. The **German Condominium Modernisation Act (WEMoG)**, which defines the requirement for new buildings to install private charging posts and will make it easier for tenants to erect charging posts, is a step in the right direction. However, efforts must continue to be made to facilitate the erection of charging posts. In particular the administrative cost should be reduced and network access needs to be accelerated (NPM, 2019b).

Industrial policy support for battery cells

458. The EU and the German government have presented support programmes designed to encourage the production of battery cells in Europe and Germany. Various measures have been pooled at European level in the **European Battery Alliance** (EBA). They are aimed at bringing various actors together, strengthening international cooperation – both within the EU and with non-EU countries – and creating the legal framework to enable the sustainable production of batteries (European Commission, 2019b). Under the banner of the EBA, the German government itself and firms based in Germany are involved in one planned IPCEI and one already approved IPCEI, which aim to introduce innovations throughout the entire battery value chain. ↘ ITEM 440 Beyond the scope of the EBA, the BMWi (2020c) plans to directly fund the construction of production facilities.

Batteries are likely to become more important in future – especially in the automotive sector – and their **market potential** is expected to grow steadily. Given the knowledge externalities involved, the **funding of research** into batteries can be a sensible policy. ↘ ITEMS 491 FF. However, this should not be restricted to individual parts of the value chain. In addition to the actual battery cell itself it is possible to develop battery systems components such as hardware and software. Innovations in the field of second-life applications and recycling can also open up new business areas for European firms.

459. **Subsidising the production** of battery cells themselves, on the other hand, does **not appear to be a sensible option**. The manufacturing process is both capital-intensive and energy-intensive. A significant proportion of the value added lies in the resources used, and production is largely automated. The employment effects of such manufacturing are therefore likely to be only modest (Falck and Koenen, 2019). Although the leading producers of battery cells are concentrated in Asia, **competition** between providers seems to work well (Falck and Koenen, 2019). This suggests that the purchase prices of batteries are likely to be

competitive and will therefore not threaten the competitiveness of European or national carmakers.

Production subsidies pose a number of problems (GCEE Annual Report 2019 items 267 ff.), and **subsidising the production of battery cells** creates various misleading incentives. Firms that are not competitive in either the short or long term would remain dependent on subsidies. Public funds, private capital and skilled workers could be employed more efficiently elsewhere in such cases. If firms have the prospect of success in the long run, they will recognise this themselves. If profits are achievable in the long term, and provided that functioning capital markets are available, short-term losses should not act as a barrier to market entry. Subsidies in these cases would merely cause **deadweight effects**.

460. As far as the future is concerned, the **current situation** in the automotive industry is ambivalent. German carmakers and major suppliers have a high level of research intensity compared with producers from other countries. In terms of their number of patent applications they are market leaders in driverless cars and electric mobility (Bardt, 2017; Falck et al., 2017; Puls and Fritsch, 2020). They can also create parallel structures that enable them to manufacture the old and new products at the same time. **Small suppliers** are often unable to do this. The transformation process is likely to be more difficult for them to manage. Structural change will probably cause consolidation among suppliers that specialise in internal combustion engines. However, a situation should be prevented whereby suppliers fail to manage this transformation successfully owing to a **shortage of skilled workers**. In the past, however, suppliers have expressed concerns here (Priesack et al., 2018).↘ ITEMS 444 F.

3. Implementing the hydrogen strategy

461. Gas and liquid fuels will remain important for the energy system in both Germany and Europe over the long term. Accordingly, there is a need to devise ways of replacing the current fossil fuels with carbon-neutral alternatives. According to the current level of knowledge, these ways involve **green hydrogen, power-to-X processes** and **synthetic fuels** (synfuels). In addition to allowing the decarbonisation of various applications in the heating, mobility and industrial sectors, they can also open up new business areas and come along with potentials for domestic firms.

Given the stand of knowledge, green hydrogen and derivative industrial raw materials as well as **synthetic fuels provide a feasible way of decarbonising parts of the heavy good transport**, the aviation sector and the chemical or heavy industry (Hebling et al., 2019; Löschel et al., 2019; NPM, 2019c). Whereas grey hydrogen is produced using fossil fuels with corresponding carbon emissions, hydrogen can alternatively be produced by using electrolysis to split water into its constituent elements or by converting biomass or residual and waste materials. If the electricity used comes from renewable energy sources, the hydrogen is referred to as ‘green’. Nonetheless, the production of green hydrogen can currently not compete with the production of conventional grey hydrogen (Glenk and Reichelstein, 2019). Synthetic fuels have chemical properties similar to fossil fuels.

However, their application does not cause any new carbon emissions. They can, for example, be produced by using electricity and CO_2 that is extracted from the atmosphere (power-to-liquid and power-to-gas).

Hydrogen could open up many business areas in future. In the field of mobility, hydrogen and the synthetic fuels derived from it could become attractive in applications where diesel engines are currently used, for example in the running of ships, trains, trucks, buses, construction and forestry equipment, agricultural machinery and long-distance cars. The commercial-vehicle segment already uses hydrogen-based systems wherever the imperative is to avoid local emissions while at the same time ensuring continuous operation, such as in warehouse logistics. Adding hydrogen to the gas grid and using stationary fuel cells can cut emissions in the heating sector. Potential applications in industry range from the production of methanol and ammonia to the reduction of iron ore used in steel manufacturing and the provision of process heating for cement production (IEA, 2019b).

462. In order to improve coordination between market actors throughout the value chain and make the relevant markets accessible, hydrogen strategies have been presented both in **Europe** and in **Germany** at federal and state level. In addition to the strategies introduced by single and cooperating federal states, Germany's **National Hydrogen Strategy (NWS)** has been launched.

Thereby Germany and Europe have joined a number of nations that are systematically supporting markets for carbon-neutral fuels and their applications and, for this purpose, are launching comprehensive support programmes. Asian countries such as South Korea (Kan, 2020) and Japan (Nagashima, 2018; Iida and Sakata, 2019) have been endeavouring for some time to promote the use of hydrogen. Hydrogen applications in the mobility sector, for example, are being encouraged in China and California (Schimek et al., 2020).

Research funding remains a priority

463. Germany has been funding hydrogen applications since 2006 as part of its **National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP)**. Funding of €700 million was disbursed during the period from 2006 to 2016. For the second funding period from 2016 to 2026 (NIP II) the BMWi (2020b) plans to make funding of roughly €1.4 billion available for research and development as well as for demonstration projects. Further funding from the EKF as well as funding for real-world laboratories and investment under the national decarbonisation programme will be made available over the period from 2020 to 2023 (BMWi, 2020b).

The **research funding** being continued under the NWS, which has a total funding budget of €9 billion (Coalition Committee, 2020), is sensible. Due to its knowledge externalities, research funding can make a valuable contribution to gain expertise and to train skilled workers at an early stage while the relevant technology is becoming established. ↘ ITEMS 436 FF.

In this respect it seems to be a sensible approach for the NWS to take a **broad view** of the future role of carbon-neutral hydrogen and synthetic fuels. Unlike its

European counterpart, which focuses mainly on industrial applications, the German strategy comprises measures for the mobility, heating and industrial sectors.

464. As the new technology starts to become established, it is important to ensure that it is widely accepted by the general public. The experience gained from expanding the use of renewable energy could be used here so that people's concerns can be addressed at the earliest possible stage. Government-funded **demonstration projects**, as they are planned in the NWS, could not only demonstrate the functionality of the new technology but could also allay people's misgivings as quickly as possible.

Demonstration projects are supposed to create a **link between research and market launch**. In addition, they can help to illustrate the economic opportunities that hydrogen technology provides for a wide range of actors. As with other spending on research and development, however, the benefits that such projects bring for firms can be smaller than the benefit to society. ↘ ITEMS 491 FF. Public funding may therefore be appropriate (Nemet et al., 2018). In addition, the calls for tenders can come along with a coordinating function by bringing together a wide range of actors along new value chains. These projects require close cooperation between firms and research institutes. The public sector's role could include the facilitation of procedures and processes and might allow experimentation with alternative regulations. **Real-world laboratories** could potentially be used as an instrument here.

Enhancing the appeal of hydrogen applications

465. The national and European market conditions, which are faced by potential investors, significantly influence the decision to enter a market. Consistent cross-sectoral **carbon pricing** make many fragmented support measures superfluous.

An energy price reform that reduces the distorting effects on electricity prices ↘ ITEMS 391 FF. could already create incentives to build electrolysers, i.e. equipment used to produce hydrogen. Although a potential exemption for electrolysers is already being debated as part of the latest amendment to the German Renewable Energy Sources Act (EEG 2021), it has yet to be decided whether electrolysers will be classified as electricity-intensive firms – and will therefore have to pay a reduced **EEG surcharge** – or whether they will be fully exempt from these levies. ↘ ITEM 417 A **full exemption** would create the strongest incentives. Moreover, not only large electrolysers would benefit from an exemption, as would be the case with a reduction. Annual electricity consumption would need to be at least one gigawatt here. Nevertheless, it is questionable to what extent an exemption would be allowed under EU state aid rules.

466. As a potential instrument to reduce the investment uncertainty of hydrogen-based fuels and applications **quotas** are being proposed (Vogl et al., 2020). A regulatory requirement to integrate synthetic energy sources into fuels and gas supplies or to use steel which is produced using green hydrogen, would send out market signals (IEA, 2019b). A similar approach already applies to the addition of biofuels, which is governed by the Renewable Energy Directive (RED II).

Such arrangements could apply in carefully selected areas. In steel production the price gap between conventional and green steel is increasingly closing (Koch Blank, 2019; Wood and Dundas, 2020). A low quota for green steel in domestic processing could create **pull effects** without necessarily jeopardising **international competitiveness**. However, this would provide greater investment certainty for steel producers at an early stage. In the absence of further protectionist measures, however, the pull effect would work across borders. Although the additional costs incurred by the quota would be imposed on domestic producers, steel producers in non-EU countries might also benefit from these arrangements. Aimed at encouraging the domestic production of green steel, the quota's pull effect on domestic firms could therefore decrease. Moreover, a steel quota would require a reliable system for certifying green steel. At the moment, this appears to be unrealistic in the global context (Vogl et al., 2020). ↘ ITEM 375

467. An alternative to quotas might be **carbon contracts for difference** (CCfDs) (Richstein and Neuhoff, 2019). They constitute a government guarantee for a certain carbon price. If the carbon price falls below an agreed level, the contracting parties receive a subsidy. The risk attaching to the carbon price is therefore transferred from investors to the public sector. A very similar approach was adopted under the EEG, which gives a government price guarantee for the feed-in of renewable energy (GCEE Annual Report 2016 items 891 ff.). From a technical perspective, CCfDs can affect firms in the same way as a minimum carbon price (GCEE Special Report 2019 items 141 ff.). But, whereas under the BEHG, for example, the minimum price is fixed for six years only, CCfDs can be negotiated **for very long periods**. Helm and Hepburn (2005) discuss a period of between 20 and 30 years. There is also the option that the payment obligation agreed does not just apply to the public sector. If the realised carbon price exceeds the negotiated price, the CCfD could allow a profit participation (Sartor and Bataille, 2019).

Unlike quotas, CCfDs can be more accurately targeted at domestic firms. It is also clear who bears the cost incurred. In the case of quotas it would not be clear, a priori, to what extent firms or customers would bear the costs. However, CCfDs pose regulatory challenges. **Auctions** can be used to reduce the **information asymmetry** between firms and the public sector. Auctions' incentive structures can ensure that the most promising enterprises are supported and, at the same time, future payment obligations are limited (Sartor and Bataille, 2019). A **strong thematic focus** – on the steel industry, for example – could, however, severely restrict the number of bidders and reduce the auction's benefits. Nonetheless, CCfDs should not be used in all sectors. The more widely they are used, the higher the expenditure can be. And, last but not least, CCfDs could be problematic in terms of EU state aid rules (Vogl et al., 2020).

468. The **feed-in of hydrogen-based fuels** into the existing gas grid could be further facilitated. In Germany it is already possible to feed in up to 10 % hydrogen, which is a high proportion compared with other European countries (Dolci et al., 2019). The European hydrogen strategy could work towards the goal of increasing the permitted quota throughout Europe to enable sustainable energy sources to be used. If technical upgrades of the national gas system are required, the grid fees could be raised to fund them, thereby ensuring that the resultant costs are

shared according to need. On the one hand, this would increase the market for producers. On the other hand, this could make it easier for households that are dependent on gas to reduce their carbon footprint. There are, however, technical limits to this approach. As the proportion of sustainable energy sources in the gas supply grows, it is not necessarily **compatible with existing heating systems** (IEA, 2019b).

469. The use of hydrogen-based fuels enables the **electricity and gas grids to be linked**. Seasonal excess electricity capacity could be stored and then released as and when required. Future grid expansion plans could therefore be better coordinated in order to reduce the overall cost of such expansion (Board of Academic Advisors at the BMWi, 2020).

Collaborating nationally and internationally

470. Coordination between the public sector and domestic industry is especially important in order to mitigate the regulatory risks facing firms over the long term. Public support efforts could fail to achieve their objectives if there is no realistic prospect of earning profits in the long run. A **roadmap** specifying short-term and long-term milestones could send out a strong **signal** here. Politicians and industry could agree on joint targets, have their progress regularly evaluated and adapt their instruments accordingly. Politicians can use roadmaps to commit to **making the regulatory framework available within a prescribed period**. This will increase **planning certainty** for firms. However, commitments should not be given by the public sector alone. Progress should ideally be evaluated by a consortium, which could identify successes and room for improvement. A potential starting point here might be the Hydrogen Council set up as part of the NWS.

471. In addition, the government could perform an international coordinating function to promote international value chains of gas and liquid fuels. In order to meet the prescribed European climate targets, **collaborations within Europe** as well as **energy partnerships** between Europe and countries worldwide are needed so that fuels can be obtained over the longer term from regions that have a comparative advantage in their production (Runge et al., 2020).

V. CONCLUSIONS

472. The application of technologies that enable renewable energy to be used in all sectors is essential in the quest to create carbon-neutral economies across Europe and around the world over the long term. This will certainly create **opportunities**. Demand for environmentally friendly products, production processes and infrastructure is likely to grow. This offers German firms a wide range of possibilities to enter new markets and strengthen their future competitiveness. The German government can already accompany this process by **taking carefully targeted measures** that will enable firms to grasp these opportunities.

473. These measures should focus on a system that puts a consistent price on carbon while abolishing government-imposed, distorting levies and charges in energy pricing. Integrating the national emissions trading scheme in all sectors into the EU ETS and establishing a cross-sectoral emissions trading scheme in Europe should remain the guiding principle of policy (GCEE Special Report 2019 items 117 ff.). Until this goal has been achieved, an **energy price reform** can make a start right now by improving the incentives to implement sector coupling in Germany. This could involve totally abolishing the EEG surcharge for firms and households and cutting electricity tax to the minimum European rate. This would, firstly, compensate households for the financial burden imposed by the national emissions trading scheme. And, secondly, it would enhance the appeal of new technologies and markets that will become more important in future as a result of sector coupling. Enhancing the appeal of carbon-neutral technologies and products through such strengthening of the market environment could, in many areas, make fragmented, discretionary interventions superfluous and, consequently, cut costs.

Substantial private-sector investment will be needed in order to manage this transformation successfully. Current expectations about the future of carbon-neutral products and applications can, right now, mobilise private capital and investment in the real economy, provided that the climate-relevant properties of economic activity are transparent and understandable. The **certification of sustainable investments and of products and processes** therefore represents an important step towards removing barriers that are preventing investment in new firms, innovations and technologies.

474. The growing climate policy ambitions could result in increasing carbon prices in future. This shifts the focus on to considering a **carbon border tax adjustment**. A **carbon border tax adjustment**, which puts a levy (subsidy) on imports (exports) according to their respective carbon footprint, appears to be a promising instrument in theory. However, it presents a number of practical and legal obstacles that need to be considered before any such arrangement is introduced. It also poses considerable trade policy risks that would arise if a carbon border tax adjustment were introduced unilaterally. Any border tax adjustment should therefore be carefully considered and – if there are no objections from a trade policy perspective – should, at best, be applied to products in energy-intensive and export-led industries.

475. The interaction of various market imperfections can limit the effectiveness of incentives created by market-based mechanisms. It therefore makes sense to implement selected complementary measures. **Public funding of research** can make a particularly important contribution toto the innovations. The forward-looking **education and training of the workforce** can make this transformation much easier. Germany must set the right course for the future now to ensure that it has the appropriate skilled workers available when it needs them.

Network effects in the mobility sector can make it more difficult for households to cut their carbon emissions. **Switching to an electric vehicle** is only an appealing option for households if an adequate charging and filling-station infrastructure is available. It may therefore be appropriate to publicly fund the expansion of this infrastructure, although this should be done primarily to mobilise private investment.

Hydrogen technologies form a key part of attempts to achieve carbon neutrality in 2050 and, at the same time, offer opportunities for the German industry. The mobilisation of private investment will require cross-sectoral carbon pricing, an energy price reform and progress on certification. Public funding should be provided moderately and must address market imperfections such as knowledge externalities, network effects and information asymmetry. A public coordination process should be initiated to reach agreement between the government and the industry. A roadmap could help to specify targets, identify any need to adjust market conditions and strengthen investment certainty for firms.

APPENDIX

Steering effect on final energy consumption

476. The introduction of the national emissions trading scheme is intended to have an **environmental steering effect**. The price increases for heating fuel and other fuels are designed to send out signals that lead to lower demand for these energy sources. This, in turn, would reduce final energy consumption and the associated carbon emissions. The term 'final energy' refers to the energy that reaches the final consumer, i.e. households, the transport industry, as well as the trade, commerce and services sector. 'Primary energy', on the other hand, is the energy that is available from the naturally occurring energy forms or energy sources. Factors such as conversion losses lead that final energy consumption is less than primary energy consumption. More than 1 kWh of primary energy must be saved for every kWh of final energy saved.

477. The steering effect of reforms on final energy consumption can be analysed using estimated price elasticities. ↘ TABLE 17 The interpretation of these findings is subject to a few **caveats**. Determining elasticities generally involves a high degree of **uncertainty**. Instead of reducing overall demand for an energy source, carbon-

↘ TABLE 17

Price elasticities in the heating and transport sectors

Sector	Energy source	Application	Short-term	Long-term
Households	Gas	Heating	– 0.20	– 0.51
	Gas	Hot water	– 0.05	– 0.51
	Heating oil	Heating	– 0.20	– 0.32
	Heating oil	Hot water	– 0.05	– 0.32
	Electricity	Heating	– 0.20	– 0.40
	Electricity	Hot water	– 0.05	– 0.40
	Electricity	Electrical appliances[1]	– 0.025	– 0.40
GHD[2]	Gas (natural gas)	Heating	– 0.20	– 0.51
	Gas (natural gas)	Process heating	– 0.10	– 0.51
	Gas (natural gas)	Other[3]	– 0.025	– 0.51
	Heating oil (light)	Heating	– 0.20	– 0.32
	Heating oil (light)	Process heating	– 0.10	– 0.32
	Heating oil (light)	Other[3]	– 0.025	– 0.32
	Electricity	Heating	– 0.20	– 0.40
	Electricity	Process heating	– 0.10	– 0.40
	Electricity	Other[3]	– 0.025	– 0.40
Traffic	Petrol	Transport	– 0.25	– 0.80
	Diesel	Transport	– 0.05	– 0.80

1 – ICT and lighting applications. 2 – Trade, commerce and services. 3 – Refrigeration, power, ICT and lighting applications.

Source: Bach et al. (2019b)

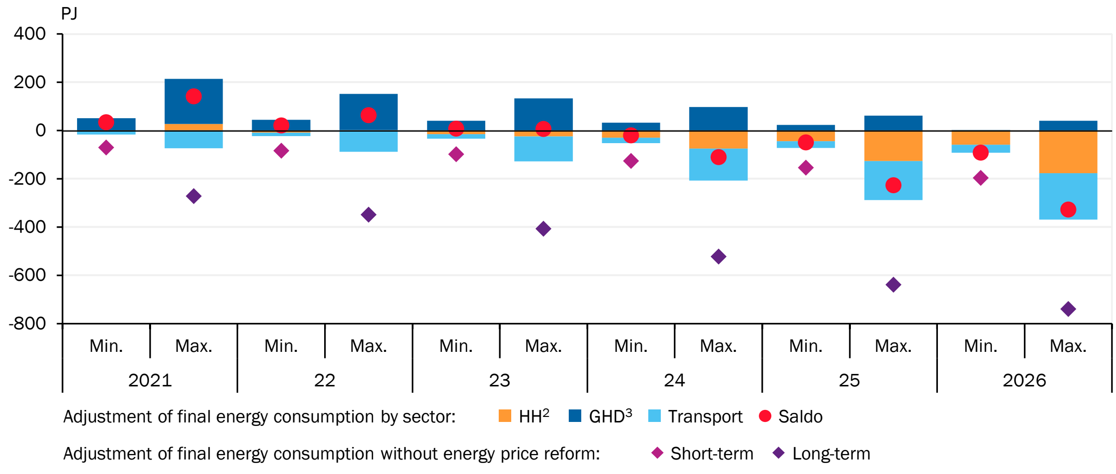
intensive energy sources can be substituted within a product category. These **potential substitutions** cannot be reflected here. These calculations cannot, for example, take account of the fact that electric mobility could become cheaper than running motor vehicles with internal combustion engines if the energy price reform is implemented. Given the high levels of cross-price elasticity, this could give rise to additional demand effects if consumers react to these reforms by switching. Despite these caveats the following model calculation can give an exemplary illustration of the steering effect of the national emissions trading scheme and the energy price reform.

478. Given these assumptions, the carbon price of €25 per tonne of CO2 planned for 2021 is calculated to **cut final energy consumption** in the heating and transport sectors **by at least 71 petajoules (PJ)**. ↘ CHART 72 Compared with 2018 this would equate to around 1.1 % of the total final energy consumed in the household sector, the transport industry, as well as the trade, commerce and services sector. The carbon price will be raised to as much as €65 per tonne of CO2 by 2026. This could reduce final energy consumption by between 196 PJ and 740 PJ compared with 2018. This corresponds to between 3 % and 11 % of the total final energy consumed in these sectors. **Households** account for the **largest share of these reductions**, which can largely be attributed to their declining demand for heating oil and gas for heating purposes.

479. The energy price reform will cause the price of electricity to fall, which in turn is likely to boost demand for electricity. This means that the proposed measures will not only **reduce demand for heating fuel and other fuels** but will also **increase demand for electricity**. Given this greater demand, instead of an overall reduction in final energy demand there would be additional energy demand of at least 30 PJ in 2021. ↘ CHART 72 This additional demand can mainly be attributed to the trade, commerce and services sector.

↘ CHART 72

Adjustment of final energy consumption as a result of carbon pricing and energy price reform[1]



1 – The minimum values for the expected steering effects are based on short-term price elasticities, while the maximum values are based on long-term price elasticities. Expressed in petajoules (PJ). 2 – Private households. 3 – Trade, commerce and services.

Sources: Bach et al. (2019b), Federal Statistical Office, Working Group on Energy Balances, own calculations

480. Reductions in consumption are therefore likely to be greater without energy price reforms. However, **changes in electricity consumption** will not increase **emissions in the electricity sector** because these are limited by fixed quantities of certificates in the EU ETS. Replacing fossil fuels with electricity-based energy sources in the heating and transport sectors could result in further emissions reductions, which are likely to help achieve German and European climate targets. The energy price reforms might therefore bring about emissions reductions combined with lower carbon prices. The climate targets set by the EU and Germany aim to increase renewable energy's share of the final energy consumed and to reduce the amount of primary energy consumed.

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