GERMAN COUNCIL
of Economic Experts

SETTING OUT FOR A NEW CLIMATE POLICY

Special Report

July 2019
- Preliminary Translation -

This is a translation of the original report published in German, which is the sole authorative text.

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Completed on 5th July 2019, 5:00 pm

PREFACE

1. With its letter of 20 June 2019, the Federal Government, through the Federal Ministry for Economic Affairs and Energy, requested the German Council of Economic Experts (GCEE) to prepare a special report in accordance with § 6 Section 2 Sentence 2 of the GCEE Act, which discusses the pricing of CO2 as a possible instrument for achieving climate protection targets.

   The special report is entitled:

   ## SETTING OUT FOR A NEW CLIMATE POLICY

2. At present, there is an intense debate in Germany about a course correction in climate policy. This was triggered, among other things, by protests expressed by parts of the population in many countries against insufficient progress in climate protection and by growing concern that the European targets for reducing greenhouse gas emissions might not be met. At the same time, there were protests in France against an increase in environmental taxes. Against this background, the GCEE analyses reform options in climate policy in this special report. Although the focus is on national climate protection measures, they are explicitly discussed with a view to their integration into European and global climate policy.

3. In preparation for the special report, the GCEE and the French Conseil d'analyse économique intensively exchanged views on climate policy issues.

4. Prof. Dr. Ottmar Edenhofer, Prof. Dr. Christian Flachsland, Prof. Dr. Matthias Kalkuhl, Dr. Brigitte Knopf (all Mercator Research Institute on Global Commons and Climate Change, Berlin) and Dr. Michael Pahle (Potsdam Institute for Climate Impact Research, Potsdam) prepared an expertise on the topic "Options for a CO2 price reform" for the GCEE and participated in various ways in a lively technical exchange with the Council on the subjects of the special report.

5. Prof. em. Dr. Ulrich Büdenbender, TU Dresden, prepared an expertise on the "Legal framework for CO2 pricing in the Federal Republic of Germany" for the GCEE and discussed its contents several times with members of the Council.

6. With Prof. Dr. Axel Ockenfels, University of Cologne, the GCEE discussed the possibilities of international coordination in climate protection.

7. With Prof. Dr. Joachim Weimann, University of Magdeburg, the GCEE discussed questions of emissions trading and German energy policy.

8. Representatives of the GCEE talked with Prof. Dr. Manuel Frondel of RWI – Leibniz Institute for Economic Research, Essen, about aspects of the implementation and distribution effects of carbon pricing.

9. In advance of this special report, the GCEE discussed climate and energy policy issues with the presidents and employees of the Federation of German Industries (BDI) and the Association of German Chambers of Industry and Commerce (DIHK).

10. The scientific staff of the GCEE met with employees of the Federal Chancellery, the Federal Ministry of Finance, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Federal Ministry for Economic Affairs and Energy and the European Commission to discuss reform options, their feasibility and effects.

11. The scientific staff exchanged views with employees of the European Central Bank on the effects of climate change on financial stability.

12. Employees of the Bertelsmann Stiftung, the CO2-Abgabe e.V., the German Economic Institute Cologne and the German Association of the Automotive Industry (VDA) discussed aspects of pricing greenhouse gas emissions with the scientific staff of the GCEE.

13. On behalf of the Working Group "National Accounts of the Länder", the Statistical Office of Baden-Württemberg provided the GCEE with comprehensive data sets. The research data centres of the statistical offices of Saxony-Anhalt and Bremen as well as the Bavarian State Statistical Office also provided data material.

14. The GCEE would like to thank the Federal Statistical Office for its excellent cooperation and valuable support as well as for the data provided, in particular the Research Data Centre for data from the sample survey of household income and expenditure. The chapter supervisors from the Federal Statistical Office made an exceptionally valuable contribution to the quality assurance of this special report.

15. Martin Fischer, Tim Hermann, Carina Kafl, Niclas Knecht, Julius Kraft, Leonard Mülstroh, Sophia Oertmann, Simon Riedl and Fabiene Weber actively supported the GCEE and its scientific staff during their internships.

16. We extend special thanks to the staff of the liason office of the GCEE, for their extraordinary commitment in preparing this special report. We would like to thank Dipl.-Volkswirtin Birgit Hein as well as Jasmin Conrad, Dipl.-Betriebswirtin (FH) Adina Ehm, Waldemar Hamm, M.Sc., Laura Mester, Volker Schmitt, Esther Thiel and Lara Wiengarten, M.Sc..

17. This special report is essentially based on the support of the scientific staff, which has supplemented the work of the GCEE with a commitment that goes far beyond the usual scope and with outstanding technical expertise. Our sincere thanks therefore go to Sebastian Breuer, M.Sc. (Deputy Secretary General), Kai Brückerhoff, M.P.P., Dr. Désirée I. Christofzik (Deputy Secretary General), Dr. André Diegmann, Dr. Jan Fries, Niklas Garnadt, M.Sc., Dr. Jens Herold, Dr. Florian Kirsch, Malte Preuß, M.Sc., Felix Rutkowski, M.Sc., Dr. Alexander Schäfer, Dr. Milena Schwarz, Sebastian Weiske, Ph.D., Nadine Winkelhaus and Dipl.-

Volkswirt Mustafa Yeter. Very special thanks shall be due to the Secretary General, Dr. Wolf Heinrich Reuter, who coordinated the work on this special report with an outstanding overview and leadership competence and shaped the content of large parts of the special report.

All remaining errors in this report should only be attributed to the authors mentioned below.

Wiesbaden, 12 July 2019

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Abbreviations

AAAS	-	American Association for the Advancement of Science
ADAC	-	German Automobile Club
Annual Report	-	Annual Report of the German Council of Economic Experts
BAFA	-	Federal Office of Economics and Export Control
BAFU	-	Swiss Federal Office for the Environment
BDI	-	Federation of German Industries
BECCS	-	Bioenergy with carbon capture and storage
BGB	-	German Civil Code
BMF	-	Federal Ministry of Finance
BMVI	-	Federal Ministry of Transport and Digital Infrastructure
BMWi	-	Federal Ministry for Economic Affairs and Energy
BMU	-	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMZ	-	Federal Ministry for Economic Cooperation and Development
CAP	-	Common Agricultural Policy
CAT	-	Climate Action Tracker
CCS	-	Carbon Capture and Storage
CCU	-	Carbon Capture and Use
CDM	-	Clean Development Mechanism
CDR	-	Carbon dioxide removal
CEWEP	-	Confederation of European Waste-to-Energy Plants
CH_4	-	Methane
CJEU	-	Court of Justice of the European Union
CO_2	-	Carbon dioxide
CORSIA	-	Carbon Offsetting and Reduction Scheme for International Aviation
CSCF	-	Cross-sectoral correction factor
DAC	-	Direct Air Capture
DICE-Modell	-	Dynamic Integrated model of Climate and the Economy
DIHK	-	Association of German Chambers of Industry and Commerce
ECB	-	European Central Bank
EEG	-	German Renewable Energy Sources Act
EEX	-	European Energy Exchange AG
EFI	-	Commission of Experts for Research and Innovation
EIB	-	European Investment Bank
ESD	-	Effort Sharing Decision
ESG	-	Environmental, Social and Governance
ESRB	-	European Systemic Risk Board
ETS	-	Emissions Trading Scheme
EU	-	European Union
EU-ETS	-	European Union Emissions Trading System

Abbreviations

EVS	-	Income and expenditure sample
GCEE	-	German Council of Economic Experts
GCF	-	Green Climate Fund
GDP	-	Gross domestic product
GEF	-	Global Environment Facility
GHD	-	Trade, commerce and services
HFC	-	Hydrochlorofluorocarbon
IBP	-	Fraunhofer Institute for Construction Physics
ICAO	-	International Civil Aviation Organization
ICE	-	Intercontinental Exchange
IMF	-	International Monetary Fund
IMO	-	International Maritime Organization
IPCC	-	Intergovernmental Panel on Climate Change
JI	-	Joint Implementation
KfW	-	Kreditanstalt für Wiederaufbau
KSpG	-	German Law for the Demonstration of the Permanent Storage of Carbon Dioxide
kWh	-	Kilowatt hour
LuftVStAbsenkV	-	Regulation on the reduction of tax rates in 2019 according to § 11 Article 2 of the German Air Transportation Tax Act
MSR	-	Market Stability Reserve
NDC	-	Nationally Determined Contributions
ND-GAIN	-	Notre Dame Global Adaptation Index
NF_3	-	Nitrogen trifluoride
N_2O	-	Nitrous oxide (laughing gas)
OECD	-	Organization for Economic Co-operation and Development
OTC	-	Over the counter
PFC	-	Perfluorinated hydrocarbons
Pkm	-	Person kilometer
RICE-Modell	-	Regional Integrated model of Climate and the Economy
RIVM	-	Netherlands National Institute for Public Health and the Environment
RWI	-	RWI – Leibniz Institute for Economic Research
SCC	-	Social Cost of Carbon
SF_6	-	Sulphur hexafluoride
SGB	-	German Social Code
SPD	-	Social Democratic Party of Germany
SRU	-	German Advisory Council on the Environment
TFEU	-	Treaty on the Functioning of the European Union
UGR	-	Environmental-economic accounts
UNEP	-	United Nations Environment Programme
UNFCCC	-	United Nations Framework Convention on Climate Change

Abbreviations		
US	-	United States
WIAGEM	-	World Integrated Assessment General Equilibrium Model
WLTP	-	Worldwide Harmonized Light-Duty Vehicles Test Procedure
ZEW	-	ZEW – Leibniz Centre for European Economic Research

Methodological Remarks

In general, the tables and figures were rounded up or down respectively. This may result in minor discrepancies between the sum of individual figures and the total stated.

Seasonally adjusted data were calculated using the Census-X-13-Arima method.

EXECUTIVE SUMMARY

1. Germany finds itself in the midst of an intense debate about a **realignment of climate policy** and the possibilities and limits of reform options in this area. This debate has been triggered not least by **protests** among parts of the population in many countries about the lack of progress in combatting climate change. It is also being fuelled by the growing sense that it will be very difficult for this country to achieve the internationally agreed binding European **targets** for cutting greenhouse gas emissions. At the same time there have been protests in France against, among other things, the raising of environmental taxes. It is against this backdrop that the German government has asked the German Council of Economic Experts to compile a **special report** discussing the options for reforming climate policy.

Economic principles: effectiveness and efficiency

2. Any climate policy that ignores economic considerations is ultimately doomed to failure. Effective protection against climate change requires a **drastic reduction of global greenhouse gas emissions** and, consequently, a **comprehensive transformation** of energy supply systems away from the fossil fuels that currently dominate. The Paris Climate Agreement has set the clear target of limiting global warming to well below two degrees. This is a **monumental task** that can only be achieved with the help of carefully targeted political measures and the use of considerable economic resources. Cost-effectiveness is therefore essential.

3. This realignment of climate policy should obey the **economic principle of the division of labour** in order to minimise the economic cost of this transformation. The potential for the division of labour tends to grow as the **number of actors involved increases**. The guiding principle here is that greenhouse gas emissions can be reduced economically efficiently if the next unit is saved wherever this is the most cost-effective – irrespective of at what location, with which technology, in which industrial sector and by which polluter this is achieved. This principle therefore dictates that the lowest-hanging fruit – according to the technical possibilities available at the time – should be harvested first. Technological advances then enable further necessary savings to be achieved more cost-effectively over time.

4. A **number of different actors** will determine the actual process of this transformation by making decisions – partly based on private information not available to outsiders – about their energy consumption and their investments. **A coordination strategy guided by market-based principles** thus plays a key role in achieving the goal of a cost-effective transformation. A **uniform price** on **carbon dioxide (CO_2)** emissions would ensure that CO_2 would never be emitted if its avoidance was cheaper than its price. The basic mechanism and the relevant conclusions also apply to all other greenhouse gas emissions such as methane and nitrous oxide. On the other hand, detailed targets – especially

those set for individual sectors within economies – stand in the way of effective solutions. Moreover, it is questionable whether they are fundamentally suited to achieving the general climate objectives.

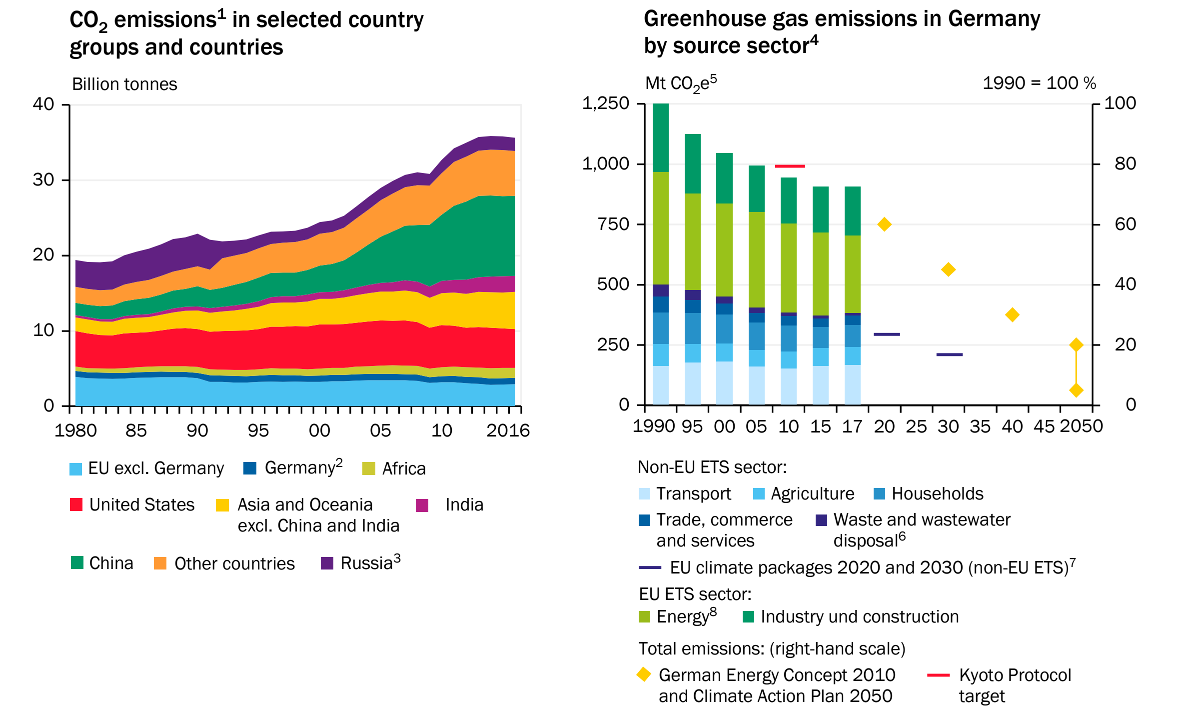
Global coordination essential in combatting climate change

5. A **globally coordinated, common approach is essential** in order to contain global warming effectively and ensure economic cost-efficiency. Even if they were to eradicate all of their own greenhouse gas emissions, Germany and the European Union (EU) could only make a very modest direct contribution to containing global warming. ↘ CHART 1 Global coordination must therefore play a key role in Germany's climate policy, and a movement towards a globally uniform pricing of greenhouse gas emissions must be initiated.

6. The **Paris Climate Agreement** represents a first major step in setting common targets for the maximum temperature rise in an international treaty. The implementation and enforcement of this agreement will, however, require further efforts. A worldwide uniform price would provide the ideal signal for containing the global transformation costs and, at the same time, it would be the best instrument for effectively achieving and monitoring the worldwide coordination of efforts on climate policy. Once a corresponding **global minimum price for greenhouse gas emissions** was agreed, the specifics of implementation could be left to each region. A suitable option in this case would be, for ex-

↘ CHART 1

Global CO_2 emissions and greenhouse gas emissions in Germany



1 – Total CO_2 emissions from energy consumption (burning of coal, coke, gas, oil and other liquids). 2 – Germany: 1980 to 1990 West Germany. 3 – Russia: 1980 to 1991 former Soviet Union. 4 – Excl. land use, land-use change, and forestry. 5 – Megatonnes of CO_2 equivalents. 6 – Including other furnaces. 7 – For Germany this equates to a reduction of 14 % by 2020 and 38 % by 2030 compared with 2005. For the EU this equates to a reduction of 10 % by 2020 and 30 % by 2030 compared with 2005. 8 – Including diffuse emissions from fuels.

Sources: EIA, Eurostat, own calculations ample, an emissions trading scheme that covered all sectors and actors in a region, such as the one that could be created in the EU by extending the system that already exists there.

7. In trying to persuade other countries around the world to adopt such uniform pricing, Germany and the EU will need to have the **strongest possible negotiating position**. When evaluating climate policy measures it is therefore necessary to consider their impact on this negotiating position:

   - National measures to mitigate the consequences of climate change (**adaptation**), which – given the already advanced temperature rise and its impacts – will probably be needed anyway, would strengthen this negotiating position on the international stage.
   - It will probably not be very helpful to aspire to a **pioneering role** which, by achieving a more ambitious reduction of greenhouse gas emissions, goes beyond what has been internationally agreed. Rather, the guiding principle of international negotiations on combatting climate change should be **reciprocity**.
   - In contrast to performing such a pioneering role, acting as a **role model** could certainly be helpful. This would be the case, for example, if a highly developed economy such as Germany, which makes intensive use of fossil fuels, managed to achieve the internationally agreed targets efficiently and without causing major social disruption.
   - Another key component of the global negotiating strategy might be **additional financial incentives**, especially given the need for development outside the industrialised nations and the considerable variations in avoidance costs worldwide. The willingness to introduce appropriate carbon pricing could, for example, be included in negotiations of free trade agreements or determine access to the financial resources of an enlarged international climate fund.

Consistent carbon pricing in Germany and the EU

8. The transformation towards lifestyles and forms of production with fewer CO_2 emissions will require **new technologies** to be developed. As can be empirically observed at present, innovations are one of the key factors that will enable poorer regions to catch up economically without creating the same level of **CO_2 emissions** as the advanced economies have in the past. Achieving climate neutrality in the long term will, in all probability, require competitive technologies and investments that prevent newly generated CO_2 from escaping into the atmosphere or remove from the atmosphere CO_2 that has already escaped.

9. A carbon price strengthens the **incentive to invest** in lower-emission machinery and equipment, encouraging suitable business models and the search for innovations. In order to complement this approach, the richer economies should step up their technology-neutral funding of **(basic) research**. Given the spillover effects and the economies of scale involved in this area, a coordinated approach at the European level would be beneficial.

10. However, technological advances alone will not be sufficient to meet this climate policy challenge. In the long term, Germany and the EU will have to make their **economies carbon-neutral**. The key question is what is the **best way** to achieve this? Under the Paris Climate Agreement the EU has committed itself by 2030 to **cutting greenhouse gas emissions** by 40 % compared with their level in 1990.

    – The EU aims to meet this target partly by reducing the quantity of certificates available in its **emissions trading scheme (EU ETS)**. This system currently covers the **energy and industrial sectors**, which account for roughly 45 % of emissions. The way in which the EU ETS is constructed means that its emissions reduction target is bound to be achieved.

    – The member states have also agreed emissions reduction targets for the **sectors outside the EU ETS**. These targets relate to the transport, buildings and agriculture sectors in particular.

11. The targets set at European level effectively make **additional national limits redundant** – both for the economy as a whole and especially for individual sectors. Nonetheless, **Germany** has set itself a number of **national targets** for cutting greenhouse gas emissions. Its expensive environmental projects, the support provided by **the German Renewable Energy Sources Act (EEG) and the phase-out of fossil fuels** (Kohleausstieg) all relate to areas that are already covered by the EU ETS and – without any appropriate accompanying measures – would not help to further reduce EU-wide emissions. From a climate policy perspective these measures are therefore questionable.

12. The measures that Germany has implemented in the **sectors not covered by the EU ETS** have so far consisted of a variety of fragmented targets and action plans as well as **taxes and levies that are inconsistent from a climate policy perspective**. Germany – in common with other member states – is at risk of **failing to hit the targets** set for 2020 and 2030 in this area. This violation could impose considerable fiscal costs on Germany or even result in it facing an infringement procedure. Given this situation, the question is what reform options Germany and Europe should be pursuing as a matter of priority.

13. Since a uniform price would minimise the macroeconomic costs of reducing emissions within the EU, the division between EU ETS and non-EU ETS emissions is not in line with the principle of the division of labour. To follow this principle, **extending the EU ETS to all sectors in all member states** should be the **primary objective of EU climate-policy efforts**. What is important is a credible medium- to long-term price signal that creates incentives for emissions reduction and suitable investments.

14. A uniform carbon price would also be an important element of the European internal market. Germany should work towards an **agreement between all member states about an expansion of the EU ETS**. As part of the persuasion process, Germany could hold out the prospect of additional funds via the EU Structural Fund. Should it prove difficult to reach a comprehensive agreement involving all member states, Germany could, together with other member

↘ TABLE 1

Evaluation[1] of different options for carbon pricing

	Incorporating additional sectors into the EU ETS	Separate emissions-trading system for non-EU ETS sectors	Carbon tax for non-EU ETS sectors	Memorandum item: regulatory law
Achieving the 2021-2030 targets under EU Effort Sharing Regulation	no more national targets needed	when retaining the path for issuing allowances	regular readjustment necessary	challenging, small-scale readjustment necessary
Cost efficiency	cross-sector and EU-wide	within the system boundaries	within the system boundaries	low
Administrative feasibility	medium effort (monitoring)	medium effort (monitoring)	relatively little effort	medium effort (enforcement necessary)
Timely political feasibility	medium term, EU negotiations	short to medium term	short term	short term
Revenue for redistribution	additional revenue	additional revenue	additional revenue	no additional revenue
Reaction to changes in economic conditions	endogenous reaction	endogenous reaction	readjustment difficult	readjustment difficult
Planning reliability for actors	price corridor possible at expense of target achievement	price corridor possible at expense of target achievement	fixed price path only without readjust-ments	depends on design
European link possible	joint EU instrument	linking possible	coordinated tax rates possible	low

1 – green = Option largely meets criterion, yellow = neutral red = option unlikely to meet criterion.

states, integrate the non-EU ETS sectors into the EU ETS under the **opt-in** arrangements already provided for by EU regulations.

15. An extension of the EU ETS or an opt-in should take place as quickly as possible, although it could involve **lengthy legal and political procedures**. In order to still efficiently reach the targets allocated to Germany for the non-EU ETS sectors in the short term, a separate pricing scheme for the non-EU ETS sectors is therefore necessary as a **transitional solution**. Options that would allow this in the short term are **separate emissions trading** for these sectors or a **carbon tax**. ↘ TABLE 1 The solution chosen for the transition should also be implemented by a coalition of as many member states as possible. Both solutions are still superior to a national regulatory or subsidised approach for achieving the objectives for the non-ETS sector in terms of cost efficiency, even if they are only implemented at the national level. Advantages and disadvantages must be considered when weighing up these options:

– Separate emissions trading can directly ensure that the quantitative target is reached. In the case of a carbon tax, this would require a **regular adjustment of tax rates**, which could undermine the credibility of political action from the point of view of its reliability. In emissions trading, on the other hand, the price results from the fixed development of the number of allowances.

– The carbon tax is administratively simpler and **quicker to implement**.

- Separate emissions trading should be **easier to transfer into the existing EU ETS**. Moreover, the price would react endogenously to economic fluctuations.
- A **minimum price** could be introduced in the emissions trading system to increase security for investors. Since the prices could prove to be considerably higher than initially thought, so that the political decision-makers might feel forced to intervene, a **maximum price** should be considered. In such a case, however, achievement of the objectives would no longer be guaranteed.

Ensuring competitiveness and social balance

16. In view of the probably higher avoidance costs outside the EU ETS, the **extension of the EU ETS** to further sectors can be expected to lead to an **increase in the price of CO2 emissions**. This also affects the actors already in the EU ETS and increases their production costs. While there is little risk of companies transferring carbon-intensive operations abroad (**carbon leakage**) in the buildings and transport sectors, it is relevant in the sectors already covered by the EU ETS.

    - The EU ETS has sophisticated systems for the **free allocation of allowances** to highly energy-intensive, internationally competitive production sectors, and a benchmarking system that reduces the absolute burden – and thus the risk of carbon leakage – while still offering incentives to reduce emissions.
    - Furthermore, under state-aid law the member states have the option of **compensating electricity-intensive companies** for indirect carbon-emission costs.

17. If the existing protection against carbon leakage based on the free allocation of allowances cannot, as up to now, avoid considerable competitive disadvantages, a border adjustment could be jointly considered with the other EU member states. A **border adjustment**, which should not be confused with the introduction of customs duties, would, however, involve a lot of administrative work and has the **potential to cause trade-policy conflict**.

18. A price for CO2 emissions creates incentives for companies and households to emit less CO2 by acting appropriately and investing in equipment and consumer goods. If the EU's targets are to be met, households in particular will either have to react more strongly to price changes, or the price of CO2 emissions will have to be much higher. In order to **intensify the adjustments** following the existing incentives and thus to contain the necessary carbon price, targeted **accompanying measures** should therefore be considered.

    - **Subsidies** for the purchase of low-emission equipment could be necessary, for example in the form of premiums for the replacement of heating systems. In the housing sector, it must be ensured that landlords have incentives to invest in their rental properties.

– **Infrastructure investment** is also required, for example in local public transport, or in the grid and storage infrastructure.

– Finally, the **tax system** could be fundamentally overhauled, thus increasing incentives to reduce CO2 emissions. This would affect, for example, the motor vehicle tax and the electricity tax and could include a redesigned road toll to finance the infrastructure.

19. The primary aim of pricing CO2 emissions is to efficiently reduce them, not to generate additional tax revenue. In order to increase the level of **acceptance of carbon pricing** among the population, the **resulting revenues** should be **redistributed** in a **socially balanced** manner. Whether people pay more or less tax will depend on their carbon consumption: ↘ CHART 2

– A **flat-rate reimbursement per inhabitant** would on average relieve households up to the fifth income decile. However, the net effect would be heterogeneous within the income groups. A carbon-intensive heating system and a large living area are important factors that lead to high CO2 emissions. In addition, singles would pay more. If the per-capita lump-sum payout were reduced as the household size increases, the share of households with proportionately higher bills could be reduced. On the other hand, a distinction between urban and rural areas would have a lesser effect.

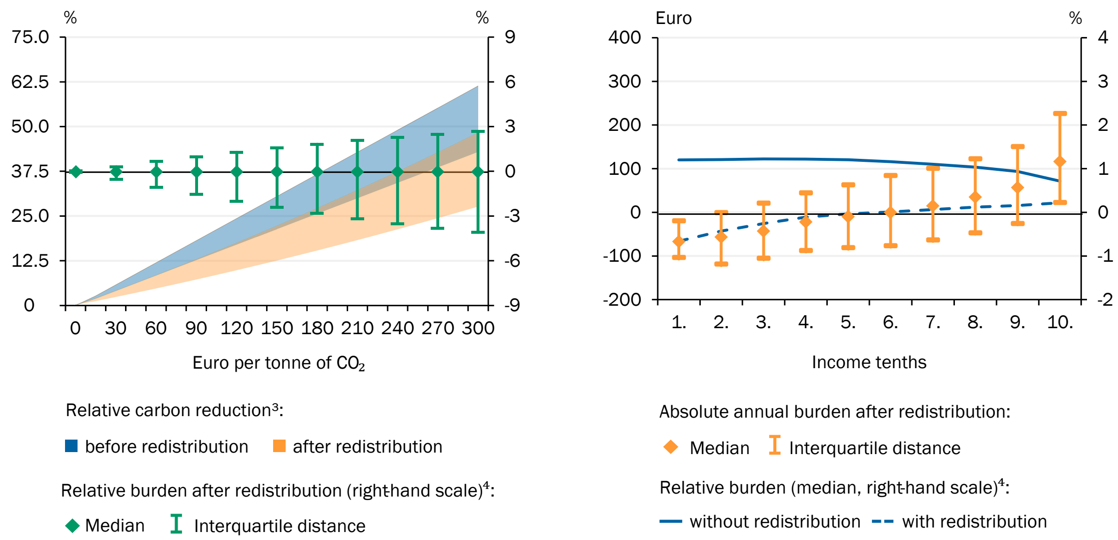
– A **reduction in electricity costs** by cutting electricity tax or financing the EEG reallocation charge from federal funds would not only mitigate the re-

↘ CHART 2

Effects of a uniform carbon price on private households' income and carbon consumption[1]

Relative reduction in CO_2 emissions according to different price and elasticity scenarios and the corresponding relative annual burden after lump-sum return[2]
for different carbon prices

Absolute and relative burdens at a uniform carbon price of €35 per tonne of CO_2
by income tenths



1 – Calculations refer to the base year 2013. 2 – Revenue-neutral lump-sum return. 3 – Upper interval limit determined by 30 % higher elasticities and 10 % higher CO_2 content of goods. 4 – Burden relative to equivalence-weighted disposable income.

Sources: Federal Statistical Office, Pothen and Tovar Reaños (2018), RDC of the Federal Statistical Office and Statistical Offices of the Länder, Einkommens- und Verbrauchsstichprobe 2013 Grundfile 5 (HB), own calculations

gressive effect of pricing, but also have a strengthening effect on sector coupling. This option would also be easier to implement.

– A **reduction in direct taxes or social security contributions** could reduce the burden on labour. This could lead to positive effects on production and employment. Such a measure would benefit only part of the population directly, but could be accompanied by other redistribution options.

– The German transfer system already has many ways of easing hardship by means of **existing mechanisms**. For example, the state pays the actual heating expenses for recipients of basic security benefits (SGB II) and income support. Should additional interventions become necessary, the housing allowance (Wohngeld) could be adjusted.

Conclusions

20. The current debate offers a historic opportunity to change German climate policy from a detailed, expensive and inefficient approach to a system centred around the pricing of greenhouse-gas emissions. A global approach is indispensable in order to curb global warming, and a newly designed climate policy can be a valuable building block in this context. But even if this were not to succeed in the medium term, this conversion would still enable Germany to achieve emission reductions at lower costs. Europe and Germany can only serve as role models if **emission reductions** can be combined **with growing prosperity and social acceptance**.

I. SETTING OUT FOR A NEW CLIMATE POLICY

1. Germany is in the midst of an intense debate surrounding the **realignment of its climate policy**. This has been prompted by, among other things, the protests staged in many countries by parts of the population against insufficient progress on climate protection and increasing concerns that European targets for reducing emissions of greenhouse gases may fail to be met. At the same time, protests were held in France to oppose among others the increase in eco taxes. It is against this backdrop that the Federal Government has asked the German Council of Economic Experts to compile a **special report** discussing the options for reforming climate policy. The special report presented here therefore focuses on national climate protection measures. However, these are explicitly discussed with reference to how they dovetail with European and global climate policy.

2. **Climate change** must be treated consistently as a phenomenon that affects all of humanity. Climate change is becoming increasingly visible with the perceptible rise in the global average temperature. ↘ CHART 1 LEFT In addition, climate fluctuations are becoming more marked and meteorological extremes, such as storms, droughts and summer heat waves, are occurring with increasing frequency (IPCC, 2013). The world has experienced recurring periods of warmer and cooler global temperatures over past centuries. However, in contrast to these, the main cause of the warming observed since the middle of the twentieth century has been the **concentration of greenhouse gases** in the atmosphere due to human activity (National Academy of Science, 1979; AAAS, 2009; Anderegg et al., 2010; Cook et al., 2013; IPCC, 2013; Powell, 2016; Nordhaus, 2019).

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Greenhouse gases are gases in the Earth's atmosphere that absorb and reflect infrared radiation emitted by the Earth, thereby intensifying the greenhouse effect. Direct greenhouse gas emissions in Germany (as recorded in 2017) consist of 88 % carbon dioxide (CO_2), 6 % methane (CH_4), 4 % nitrous oxide ("laughing gas", N_2O), 1 % hydrochlorofluorocarbons (HFC), as well as other gases including perfluorocarbons (PFC), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3) (German Environment Agency, 2019a). The different types of greenhouse gases contribute to climate change to varying degrees. For instance, nitrogen trifluoride, which is used, for example, in the production of liquid crystal display screens and solar panels, is only emitted in infinitesimal volumes. However, its greenhouse effect is approximately 16,000 times greater than that of CO_2 (IPCC, 2016). Meanwhile, laughing gas is 265 times more harmful to the environment than CO_2, while methane is more harmful by a factor of 28. In 2016, approximately 60 % of methane and around 80 % of laughing gas emissions in Germany were attributable to agricultural production (German Environment Agency, 2019b).

Given the range of greenhouse gases that exist and their various effects on climate, these should be consistently taken into account in climate policy as CO_2 equivalents in order to exclude substitution and evasion effects due to the restriction of CO_2. For example, the reduction in methane emissions as a result of the landfill ban may have caused slightly higher carbon emissions from waste incineration. The global climate change agreements of Kyoto and Paris have already explicitly addressed the various greenhouse gases. In the report presented here, **CO_2 equivalents** are used in the calculations where possible. At the same time, there is a clear focus on CO_2 emissions and, in most cases, these are mentioned as representative of the other greenhouse gases. That being said, the basic mechanics described and conclusions drawn are equally valid for all greenhouse gas emissions. Therefore, all greenhouse gases should, in principle, be taken into account on the basis of the same classifications and considerations when implementing the reform options discussed here.

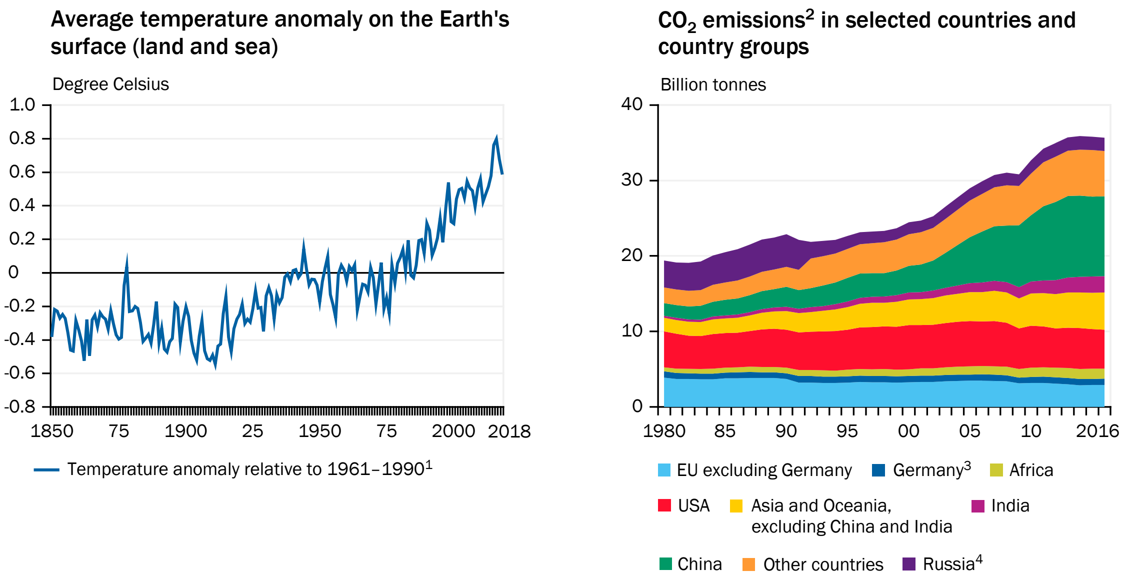
3. Global climate change has significant consequences for individuals and society. For example, changes in climate impact human health, biodiversity and agriculture. Such changes may also trigger migration on a massive scale and ignite violent conflict. The resulting **economic costs** differ greatly from region to region. Therefore, exact predictions are clouded by a **large degree of uncertainty**. However, these costs are likely to be significant, in particular in the absence of climate policy countermeasures and in the event of particularly adverse scenarios. Typically, though, such scenarios are not detected until it is too late for them to be avoided due to the inertia of the processes involved. If a rational economic approach is to be taken, it is therefore ideal if an industrial nation like Germany is actively involved in a global strategy to mitigate climate change.

With this approach, the consequences of climate change for each region is jointly determined by the climate policy activities of all national economies. For these reasons, climate policy considerations present policymakers with particularly complex problems in terms of decision-making and negotiation.

4. Two basic strategies are available to humanity in dealing with global climate change, i.e. limiting its magnitude by reducing greenhouse gas emissions (**climate change mitigation**) and adapting to its negative effects (**climate change adaptation**) (Advisory Board to the Federal Ministry of Finance, 2010; GCEE Annual Report 2016, Item 857). Reversing climate change or preventing any further temperature increases no longer appear to be realistic options in the medium-term. Even the Paris Climate Agreement, to date the most ambitious agreement on climate change, assumes that temperature increases will continue. Therefore, the most appropriate response is a **combination** of adaptation measures at national level and international efforts to mitigate global greenhouse gas emissions. Both require macroeconomic resources, and so a weighing and balancing process is required to establish the right equilibrium.

5. An international comparison demonstrates the importance of finding a globally coordinated solution to climate change. In 2016, **Germany** was responsible for **2.3 % of global CO_2 emissions**, while the European Union (EU) was responsible for 10.5 %. ↘ CHART 1 RIGHT It can already be observed that technological change has led to emerging economies and developing countries currently having lower emissions per head of population than today's industrialised countries ever had in the past at the same stage of their development. However, the contributions made by Germany and the EU to global emissions are likely to decrease further as a result of the very vibrant population growth occurring in Africa and Asia in particular. This means that, even if Germany's emissions and EU's emissions were reduced to zero, this would only make a small contribution to the reduction of global emissions and would not halt climate change.

↘ CHART 1
Global average temperature and CO_2 emissions



1 – Deviation from the average temperature in the current climate reference period (1961–1990) according to the World Meteorological Organization (WMO). 2 – Total CO_2 emissions from energy consumption (combustion of coal and coke, natural gas, petroleum and other liquids). 3 – Germany: West Germany in the period of 1980 to 1990 . 4 – Russia: Former Soviet Union in the period of 1980 to 1991.

Sources: EIA, Met Office Hadley Centre, own calculations

6. Therefore, if German climate policy aims to **curb global climate change**, it must strive to make progress in three different fields in parallel. It must seek to ensure a **globally coordinated approach**, foster the development of low-emission or even greenhouse gas-reducing technologies and approaches and lead by example in emission reduction by achieving the internationally agreed **targets in an economically efficient manner** without causing social disruption.

From the perspective of climate protection, on the other hand, it is not sufficient to merely achieve the targets that have already been agreed for **national greenhouse gas reduction in an economically efficient manner**. These two fundamental objectives give rise to two different answers to the question of the best policy measures to pursue.

7. A rational climate policy should pursue the **economic principle of the division of labour** in order to minimise the national economic costs of transformation. A corresponding strategy essentially requires that the next unit of greenhouse gas emissions is always saved wherever this is most cost-effective based on the current (technological) circumstances. This saving should be made irrespective of the location where the emission originated and who is responsible because greenhouse gases disperse freely in the atmosphere.

Reducing the level of global emissions is essential to making a meaningful contribution to curbing global climate change. In this context, the goal of a **uniform global price for greenhouse gas emissions**, ideally one that is valid for all **regions, sectors and polluters**, must be pursued (GCEE Annual Report 2016, Items 860 ff.). This approach is proposed in many contributions on the subject (Monopolkommission, 2017; Bundesrechnungshof, 2018; Bureau et al., 2019; EFI, 2019; Advisory Board to the Federal Ministry of Finance, 2019) and in the recently published statement by leading US economists (Econstatement, 2019).

If only the specified national targets are to be achieved, the coverage area comprises national emissions or those in individual sectors only. Nevertheless, also in this case the goal of a **price for greenhouse gas emissions** should still be pursued for Germany.

8. This special report demonstrates, firstly, how German climate policy **endeavours to take a globally coordinated, joint approach** and can thus bring about a step in the direction of a uniform global price for greenhouse gas emissions. An important component of an ambitious climate policy is large-scale **support for research and innovation** in the area of climate protection, with the aim of developing new solutions with global application potential and thereby reinforcing Germany's status as a location for business and investment, with particular reference to its export opportunities.

Secondly, this report also discusses competing options on how market-based instruments could be used to establish a **more efficient system for reducing greenhouse gas emissions**, even if the progress sought at a global level cannot be achieved. While the impact on global climate would be small in this case, replacing the current compartmentalised and inefficient systems for reducing emissions would conserve economic resources in Germany. The German Council of Economic Experts incorporates two expert opinions into its analysis – one from Professor Edenhofer and the Mercator Research Institute on Global Commons and Climate Change (Edenhofer et al., 2019) and the other from Professor Büdenbender (2019).

9. As most emissions from the energy and industrial sectors in Germany are already covered by the **EU Emissions Trading System (EU ETS)**, these are currently subject to a uniform price in all member states and national targets do not apply. Germany risks failing to meet the targets agreed at European level for the years 2020 and 2030 for the reduction of emissions in the **sectors not covered by the EU ETS system**. The primary goal of efforts made in this regard should be to also integrate these sectors **into the EU ETS system** as soon as possible, ideally together with all member states, thereby overcoming the separate setting of targets for reducing emissions in individual sectors.

10. As short-term implementation is likely to be difficult for political and legal reasons, a **transitional solution** should be implemented so that we can quickly move towards the ideal of a fully integrated European emissions trading system. Various options are available for this purpose, in particular the temporary introduction of a **separate emissions trading system** for the sectors that are not yet covered by European emissions trading and the temporary levying of a **carbon tax** in this area. Germany should ideally implement the selected transitional solution jointly with other member states. Both transitional solutions should be geared towards being incorporated into a fully integrated emissions trading system as soon as possible and by 2030 at latest.

There are **benefits and drawbacks** to both implementation options. The advantage of a temporary separate emissions trading system is that it is **easier to communicate** the associated climate-policy steering concept and it is more easily **integrated** into the existing emissions trading system. The advantage of a temporary and separate carbon tax is that this option can be **introduced** within a shorter period of time. The decision as to which approach is to be pursued in policy should be based on a consideration of how **credible binding commitments** can be made, rather than on an assessment of technical aspects. After all, a goal-oriented climate policy will ultimately succeed or fail on the ability of policymakers to establish themselves as being credibly committed to a climate policy in which the price of carbon emissions (carbon price) is the pivot point for all policy instruments.

If policymakers choose the option of a **separate emissions trading system** in the sectors not covered by the EU ETS system, they must succeed in committing themselves in a credible and binding way to the targets defined in the burden sharing agreement. Another key requirement for this strategy is that it should only be considered as a serious attempt to reorient climate policy if it immediately results in visible efforts that prevent any further delays to policy reorientation. If, on the other hand, policymakers choose the option of a **carbon tax**, they will be required, over time, to adjust the tax rates in non-EU ETS sectors due to the largely unknown avoidance costs to the extent that the burden sharing agreement targets will be met. In addition, it will be mandatory for the carbon tax to be abolished as soon as the sectors not covered by the EU ETS system are incorporated into the fully integrated emissions trading system.

11. The reorientation of the national climate policy described here would provide greater scope for negotiating the transformation of the system of energy supply by means of the **Renewable Energy Sources Act (EEG)** – a process that has been **very socially unbalanced thus far.** Consistently reorienting climate policy towards a **price of carbon emissions** will reduce the overall burden on companies and households arising from the transformation of the energy system and make these burdens **more transparent**. At the same time, the risks to the international **competitiveness** of companies must be taken into consideration and the transfer of emissions abroad (i.e. **carbon leakage**) must be avoided.

On the other hand, the sole objective of carbon pricing should be to reduce CO_2 emissions in an efficient manner, rather than to generate new state revenue from emissions trading or carbon tax. For this reason, **revenue should be fully redistributed**. In addition to revenue redistribution, accompanying climate policy measures are also conceivable. This may help make the transformation **socially balanced**, thereby significantly increasing acceptance of carbon pricing and, ultimately, of the overall transformation of the energy system. This special report explores the benefits and drawbacks of various options for social equalisation.

12. Overall, policymakers can avail of an extensive range of options for creating a **package of reforms** that makes sense in climate policy terms thanks to a consistent focus on the concept of prices for greenhouse gases, while also restricting

the economic burdens arising from the need for transformation and bringing social balance to the transformation.

II. THE NEED FOR GLOBAL COORDINATION

KEY POINTS

- Curbing climate change is a global challenge that can only be met by adopting an internationally coordinated approach.
- The Paris Climate Agreement targets for avoiding emissions require effective and efficient implementation based on a global price for greenhouse gas emissions.
- The fastest way to achieve global coordination is by means of a strong negotiating position. Adaptation measures, leading by example and reciprocity will all be beneficial in this regard.

13. Climate change presents a two-fold **global challenge**. First, no one on the planet can entirely escape this problem, even if states and individuals are affected to varying degrees by the consequences of climate change. Calculations based on **climate models** highlight the immense challenge involved in curbing this problem and the expected economic costs of doing so, even though their quantitative statements are naturally associated with a considerable degree of uncertainty.

Second, climate change is influenced by all states and individuals worldwide. Therefore, states can only influence its "own" climate to a very limited extent by adopting its own measures to avoid (**mitigate**) climate change. This gives rise to a **free rider problem**, whereby the negotiating state bears the costs of its efforts but fails to reap the benefits to anywhere near the same extent. Meanwhile, other states and individuals can enjoy the benefits of these measures without bearing the full cost. This situation leads to inadequate efforts being made to prevent emissions. A successful global mitigation strategy must overcome these individual incentive problems.

This problem is exacerbated by a **generational conflict**. On the one hand, the climatic effect of greenhouse gases results in costs that are not priced by markets ("external" costs) and are passed on from the current generation to future generations. On the other, a rapid transformation of the national economy means high costs of adjustment, which will have to be borne by present generations. These considerations must be included in the assessment and "internalisation" of costs.

14. In light of these significant coordination difficulties, it makes sense, from a state perspective, to explore which **adaptation** strategies are available as an alternative. These strategies seek to react to the changes brought about by climate change in a way that minimises the economic and social costs or even to systematically exploit the opportunities that global warming will bring about for some regions. ↘ ITEMS 28 FF. With adaptation, in contrast to mitigation, those who bear the costs of the policy are usually also those who benefit from them, and so their implementation can be left to state-run and private-sector processes at a national level (Advisory Board to the Federal Ministry of Finance, 2010). The strategy of adaptation therefore offers opportunities for a **unilateral, national climate**

policy in many areas. Adaptation only has an international dimension through the support that may be necessary for regions that are particularly affected.

15. However, **focussing exclusively** on the strategy of adaptation at a global level would **not be economically efficient** and would lead to higher costs for national economies due to climate change, as well as to an unequal distribution of burdens (Nordhaus, 2018). It is much more advisable for climate policy to adopt a mixed strategy. In this context **mitigation** is an essential element of global climate policy endeavours. Signing the Paris Agreement on climate change is an important first step in this direction but is far from sufficient in and of itself. Of far greater importance is the effective implementation of the agreed targets to reduce global warming. A guaranteed, target-based reduction in emissions represents an absolute prerequisite for achieving this. Ideally, the reduction will be implemented by means of a uniform global price for greenhouse gas emissions, with continuous monitoring to ensure compliance.

In seeking to establish a globally coordinated mitigation strategy, the **feedback effects** of the individual adaptation measures for the realisation of a trading solution must be taken into account (Kane and Shogren, 2000; Board of Academic Advisors to the BMF, 2010; Buob and Stephan, 2011; Konrad and Thum, 2014; Auerswald et al., 2018): The greater the damage that can be caused to a country as a result of climate change, the greater that country's **interest in establishing a global trading solution**. If a state steps up its adaptation efforts now, this reduces the potential costs to the state from emissions, while simultaneously reducing the marginal benefits from mitigation (Zehaie, 2009). A successful adaptation strategy thus leads to an immediate reduction in the country's own consequential costs of climate change and may contribute to reaching a joint agreement on mitigation at an international level.

1. Climate scenarios associated with high uncertainty

16. **Climate models** simulate future climate changes based on various development trajectories for the emission of greenhouse gases. Emission scenarios thus serve as a basis for predicting temperature changes in the longer term, i.e. up to the year 2100. ↘ CHART 2 LEFT When **interpreting the results** of these calculations, it is essential to consider that they are based on many assumptions about future developments like population growth, economic and social developments, technological changes or the global consumption of resources. In addition, there are significant uncertainties with regard to impact channels and interdependencies. Accordingly, there are some significant differences between climate models in terms of annual emission levels and the associated temperature changes. ↘ CHART 2 RIGHT

17. If **no new policies** are introduced in future, the Climate Action Tracker (CAT, 2018) projects net greenhouse gas emissions of 83 to 175 gigatonnes of CO2 equivalents based on the baseline scenarios (AR5) outlined by the Intergovernmental Panel on Climate Change (IPCC, 2014). ↘ CHART 2 LEFT These baseline scenarios envisage a potential rise of **more than four degrees in global**

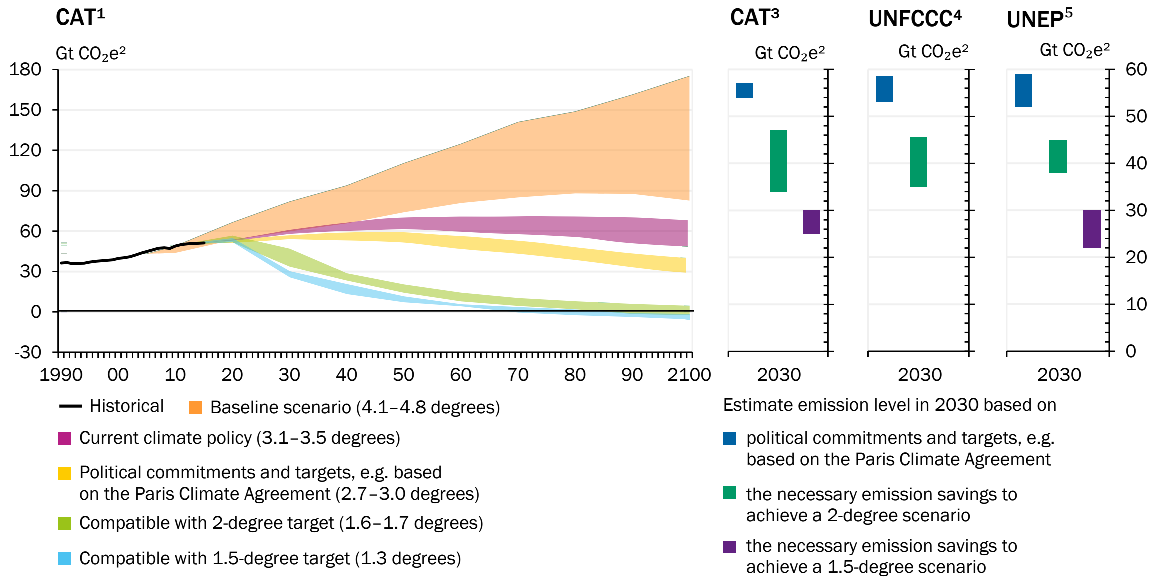
surface temperature compared with pre-industrial temperature levels (Hsiang and Kopp, 2018; Nordhaus, 2019). A comparison of various models shows that the average standard deviation of temperature estimates is almost 1 degree (Nordhaus, 2018), thus highlighting the uncertainty attached to this prediction. If, on the other hand, governments fulfil the commitments they have made on climate protection, e.g. in the context of the **Paris Climate Agreement** in its updated version from December 2018, CAT (2018) projects a lower temperature rise **between 2.7 and 3 degrees**.

18. Although the **emission scenarios** described here are heavily dependent on the underlying model and the assumptions postulated and are therefore associated with a significant degree of uncertainty, they allow various temperature targets to be used as a basis for determining the required emission savings, expressed either as an emissions reduction pathway or as the total allowed emissions level (Edenhofer et al., 2019). The total cumulative net emissions that can still be released while allowing us to prevent global warming from exceeding a defined temperature target with a certain degree of probability is known as the **carbon budget** (IPCC, 2014; Rogelj et al., 2018). Presenting this measure as a budget or allowance makes it clear that the cumulative level of greenhouse gas emissions in the atmosphere is a much more important factor in climate change than specific emission pathways.

19. In order to limit global warming to less than 2 degrees, estimates specify an available **global carbon budget of approximately 800 to 1,000 gigatonnes of CO2** (IPCC, 2014; MCC, 2016; EASAC, 2018). The IPCC states that a carbon budget of 420 gigatonnes of CO2 is required to keep the ma-

↘ CHART 2

Potential greenhouse gas emission scenarios based on various climate policy assumptions



1 – The chart shows annual emission levels based on the Climate Action Tracker (CAT) emission scenarios, taking account of the update from December 2018. Temperatures represent the estimated global changes compared with the pre-industrial level. The shaded areas indicate the ranges of the potential changes. 2 – Gigatonnes of CO_2 equivalents. 3 – Climate Action Tracker (CAT) taking the December 2018 update into account. 4 – United Nations Framework Convention on Climate Change (UNFCCC). Emission level to achieve a 1.5 degree scenario not available. 5 – United Nations Environment Programme (UNEP).

Sources: CAT, UNEP (2019), UNFCCC (2015) ximum temperature rise to 1.5 degrees with a probability of 66 % (IPCC, 2018). Based on various estimates, the global emissions level in 2018 was between 30 and 50 gigatonnes of CO2 (MCC, 2016; EASAC, 2018). This means that, if this figure remains constant over the coming years, the carbon budget will be entirely **expended in around 8 to 14 years**.

20. Studies by the United Nations Framework Convention on Climate Change (UNFCCC, 2015) and the United Nations Environment Programme (UNEP, 2019) to identify the emissions reduction pathways that should be pursued came to the same conclusion as CAT (2018). This means that, to limit warming to no more than 2 (1.5) degrees, the net greenhouse gas emissions level must not exceed **36 to 46** (24 to 30) **gigatonnes of CO2 equivalents** in the year 2030. ↘ CHART 2 RIGHT

21. In all likelihood, it will only be possible to reduce emissions gradually rather than in a dramatic fashion. Therefore, net greenhouse gas emissions will need to be close to zero at a certain point if global warming is to be limited to a maximum of 2 or 1.5 degrees by the year 2100 (**climate neutrality**). In this scenario, the level of greenhouse gas emissions released does not exceed the level that can be removed from the atmosphere by natural sinks (such as forests and oceans) or by technological sinks (e.g. using chemical methods). If global warming is be confined to a maximum of 2 (1.5) degrees, the IPCC (2018) states that climate neutrality must be achieved by about 2070 (2050).

22. **Gross emissions** may exceed the available carbon budget, provided that sufficient compensation can be made in the form of **negative emissions**. In the case of emissions from certain industrial processes, for example, there are no means available as yet for avoiding emissions or, alternatively, the avoidance costs are very high. Therefore, policies are required to remove greenhouse gases from the atmosphere or to prevent the emissions produced from being released into the atmosphere. ↘ BOX 1

This consideration has already been incorporated into many climate scenarios, and these proceed from the assumption that reducing greenhouse gas emissions alone will be inadequate if global warming is to be stabilised at 2 or 1.5 degrees and that greenhouse gases will also need to be removed from the atmosphere (Smith et al., 2015; MCC, 2016; Fuss et al., 2018; Rogelj et al., 2018). The need for negative emissions increases as the temperature targets to be achieved become more ambitious and as policy measures to reduce greenhouse gas emissions are postponed further into the future.

↘ BOX 1

Technologies for capturing or recovering carbon dioxide from the atmosphere

The process of **Carbon Capture and Storage** (CCS) captures greenhouse gases and stores them in the long-term. CCS can be used to directly capture emissions from industrial processes and store them in deep geological formations. Alternatively, instead of being stored, the carbon can be reused for synthetic fuels or chemical products (**Carbon Capture and Use**, CCU). In this way, the carbon dioxide that is created during a production process and cannot be prevented with current technology (or only at high costs) is prevented from escaping into the atmosphere. The procedure has already been successfully tested in some countries (German Bundestag, 2018a, IOGP, 2019). However, a significant amount of energy is currently required for capturing, transporting and storing carbon (German Environment Agency, 2018a). There is also some controversy about the extent to which CO_2 storage poses high risks to health, safety and the environment. For example, the IPCC (2005) estimates that the risks are comparable with the existing storage of natural gas and that the probability of the stored CO_2 escaping is extremely low.

There are biological, chemical and physical processes for capturing CO_2 from the air (**Carbon Dioxide Removal**, CDR). These include afforestation programmes or marine fertilisation, which increase the CO_2 absorption of natural sinks. **Direct Air Capture** (DAC) describes a method that allows the filtering of CO_2 from the normal ambient air by chemical processes and its permanent storage underground. One of the most important technologies for achieving negative emissions is **BECCS**, bioenergy with CO_2 capture and storage. In this process, (rapidly growing) biomass that absorbs CO_2 from the atmosphere during its growth is incinerated in power plants, for example, and the CO_2 is immediately captured and stored (MCC, 2016). BECCS can generate negative emissions with less land use compared to afforestation. It therefore poses less of a competitive threat to other land uses, such as food production.

In general, negative emissions entail potential **conflicting objectives**, not only in relation to land use, but also to the use of water, energy and nutrients (MCC, 2016). Furthermore, the geophysical limits and possibilities of using multiple negative emission technologies are associated with great uncertainty. What all of the options have in common is that they are only available to a limited extent. Some of the methods are still associated with significant costs per tonne of CO_2, are poorly understood, and it is not certain that they will ever be available to any significant degree (Smith et al., 2015; Fuss et al., 2018). Since individual technologies are of limited use and have specific conflicting objectives, one option would be to use a portfolio of CDR technologies (Nemet et al., 2018).

In response to controversy and reservations in certain sectors of the population, the Federal Government enacted a law in 2012 on carbon dioxide storage (KSpG) Since then, the application of CCS technology **in Germany has been largely limited to demonstration projects due to temporal and quantitative restrictions** (German Bundestag, 2018b). Meanwhile, the European Commission emphasises the role played by CCS technology in achieving long-term emissions targets at EU level (European Parliament, 2009).

The IPCC expects, in more than two-thirds of the scenarios for 2100, a maximum temperature rise of 2 degrees with a BECCS share in the primary energy of more than 20 % and assumes that by 2100 about **one third of the emission savings required** to achieve a 1.5-degree scenario will come from CDR technologies (IPCC, 2018). At present, the IPCC mainly takes afforestation programmes and BECCS into account in its scenarios. While CDR technologies do not play a significant role in the IPCC scenarios for 2030, a total of 100 to 1,000 gigatonnes of CO_2 would need to be extracted from the atmosphere to reach a maximum temperature rise of 1.5 degrees, depending on the scenario (IPCC, 2018).

23. Economic resources must be used in order to reduce greenhouse gas emissions. The requirements increase with the targeted reduction of emission levels. At the same time, the emission of additional greenhouse gases results in damage and thus costs for the economy and society. These costs arise, for example, as a result of a decline in land yields and decreasing labour productivity and the consequences of these developments. To quantify these **economic costs of climate change**, models such as Nordhaus's DICE model (1994, 2018), Nordhaus and Yang's RICE model (1996), the IMAGE model of the Dutch National Institute for Public Health and the Environment (RIVM) or the WIAGEM model by Kemfert (2002) all integrate submodels from various disciplines into an overall model. They usually contain at least one climate model and one economic model, such as a general equilibrium model.

Since these estimates combine multiple models, additional assumptions are typically required and there is increased **uncertainty** associated with the model results (OECD, 2015, Hsiang and Kopp, 2018). Accordingly, different economic studies, depending on the underlying valuation model and the assumptions made, highlight significant differences in the estimated effects on global gross domestic product (GDP) for different warming scenarios.

24. In literature reviews, Tol (2018) and Nordhaus and Moffat (2017) present estimates for the **long-term effects of climate change on global welfare**. According to these, a temperature rise of 2 to a maximum of 3 degrees is likely to have a level effect of between -3.6 % and +0.1 % on global income compared to a baseline scenario without warming. ↘ CHART 3 LEFT With a temperature rise of more than 3 to a maximum of 4 degrees, the estimated values are between -17.8 % and +0.9 %. It should be pointed out that the presentation of a single estimate per study conceals the even greater uncertainty that arises from the uncertainty within each study. According to estimates in Hsiang et al. (2017) the damage is expected to increase approximately quadratically with the global change in temperature.

Mutually reinforcing effects caused by non-linearities could occur as of certain **tipping points**, especially in the case of large increases in temperature, thus making it difficult to estimate the costs and leading to greater effects (Lemoine and Traeger, 2014). Burke et al. (2015) therefore arrive at a 2.5 to 100 times greater decline in GDP for scenarios with a temperature rise of 2 degrees when including **non-linear effects** rather than linear effects only. With a temperature rise of 4 degrees, they estimate the global GDP in 2100 to be 23 % lower than the projected level of economic output in the baseline scenario.

Considerations in line with rational risk management therefore strongly suggest to consider catastrophic but yet unlikely events (**tail risks**). The relatively low estimates of linear effects should not be ignored. Rather, the use of economic resources to avert climate change should be viewed as essential. This approach can be considered as insurance against catastrophic events, which is made necessary due to methodological issues when dealing with deep uncertainty and fat-tail events (Weitzman, 2009, 2011).

25. Furthermore, the models can only take limited account of the effects of climate change that are difficult to assess in monetary terms, but can pose significant threats to global prosperity. As early as 1990, the IPCC noted that the greatest single effect of climate change could be its impact on **global migration** (IPCC, 1990). Millions of people could be displaced by coastal flooding, agricultural disruption or extreme weather events. The estimates for this migration are highly uncertain and vary between about 25 million and 1 billion people by 2050 (IOM, 2009). There is also a higher risk of violent conflict occurring as a result of migratory movements and climate change (Scheffran et al., 2012, Hsiang et al., 2013). Other consequences that are only explored to a limited extent in the models are the effects on flora and fauna, biodiversity, society and health.

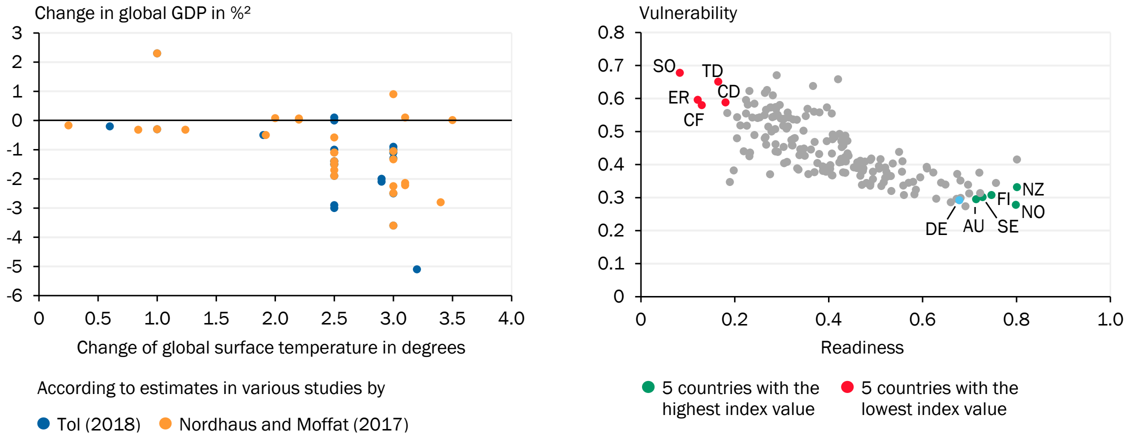
26. Using the calculations from the climate-economy models, it is possible to calculate approximately the **social cost of carbon** (SCC) in the atmosphere, i.e. the marginal costs of an additionally emitted tonne of CO_2 (Edenhofer et al., 2019). With proper pricing, these marginal costs should ultimately reflect the price for carbon emissions imposed by global political action. These estimates vary considerably based on assumptions such as economic growth rates, emission intensities and assigned damage functions. One of the key uncertainties also concerns the discount rate, which translates future costs into current values.

For example, estimates of marginal costs in the Nordhaus baseline scenario (2019) project a price of **US$45 in 2020** and **US$108 in 2050**. The US National Academies of Sciences, Engineering, and Medicine (2017) estimate the social cost of one tonne of CO_2 at US$12-US$62 by 2020 and US$26-US$95 by 2050. However, SCC estimates may be significantly higher depending on the scenario, target and climate policy (Edenhofer et al., 2019).

↘ CHART 3
Global impacts of climate change

Estimates of the economic effects of climate change[1]

Notre Dame Global Adaptation Index (ND-GAIN) 2017[3]



1 – Each individual point shows the central estimates of the economic costs of climate change from various studies compiled in the meta-analyses carried out by Tol (2018) and Nordhaus and Moffat (2017). Due to the greater uncertainty associated with warming scenarios above 3.5 degrees, only studies that estimate costs based on a temperature rise of up to 3.5 degrees are included. 2 – Effects on global income compared to a base scenario without warming. 3 – AU-Australia, CD-Democratic Republic of the Congo, CF-Central African Republic, DE-Germany, ER-Eritrea, FI-Finland, NO-Norway, NZ-New Zealand, SE-Sweden, SO-Somalia, TD-Chad.

Sources: Nordhaus and Moffat (2017), Notre Dame Global Adaption Initiative, Tol (2018)

27. Climate policy must strike a balance between the benefits to be achieved and the costs associated with them. Nordhaus (2019) observes in a **cost-benefit analysis** of this type that an optimal pathway could possibly arise beyond limiting a temperature rise to a maximum of 2 degrees: The optimal cost-benefit ratio, even based on pessimistic assumptions, would therefore adjust to an emissions pathway leading to global warming of 3 degrees by the year 2100. In addition, he argues in favour of setting average temperatures as a target for international climate policy rather than maximum temperatures. This would allow the target temperature to be **exceeded** for a period of time.

However, such considerations only take limited account of the fact that the optimal strategy for addressing climate change should focus not just on the average pathway to be expected, but must also protect against **tail risks** in **rational risk management**.

2. Adaptation policies largely ignored to date

28. Climate change is likely to have **greatly varying regional** effects. The Notre Dame Global Adaptation Index (ND-GAIN) measures which countries are likely to suffer in particular from climate change in the future. With this index, the vulnerability (potential danger), potential intensity of the effects and, on the other hand, the adaptability of each country to climatic changes are compared to the assumed national readiness to implement necessary adaptation measures, i.e. the economic, institutional and social ability of each country to make efficient use of investment for adaptation purposes. ↘ CHART 3 RIGHT Assessing the regional economic consequences of climate change is associated with a high degree of uncertainty.

29. According to this indicator, **developing and emerging markets** are likely to be more susceptible on average to the economic consequences of climate change. The regional economies in Africa, in particular, are likely to be especially vulnerable to climate change, while being limited in their readiness to implement national adaptive policies. ↘ CHART 3 RIGHT In a scenario where no further policy measures are carried out, GDP could be 1.1 % to 8.3 % lower in North Africa, for example, in the year 2060 than in the baseline scenario without damage caused by climate change (OECD, 2015). When non-linear effects are taken into account, GDP in the poorest economies could even be 75 % lower in 2100 than in a world without climate change (Burke et al., 2015).

30. Nordhaus (2019) estimates that most **industrialised countries** will be able to adapt to climate change at least for the next few decades at relatively low cost. In this case, the adaptation measures are already taken into account in the studies on the estimates of the economic consequences of global warming. ↘ ITEMS 23 FF. For industrialised countries, the direct economic costs due to climatic change are therefore likely to remain relatively low in the medium term. Individual states and regions that are less directly affected by climate change could even experience medium-term economic benefits as a result of climate change, in particular in the tourism sector and through trade profits.

For example, the OECD (2015) estimates that, by 2060, climate change will only have minor adverse effects on the level of GDP for the group of the four largest EU member states. The ILO (2019) also only identifies marginal effects on GDP and the European labour market by 2030. The biggest economic costs in Europe will probably arise to be in the south (Ciscar et al., 2014). However, Germany and the EU could be particularly vulnerable to economic consequences in other parts of the world, mainly because of their strong links through world trade (Peter et al., 2018) and not least because of migration prompted by climate change. In addition, the studies consider only temperature increases of up to 2 degrees, as the consequences of higher temperature changes are difficult to estimate. However, these are also likely to have a significant impact on Europe.

31. **Specific adaptation strategies** depend heavily on the **national circumstances** that apply in each case. They include, for example, improving the efficiency of energy and water usage, adapting regulations, for example in the field of building standards, upgrading of flood defences, climate-proofing public infrastructure, strengthening health and social protection systems and developing drought-resistant crops (IMF, 2019).

Other useful policies could include building national fiscal buffers as insurance against shocks from natural disasters and greater channelling of private capital towards investments that contribute to reducing emissions. (IMF, 2019). In addition, adaptation measures within the financial sector may be necessary in light of the systemic risk posed by climate change for financial markets (ESRB, 2016).
↘ BOX 6

32. In Germany, the **German Strategy for Adaptation to Climate Change** (DAS) adopted in 2008 forms the basis of government adaptation policy. Action plans promote the development of methods to identify the effects of climate change and adaptation options. Two core projects that have already been implemented are a monitoring system for monitoring the effects of climate change and a vulnerability analysis for Germany to identify regions affected by climate change. The DAS currently focuses on research and adaptation policies aimed at reducing damage caused by flooding or the effects of warming in cities.

33. The countries that are particularly affected by climate change will face high costs of adaptation. The financing needs for some of the most severely affected regions cannot be met without **international support**. This therefore forms an important part of German **development cooperation**. At the climate summit in Paris, a commitment made by the industrialised countries in 2009 was confirmed and expanded: According to this commitment, US$100 billion will be provided from 2020 onwards from public and private sources for climate protection and the adaptation of emerging and developing countries to the consequences of climate change, while a more ambitious financing target will be set by 2025 (Federal Ministry for Economic Cooperation and Development, 2017).

In total, Germany provided about €3.65 billion in 2017 for climate protection and adaptation measures outside Germany (Federal Ministry for Economic Cooperation and Development, 2019). The amount of €1.1 billion will be spent on adaptation policies in partner countries as part of bilateral climate finance.

(Federal Ministry for Economic Cooperation and Development, 2017). Germany also contributes to **multilateral climate funds**. The central instrument is the Green Climate Fund (GCF), which was established at the UN Climate Change Conference in Cancun to finance mitigation and adaptation policies in developing countries. The fund was provided with a total of US$10.3 billion (2014), of which approximately US$1 billion (750 million euros) were contributed by Germany. The EU member states have already confirmed replenishment of the Fund (European Council, 2019), while Germany has announced that it will double its contribution to € 1.5 billion (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2018a). Germany also finances other smaller funds and is the second largest member of the Global Environment Facility (GEF) (Federal Ministry for Economic Cooperation and Development, 2018) after Japan, contributing about €420 million (2018 to 2022).

34. Germany's total expenditure on national and international adaptation policies amounts by comparison to **only a fraction** of its total expenditure on mitigation policies. One possible reason for this is that these measures can often be implemented without major time lag as soon as a specific scenario occurs. Adaptation policies could reduce the damage caused by climate change, especially in other parts of the world. However, in the case of particularly adverse events with catastrophic consequences, adaptation will not be possible. Its ability to function as an insurance policy is therefore limited and mitigation policies are indispensable.

3. Aiming for a strong negotiating position

35. While measures for adapting to the effects of climate change can be handled at national level, **mitigation measures** require **international action**. For example, the share of German emissions in global emissions is so small that even eradicating these completely would have only a **marginal impact on the global climate**. ↘ CHART 1 RIGHT Even the EU's share is not big enough to have a major impact on its own. Furthermore, a national or purely European approach tends to affect the competitiveness of the domestic economy. This approach risks merely shifting emissions abroad through **carbon leakage,** rather than achieving a reduction in emissions.

By the same token, an internationally coordinated approach could counteract a potential reduction in the price of fossil fuels triggered by fossil fuel owners accelerating the rate of their extraction because they expect carbon emission prices to rise in the future. This would significantly increase the supply of fossil fuels on the world market ("**Green paradox**"; Sinn, 2008; Board of Academic Advisors at the Federal Ministry for Economic Affairs and Energy, 2016). The more countries that participate in a coordinated approach, the lower the risk of both forms of carbon leakage.

36. The **Paris Climate Agreement** is a first important step in setting the common goals for a maximum temperature rise in an international agreement. ↘ ITEMS 45 F. However, further efforts will be required to **implement and enforce** the ag-

reement. The announced national contributions to the agreement, even if complied with, do not yet yield the emission reductions needed to curb the rise in temperature. ↘ ITEM 46 This raises the question of how the most efficient implementation possible combined with an ambitious approach can be achieved globally.

Whether to aspire to **a pioneering role** and have other countries follow a more ambitious reduction in greenhouse gas emissions than that agreed in international treaties is **addressed** in behavioural and game theory research (Cramton et al., 2015). The main concern here is that national action could promote **free rider behaviour** and unnecessarily give up an important element to be offered in international negotiations. In this case, playing a pioneering role would only result in high costs, without achieving any significant improvements in the global climate (Advisory Board to the Federal Ministry of Finance, 2010). For some of the advantages of a pioneering role mentioned in the literature (Schwerhoff et al., 2018), such as the development of new technologies or gaining credibility in international negotiations, there would be no need to set ambitious reduction targets.

37. In game theory, the principle of **reciprocity** is identified as an important element of international agreements. A lack of reciprocity tends to reduce participation and ambition (Kraft-Todd et al., 2015). Both the empirical and theoretical literature indicates that a go-it-alone approach does not inspire strong collective efforts (Ledyard, 1995). International agreements with ambitious goals must therefore be designed around a common commitment, i.e. an assurance to participants that others will match their efforts (MacKay et al., 2015). The aim of these negotiations should therefore be to achieve greater cooperation through the skilful application of each participant's own binding commitments (**"I will if you will" effect**).

38. Rather than aspiring to a pioneering role in setting goals for the national or European reduction of greenhouse gas emissions, an aspiration which could be strategically ill-advised, consideration should instead be given to acting as a **role model** and leading by example. This could certainly be helpful if, for example, a highly developed national economy such as Germany that makes intensive use of fossil fuels succeeds in achieving the internationally agreed goals in an economically efficient manner and without causing major social disruption (GCEE Annual Report 2016, Items 856 ff.). Until now, this has not been a priority for German climate policy.

39. It is not easy to establish and monitor reciprocity when allocating global quantitative targets to regional and national targets or initially allocating emissions certificates (allowances), due to the varying stages of development and future developments of the participating countries. Cramton et al. (2015) therefore propose only agreeing **globally** on a **uniform minimum price** for greenhouse gas emissions. The decision on whether to implement the uniform price by means of a tax or by emissions trading would be up to each region. The only condition would be that the average burden of carbon emissions within the region at least corresponds to the agreed global price. This would mean that revenues could

remain in each country, while there would be no need for the tricky worldwide distribution of allowable emission levels to different states, by means of international treaties or emissions trading systems.

There are two **political and economic problems** associated with this proposal: First, iterative changes to a global price would be required (depending on progress towards the targeted emissions level), which would be agreed in recurring fresh rounds of negotiation or according to a fixed formula. Second, the burden of reducing emissions through different avoidance costs is distributed very unevenly worldwide, at least initially. These costs could be adjusted retrospectively by transfers through a climate fund, for example. If a global emissions trading system were to be established instead, the price would automatically be based on the projected emissions level. It would thus be more volatile. However, in this case the burden sharing could be relatively easily controlled by the initial allocation of emission certificates or allowances.

40. The emergence and observance of ambitious international agreements also depend on further factors. In particular, the extent of mitigation and adaptation already implemented or planned in the participating countries may have an influence. Special mitigation **efforts** made by individual countries **without a prior international agreement** reduce the remaining benefit of establishing a common solution (Advisory Board to the Federal Ministry of Finance, 2010).

On the other hand, a unilateral adaptation policy can increase the chances of international agreement since it involves less national dependence on the consequences of climate change. The fallback position of the country and its ability to negotiate are thus improved (Zehaie, 2009, Benchekroun et al., 2011, Auerswald et al., 2018).

41. According to the ND-GAIN, the current and future largest polluters of greenhouse gas emissions are affected to a greater or lesser degree by climate change. ↘ CHART 3 RIGHT It reveals that the large EU member states appear to be less vulnerable than most other states: While Germany is ranked in 4th place in ascending order in terms of a vulnerability score out of 181 states, France is in 6th place and Italy in 15th place, the United States is ranked 22nd. China is in 66th position, India is in 131st position, and the African and smaller island states have the lowest ranking. Given the higher vulnerability of the other states, there should be considerable international **interest in reciprocity** and in the involvement of Germany and the EU in global efforts to protect the climate.

42. To further promote the launch of an ambitious and price-oriented global approach, Germany and the EU could link participation to additional **financial incentives**, in addition to strengthening their negotiating position through adaptation policies and calls for reciprocity. These incentives could take the form of access to the common market or transfers from a climate fund, for example. In exchanges with developed economies, adequate carbon pricing could be part of free trade agreement negotiations. With the introduction of an international price of carbon emissions, less developed economies could be granted access to additional funds from a climatic fund raised by the developed economies. These international transfers could result in costs and benefits being shared between the

countries participating in the uniform pricing and thus to a more stable coalition (Cramton and Stoft, 2012, Kornek and Edenhofer, 2019).

43. In many cases, there is discussion of imposing generalised tariffs on imports from countries that do not participate in international action in order to implement ambitious international agreements. Nordhaus (2015) shows that relatively low unit **tariffs on non-members** of a "Climate Club" can produce a large coalition with high targets for reducing emissions. However, this general tariff increase (as distinct from a border adjustment ↘ ITEMS 197 FF.) would entail high risks for an open economic area such as the EU and Germany and is therefore not advisable. Tariffs would increase the risk of an escalation in protectionism in world trade and also run counter to the global economic system based on division of labour.

III. FRAGMENTED APPROACH IS A WASTE OF RESOURCES

KEY STATEMENTS

- ↘ The European emissions trading scheme (EU ETS) already provides a functioning, market-based instrument which ensures that industry and the energy sector will meet their relevant targets.
- ↘ So far politicians have been trying to introduce fragmented measures in order to cut emissions in the non-EU ETS sectors. The national targets agreed at European level are likely to be missed.
- ↘ The policy of transforming Germany's energy sector is inefficient. Any consistent reconfiguration of climate policy would include reforms of environmental taxes and levies.

1. Additional national targets are superfluous

44. Germany has entered into various **climate protection commitments under international law at a European and global level** with the objective of limiting its carbon emissions. These include international agreements such as the Kyoto Protocol and the Paris Climate Agreement as well as resolutions adopted at European level. Germany has also set itself further targets for cutting greenhouse gas emissions.

Global target agreements

45. Germany entered into its first **legally binding commitment** to reduce greenhouse gas emissions **under the Kyoto Protocol** signed in 1997. This committed the German government to cutting emissions by 21 % by 2012 compared with the baseline year of 1990. **An extension** of **the Kyoto Protocol** for the period from **2013 to 2020** was approved in Doha in 2012. New Zealand, Japan and Russia no longer participated in the second commitment period, and by May 2018 the agreement covered only around 15 % of global emissions (BMU, 2017a). The EU member states ratified the agreement in 2017 in what was a rather symbolic act, because in December 2015 the 195 countries of the United Nations Framework Convention on Climate Change (UNFCCC) meeting in Paris had already agreed on a successor agreement to the Kyoto Protocol from 2020 onwards.

46. The **Paris Climate Agreement** came into effect in November 2016 (United Nations, 2019). The agreement's main objective is to limit the **global rise in temperatures to well below 2 degrees Celsius** compared with the pre-industrial age. Furthermore, efforts would be made to limit the global rise in temperatures to as little as 1.5 degrees Celsius. The aim was therefore to significantly reduce global greenhouse gas emissions – especially carbon emissions. The plan here is to achieve worldwide climate neutrality by the end of this century.

Unlike the Kyoto Protocol, the Paris Climate Agreement includes countries with very high carbon emissions such as China, India, Brazil and – initially at least – the United States. In June 2017, however, the US announced that it would be withdrawing from the Paris Climate Agreement at the end of 2020. This means that one of the world's biggest polluters would no longer be covered by this agreement. Nonetheless, the impact of the Americans' withdrawal on the global climate is uncertain because it is primarily the US states that are implementing the targets set in the agreement. Some of these states intend to stick to their climate protection targets or increase their use of renewable energy (BMU, 2019a).

47. The **Paris Climate Agreement** obliges the signatory countries to draw up plans for their respective **nationally determined contributions (NDCs)** and to submit them to the UNFCCC every five years. These plans are supposed to contain concrete measures and a timetable for their transposition into national law. A disclosure system is used to verify compliance with the NDCs. Reporting and implementation based on common guidelines are intended to make emissions mitigation measures and their funding comparable in order to build trust while exerting pressure in the event of non-compliance (BMU, 2017b). However, there are no legal sanction mechanisms available (Deutscher Bundestag, 2018c).

184 signatory countries have already submitted NDCs for the next few years (UNFCCC, 2019). The NDC for the EU stipulates that, by the year 2030, greenhouse gas emissions should be reduced by at least 40 % compared with 1990 levels and by at least 29 % compared with 2010 levels. ↘ CHART 4 However, the aggregate NDCs submitted by all the participating countries suggest that total greenhouse gas emissions are set to rise from 53.5 gigatonnes of CO2 equivalents in 2017 to 56 gigatonnes of CO2 equivalents in 2030 (UNEP, 2019). This is likely to be insufficient for meeting the two (1.5) degree target specified in the Paris Climate Agreement because – according to the UN Emissions Gap Report (UNEP, 2019) – the emissions for these targets would instead need to be reduced by 15 (32) gigatonnes of CO2 equivalents.

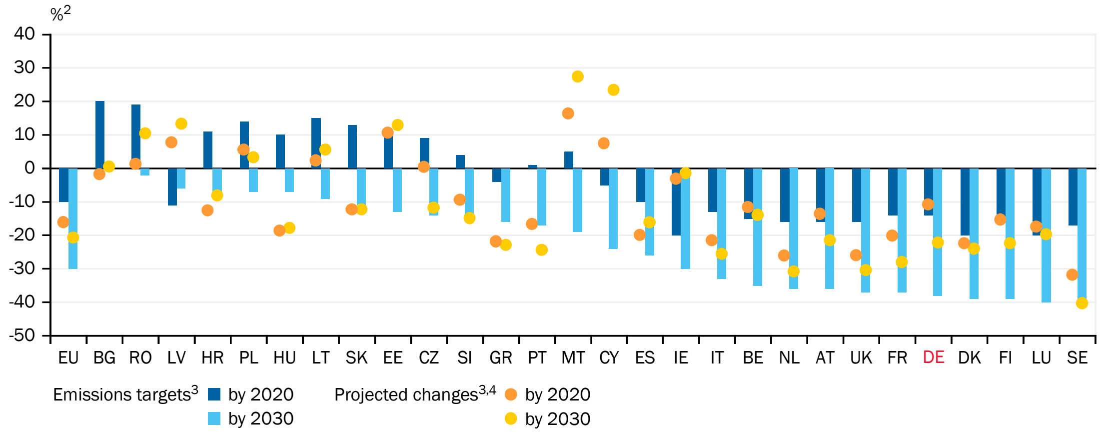
Targets set by the European Union

48. In addition to the NDCs relevant to the Paris Climate Agreement, the EU has imposed its own climate targets on itself. In November 2018 the European Commission presented a draft climate policy for its **long-term strategy 2050**, which is intended to be consistent with the targets of the Paris Climate Agreement and plans to cut greenhouse gas emissions by between 80 % and 95 %. This long-term strategy is to be approved by the member states at the beginning of 2020 such that it can then be submitted to the UNFCCC as the EU's contribution up to 2025. In 2007 and 2014 the European Council also adopted the EU's climate packages for 2020 and 2030 in the form of various directives and regulations. They constitute **binding interim targets** for the long-term strategy 2050.

The **Climate Package 2020** stipulates not only that greenhouse gas emissions should be cut by at least 20 % by 2020 compared with 1990 levels. Moreover, it also states that renewable energy as a proportion of total energy consumption as well as energy efficiency should both be increased by at least 20 percentage

↘ CHART 4

Effort-sharing: member states' emissions targets[1]



1 – BG-Bulgaria, RO-Romania, LV-Latvia, HR-Croatia, PL-Poland, HU-Hungary, LT-Lithunia, SK-Slovakia, EE-Estonia, CZ-Czech Republic, SI-Slovenia, GR-Greece, PT-Portugal, MT-Malta, CY-Cyprus, ES-Spain, IE-Ireland, IT-Italy, BE-Belgium, NL-Netherlands, AT-Austria, UK-United Kingdom, FR-France, DE-Germany, DK-Denmark, FI-Finland, LU-Luxembourg, SE-Sweden. 2 – Change compared with 2005. 3 – Targets relate to emissions from economic sectors that are not covered by the EU ETS. 4 – Based on existing measures.

Sources: European Commission, European Environment Agency, own calculations

points (European Commission, 2019a). The **Climate Package 2030**, meanwhile, requires – in accordance with the NDC – that EU greenhouse gas emissions would be reduced by at least 40 % by 2030 compared with 1990 levels. In addition, the proportion of renewable energy sources used needs to be raised by at least 27 percentage points and energy efficiency should also be increased by at least 27 percentage points (European Commission, 2019b).

49. Implementation of the EU's climate targets is divided into two areas. Greenhouse gas emissions under the **EU ETS** are to be cut by 21 % by 2020 and need to be reduced by 43 % by 2030 compared with 2005 levels. ↘ ITEMS 55 FF. There are no separate national targets for this sector. In the **non-EU ETS sectors** – which comprise transport, buildings and agriculture in particular – greenhouse gas emissions for the EU as a whole are to be cut by 30 % by 2030 compared with 2005 levels.

To this end, country-specific reduction targets have been set as part of the **effort-sharing decision (ESD)**. These targets are roughly based on the member states' levels of economic development and were decided in 2018. ↘ CHART 4 The targets stipulate that Germany must cut its emissions in the non-EU ETS sectors by 14 % by 2020 and **by 38 % by 2030** compared with 2005 levels (BMU, 2018b). No detailed sector-specific targets were set within the non-EU ETS sectors as part of this process.

50. Although it is already becoming clear that the overarching emissions target for 2020 at EU level as a whole is likely to be more than comfortably achieved (BMU, 2018b), unless many EU countries take additional measures they will probably fail to achieve by 2030 their emissions mitigation targets set under the ESD for the non-EU ETS sectors. As things stand, Germany is also likely to **miss** by a long way its **mitigation target** in the non-EU ETS sectors for 2030. ↘ CHART 4

The effort-sharing regulation offers scope for various types of flexibility (Edenhofer et al., 2019). These include, for example, limited amounts of compensation over time or, to a limited extent, the inclusion of emissions reductions from the forestry sector and land use. The only realistic option available to Germany, however, is likely to be the **transfer** of emissions allowances not required by **other EU member states**.

51. Given the expected shortage of emissions allowances available in the non-EU ETS sectors up to 2030, this could impose **significant costs** on Germany's public finances. This ultimately depends on the price that the other member states charge for transferring such allowances. Agora Energiewende and Agora Verkehrswende have estimated (2018) that the total financial cost of these permits for the period from 2021 to 2030 could amount to between €31 billion and €62 billion, although there are no reliable estimates of the prices of such allowances (Edenhofer et al., 2019).

This is because it is questionable whether sufficient allowances will be available in the EU in the first place. Assuming that they continued their existing energy and climate policies, most member states would fail to hit their mitigation targets by 2030 (European Commission, 2018a). In this event, Germany and other member states might face a lawsuit for breach of contract. It is not possible for Germany to substitute certificates from the EU ETS. By contrast, other member states that had previously shouldered mitigation costs had negotiated this at an early stage (Edenhofer et al., 2019). A member state could, however, apply to the European Commission to have **non-EU ETS sectors unilaterally included** in the emissions trading scheme (opt-in) to enable it to meet its mitigation targets in the non-EU ETS sectors (Agora Energiewende and Agora Verkehrswende, 2018). ↘ ITEMS 117 FF.

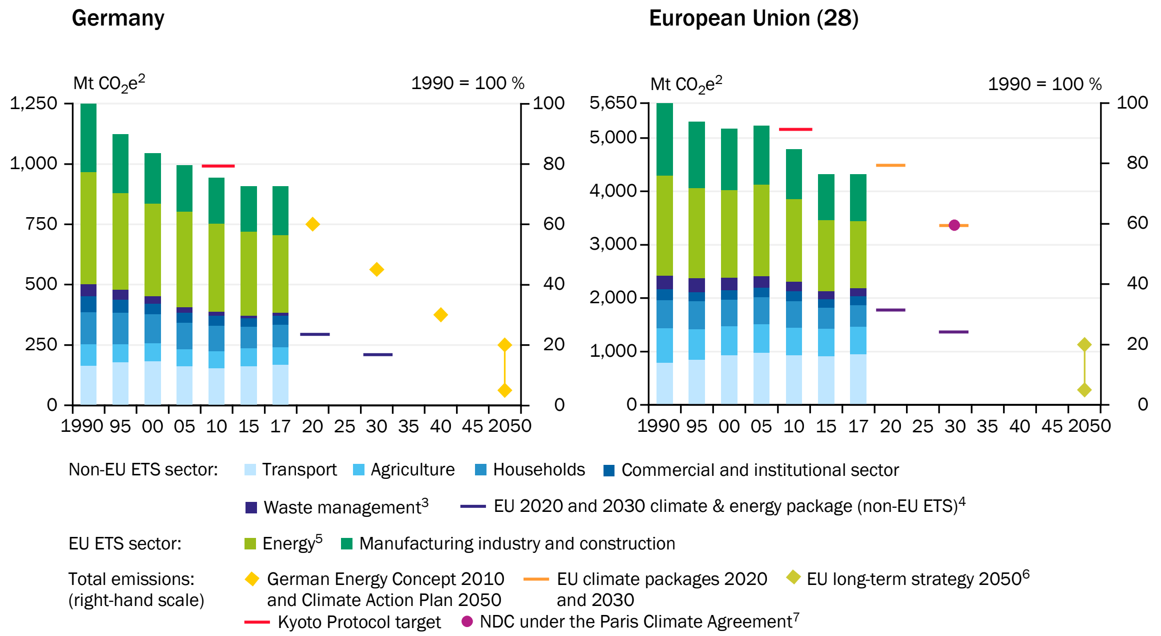
Additional national targets

52. Although Germany is implementing international climate targets, it is formulating its own climate policy objectives at the same time. However, these are not legally binding under international climate protection agreements (World Energy Council, 2018). The **German Energy Concept 2010** and the **German Climate Action Plan 2050** from 2016, which has largely been reaffirmed by the German governing parties' coalition agreement, therefore ultimately constitute political undertakings by a national government without in any way altering the commitments arising from the international agreements (World Energy Council, 2018). The refinement and verification of the German Climate Action Plan 2050 follow the five-year cycle of the nationally contributions determined under the Paris Climate Agreement (BMU, 2017c).

53. The German Energy Concept 2010 sets **national targets** for cutting total greenhouse gas emissions by 40 % by 2020, by 55 % by 2030, by 70 % by 2040 and by between 80 % and 95 % by 2050 compared with 1990 levels (BMWi, 2010). ↘ CHART 5 The German Climate Action Plan 2050 reaffirms the targets for the years from 2030 onwards and for widespread greenhouse gas neutrality by 2050. It also sets **targets for individual sectors** over and above the macro-

↘ CHART 5

Greenhouse gas emissions in Germany and the EU by source sector[1]



1 – Excluding land use, land-use change, and forestry (LULUCF). 2 – Megatonnes of CO_2 equivalents. 3 – Including other fuel combustion sectors. 4 – For Germany this equates to a reduction of 14 % by 2020 and 38 % by 2030 compared with 2005. For the EU this equates to a reduction of 10 % by 2020 and 30 % by 2030 compared with 2005. 5 – Including fugitive emissions from fuels. 6 – Long-term strategy not yet decided. 7 – Nationally determined contributions.

Sources: Eurostat, own calculations

economic level (BMU, 2017c). According to these targets, by the year 2030 the energy sector is supposed to cut its emissions by between 61 % and 62 %, the buildings sector is supposed to reduce them by between 66 % and 67 %, transport by between 40 % and 42 %, industry by between 49 % and 51 %, and agriculture by between 31 % and 34 %. No specific targets for 2030 have been agreed for land use or forestry. These individual sectors are facing very different challenges. ↘ ITEMS 150 FF.

54. National targets for total emissions, which – for 2020 at least – are likely to be missed, include the EU ETS sectors for which there are no national targets at European level and which cannot be coordinated at national level via the EU ETS at least. The achievement of national targets in the EU ETS sectors has **no impact** on the overall reduction of greenhouse gas emissions in the EU in the absence of any additional measures. Compliance with European targets is the sole determinant of contributions to the global reduction of greenhouse gas emissions. Consequently the German government should **not set any additional national or**, in particular, **sectoral targets**.

2. EU ETS sectors: targeted emissions reductions

55. The **EU ETS** constitutes a market-based instrument for cutting a large proportion of the greenhouse gases emitted in Europe's industrial and energy sectors. The EU ETS, which was created in 2005, covers a total of 11,000 furnaces in the industrial and energy sectors. The EU ETS therefore covers roughly **45 % of to-**

tal greenhouse gas emissions in the EU. ↘ CHART 6 LEFT Since 2012 the EU ETS has also included the emissions caused by aviation. At present, however, the relevant reporting and disclosure requirements only cover inner-European flights. The EU ETS includes carbon dioxide (CO_2) as well as nitrous oxide (N_2O) and perfluorocarbons (PFCs). Other greenhouse gases such as methane (CH_4), however, are not covered. Iceland, Liechtenstein and Norway participate in the EU ETS in addition to the 28 EU member states.

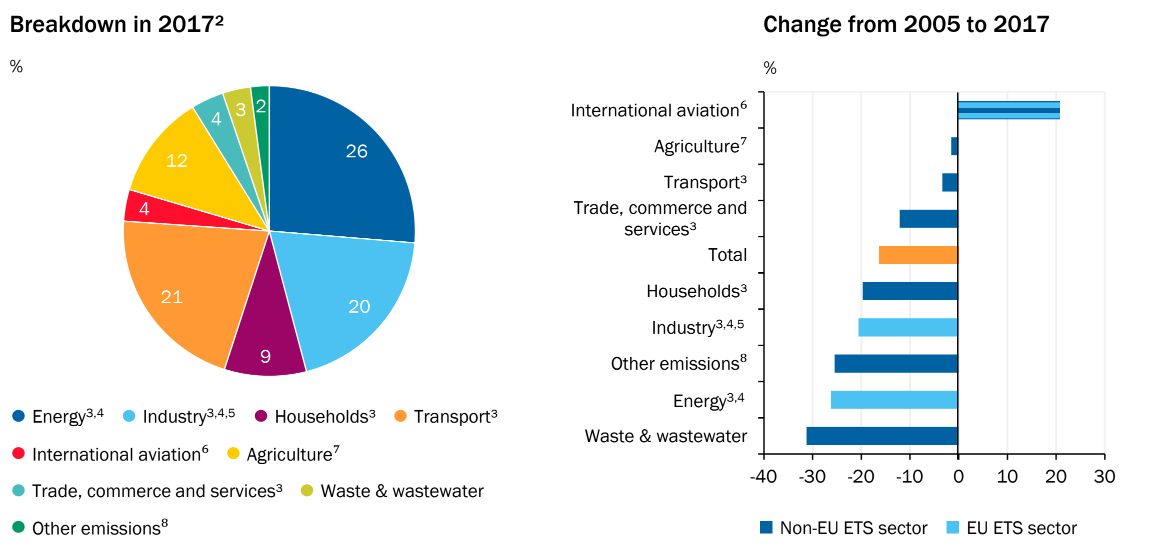
Functioning European emissions trading

56. A **cap that declines** over time ensures that the desired **emissions mitigation target** in the EU ETS sectors is certain to be achieved cumulatively owing to the way in which the scheme is constructed. Emissions in the energy sector have fallen by 26 % since 2005 and in industry they have decreased by 21 % over the same period. ↘ CHART 6 RIGHT Where exactly emissions are reduced is not stipulated and merely arises from trading in emissions certificates and the resultant prices. The **number of certificates provided**, on the other hand, is determined by the standard of living in the participating countries and by potential impacts on companies. The question of efficiency is therefore effectively separated from the question of distribution, which – within the EU ETS sectors, at least – ensures that emissions are avoided in an economically efficient way.

The emissions reductions observed in the EU ETS sectors cannot all be attributed to the EU ETS and are also driven by other factors such as the recession of 2008/09. Nonetheless, studies that estimate the causal effects of the EU ETS find that this scheme has a significantly negative impact on greenhouse gas

↘ CHART 6

Greenhouse gas emissions in the EU by sector[1]



1 – CO_2 equivalents excl. land use, land-use change, and forestry. 2 – Discrepancies in the totals due to rounding. 3 – Combustion of fuels. 4 – Industry and energy sector in the EU ETS since 2005. 5 – Industrial processes and product use. 6 – International aviation in the EU ETS since 2012, although flights to and from third countries are currently excluded. This is illustrated by the hatching in the right-hand chart. 7 – Fermentation during the digestion process, managed agricultural land, treatment of manure, and other emissions. 8 – Other furnaces and diffuse emissions from fuels.

Sources: European Environment Agency, Eurostat, own calculations emissions (Martin et al., 2016). Dechezleprêtre et al. (2018) find for the period from 2005 to 2012 that companies within the EU ETS emitted roughly 10 % fewer greenhouse gases than comparable firms that were not included in the EU ETS.

57. Unlike in the industrial and energy sectors, the agriculture and **transport sectors** have seen only **modest reductions** in emissions volumes, while emissions in international aviation have actually risen sharply. It should be noted here, however, that the energy efficiency of passenger cars – measured, for example, in terms of traffic volumes – has improved in recent years (EEA, 2018). This has, nevertheless, been offset by the simultaneous increase in traffic, which means that cars' total carbon emissions in the EU have actually risen recently (EEA, 2018). One advantage of the emissions trading scheme is that the cap takes account of such **rebound effects**.

Without constructing a corresponding counterfactual scenario it is impossible to say how high emissions would be without any climate measures and whether the transport sector – despite the level of emissions remaining unchanged – may nonetheless have made a valuable contribution to cutting total emissions. The counterfactual case would therefore have to be constructed using appropriate identification assumptions, as is customary when estimating the impact of economic policy measures or the consequences of climate change.

58. Whereas at least inner-European flights are now covered by the EU ETS, there are no still **no market-based climate protection instruments** available at European level in other parts of the **transport sector**. The transport sector is faced with the particular challenge of having to cut emissions of greenhouse gases while at the same time traffic volumes are likely to rise further. ↘ ITEMS 77 FF. Emissions arising specifically from combustion to **generate heat** in households are not covered by the EU ETS either. Unlike in the transport sector, this sector has at least managed to cut its emissions throughout the EU. The significant reduction of 31 % achieved in the waste management sector can be largely attributed to improvements in recycling facilities, the greater utilisation of waste to produce materials and energy, and the decision to no longer dump untreated municipal waste in landfill sites (German Environment Agency, 2017; CEWEP, 2018).

59. An **emissions mitigation target**, i.e. a certain quantity of emissions allowances (certificates), is initially defined for each EU ETS trading period. The quantity of certificates issued decreases over time. Each certificate entitles the holder to emit one tonne of CO2 equivalents. It is then decided how to make these allowances available. The EU ETS follows a **downstream** approach. ↘ ITEM 120 This means that the end-users of the energy source or the emitters of the greenhouse gases must own a certificate. This contrasts with the **upstream** approach, under which only those who bring energy sources into circulation for the first time must purchase certificates. Companies can buy allowances at **regularly held auctions** or purchase them from other companies. It is also possible for companies to partially meet their mitigation commitments by conducting emissions mitigation projects in third countries.

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Companies can use **international credits** to meet their commitments under the EU ETS. The Kyoto Protocol allows industrialised countries to meet their mitigation commitments by, for example, financing or conducting projects aimed at cutting emissions in other, less-developed countries (**Clean Development Mechanism [CDM]**). Having completed such a CDM project, companies receive a credit amounting to the emissions saved (DEHSt, 2013). This credit can be exchanged for EU ETS certificates until 2020, although there are quantitative and qualitative restrictions. Nuclear energy projects, afforestation and reforestation, and projects involving the release of industrial gases are exluded. Since 2012, moreover, new projects have only been credited if they are implemented in one of the least-developed countries (European Commission, 2013). In addition to the CDM it is also possible to reduce emissions as part of **jointly implemented (JI)** projects in other industrialised nations and for the country concerned to have these reductions credited towards meeting its own mitigation targets. It is not yet clear to what extent climate protection projects in other countries will in future be able to be credited towards domestic mitigation commitments (DEHSt, 2019a).

60. All certificates were originally allocated to companies free of charge. Since 2013, however, electricity producers have not received any more free certificates, although exemptions apply to some less affluent member states. A total of 57 % of all emissions allowances issued during the third trading period (2013–2020) are auctioned. **Auctions of new allowances** (primary market) and trading in certificates (secondary market) currently take place mainly on the European Energy Exchange (EEX) and the Intercontinental Exchange (ICE), with only small volumes being traded in the secondary market on other exchanges or over the counter (OTC). Almost daily auctions are intended to ensure that these are seamlessly integrated into the market and that the prices achieved in auctions are consistent with the level of prices in exchange trading.

Since the second trading period (2008–2012) it has been possible to transfer unused allowances to the following period. Transactions in certificates are booked to an account held with the EU emissions trading register (Union Register), which is operated by the European Commission. All actors involved in the EU ETS, which include banks and trading houses, possess such an account. For Germany these accounts are administered by the German Emissions Trading Authority (DEHSt).

61. Prices in the EU ETS have repeatedly fallen sharply since 2005. ↘ CHART 7 LEFT In addition to the **free allocation of certificates** during the first two trading periods (2005–2012), severe economic downturns such as the **recession of 2008/09** and the related decline in industrial production are likely to have exerted strong downward pressure on prices. Furthermore, companies were able to use international credits to meet their commitments under the EU ETS. Unused allowances have been transferred to Phase III (2013–2020). Given the accelerated expansion of renewable energy in countries such as Germany, this situation created a large surplus of certificates in the EU ETS, so the price of certificates remained below €10 per tonne of CO2 for some time.

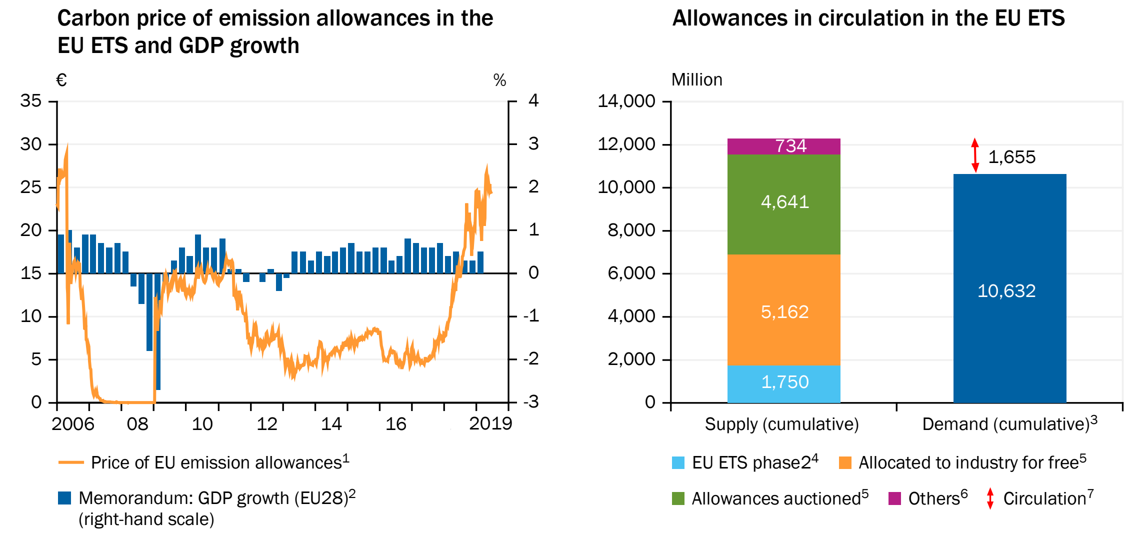
62. In order to address the problem of the surplus certificates, the emissions trading scheme has been reformed several times in recent years. Specifically, the auctioning of a total of 900 million certificates has been postponed (‘**backloaded**’) until 2019 and 2020. Starting in 2019, a portion of the certificates in circulation – the calculated surplus – will be transferred to the **Market Stability Reserve (MSR)**. This surplus is calculated once a year by the European Commission and in May 2019 amounted to 1,655 million certificates. ↘ CHART 7 RIGHT It represents the difference between the cumulative supply of and demand for certificates. During the period from 2019 to 2023 an annual 24 % of the calculated surplus from the previous year will not be auctioned and, instead, will be transferred to the MSR if the calculated surplus exceeds 833 million certificates. Conversely, the reserve will be increased if the quantity of allowances falls below the threshold of 400 million certificates.

63. From 2023 onwards the quantity of certificates in the MSR will be limited to the level of the amount auctioned in the previous year. The certificates over and above this amount will be cancelled. In addition, the **emissions trading cap will be lowered by 2.2 % per year** from 2021 onwards. This factor will remain at 1.74 % during the period from 2013 to 2020. All of these measures plus the associated expectation of rising prices have helped to ensure that the **emissions price** has **increased fivefold** over the past two years to €25.

64. A further purpose of the MSR is to neutralise as much as possible the negative effect that unilateral emissions mitigation measures would otherwise have on the price of certificates in the EU ETS. **National efforts** such as the expansion of renewable energy reduce the demand for certificates and therefore – without the MSR or other countermeasures such as the cancellation of certificates – the pri-

↘ CHART 7

EU Emissions Trading System (EU ETS)



1 – Euros per emissions allowance for one tonne CO_2; weekly averages. 2 – Real GDP: quarters, seasonally and working-day adjusted; change on previous quarter. 3 – Covers all of the verified emissions from EU ETS installations from 1 January 2013 to 31 December 2018 and the certificates cancelled during the same period. 4 – During the period from 2008 to 2012. 5 – During the period from 1 January 2013 to 31 December 2018. 6 – Certificates and allowances for international credits monetised by the European Investment Bank (EIB) for the purposes of the NER300 programme, which have utilised installations for emissions on or before 31 December 2018. 7 – Calculations by the European Commission on 14 May 2019.

Sources: European Commission, Eurostat, Thomson Reuters, own calculations ces in the EU ETS. Subsequently, demand for emissions in other areas rises while the EU ETS-wide cap limits the overall quantity of emissions (**waterbed effect**). The reforms of the emissions trading scheme mitigate this problem. Firstly, countries are now allowed to cancel certificates that are freed up when electricity generation capacity is shut down. ↘ BOX 2 And, secondly, some of the unused certificates are transferred to the MSR.

According to Burtraw et al. (2018), 88 % of marginal certificates freed up by a unilateral measure in 2018 will be removed from the market by the MSR by the year 2030. Because this happens gradually, however, this percentage is reversed for a measure taken in 2028: only 12 % of marginal certificates will then be cancelled by 2030. Just how effective the MSR will actually be is difficult to estimate and will depend largely on future emissions reductions and the associated demand for certificates (Agora Energiewende and Öko-Institut, 2018).

65. In summary we can say that the **EU ETS** already constitutes a **functioning, market-based instrument** for cutting emissions **in the industrial and energy sectors**. The latest reforms have added important elements which, on the one hand, take account of the EU ETS's interaction with member states' national measures and, on the other, strengthen the long-term price signal. The EU ETS sectors are certain to achieve their prescribed contribution to cutting emissions in the EU without requiring any additional national measures.

At present it is difficult to estimate to what extent the contribution to be made by the current EU ETS sectors would increase if the EU ETS had been extended to include those sectors that are not covered by the EU ETS at the moment. Especially in cases where the avoidance costs in other sectors are higher – as is suggested by rough estimates of the avoidance costs in non-EU ETS sectors ↘ ITEMS 133 FF. – the efficient achievement of targets might require a larger contribution by the EU ETS sectors. However, this information about potential efficiency gains resulting from the inclusion of other sectors would only become evident once the EU ETS had been enlarged.

Fossil fuel phase-out and Renewable Energy Sources Act expensive and inefficient

66. Although the EU has not set a separate target for the German energy sector because the latter is integrated into the EU ETS, the two **most expensive national emissions mitigation projects** are being conducted in this sector: the phase-out of fossil fuels and the promotion of renewable energy by the German Renewable Energy Sources Act (EEG). Given that the German government is likely to miss its self-imposed national target for cutting emissions, it has set up a commission to prepare for the planned phase-out of electricity generated from coal.

However, shutting down Germany's coal-fired power stations – in the absence of any additional measures such as the MSR or the cancellation of certificates – would not necessarily lead to a reduction of carbon emissions in the EU. Although the MSR ↘ ITEM 62 could partly offset the waterbed effect in the EU ETS, its impact would largely depend on the surpluses available in the emissions trading scheme, which means that the **climate policy effectiveness of the fossil fuel phase-out** might be **very limited** in the absence of any further measures (Edenhofer et al., 2019). If the unused certificates can be totally removed from the EU ETS, however, then Germany's phase-out of fossil fuels will actually enable the EU's targets and international commitments to be exceeded.

The Commission on Growth, Structural Change and Employment (Kohlekommission, 2019) proposes that the **phase-out of fossil fuels** should be completed by no later than 2038. This will involve structural aid for the regions affected as well as compensation for companies and households for anticipated future electricity price rises. The financial cost to Germany's public finances over the next two decades is estimated to be in the high double-digit billions of euros. ↘ BOX 2

↘ BOX 2

Phase-out of fossil fuels in Germany

At the end of January 2019 the Commission on Growth, Structural Change and Employment presented its recommendations on the phase-out of fossil fuels (Kohlekommission, 2019). These recommendations include **phasing out the generation of electricity from coal by no later than 2038**, structural aid for the regions affected, and measures to avoid electricity price rises. The phase-out of fossil fuels relates only to the generation of electricity from coal and lignite but does not include, for example, using them to produce steel. The generation of electricity from coal and lignite is to be reduced to a power plant capacity of 17 gigawatts by 2030. The current capacity is 43 gigawatts.

The pathway for the phase-out of fossil fuels will be reviewed in 2023, 2026 and 2029. This review will take account of the achievement of climate targets, the security of electricity supply, rises in electricity prices, and the impact on jobs and regional value added, and appropriate adjustments will be made where necessary. In 2032 the **option of a quicker phase-out** as early as 2035 will be examined. In order to ensure the climate policy effectiveness of the fossil fuel phase-out as part of the EU ETS, the Commission recommends that the unused emissions certificates be cancelled in accordance with the EU directive. ↘ ITEM 64

As stated in the concluding report, the coal-fired power plants should be shut down in consultation with their operators, and contractually agreed **compensation** would be paid. This compensation could be determined by the power plant contributions used as a reserve. In this case – based on the total capacity – this would amount to a total sum of roughly €25 billion. The Commission on Growth, Structural Change and Employment expects **electricity prices to rise** as a result of the phase-out of fossil fuels. Cutting the grid charges would be one way of relieving the price pressures on households. This would require a subsidy of at least €2 billion per year (Kohlekommission, 2019). Given the recent rise in EU ETS prices, the German government should also request the EU to extend the electricity price compensation paid to energy-intensive companies beyond the year 2020. ↘ ITEM 189

In mid-May 2019 the German government agreed several key points based on the recommendations made by the Commission on Growth, Structural Change and Employment (BMWi, 2019a). These points provide for **subsidies** of around **€40 billion** to be paid by 2038 to the German federal states affected by the phase-out of fossil fuels (North Rhine-Westphalia, Brandenburg, Saxony and Saxony-Anhalt). There are also plans to create 5,000 additional public-sector jobs in these regions and to relocate further government agencies there. Instead of pretending that the regionally targeted structural-change adjustment aid at the heart of these recommendations is intended to combat climate change, it would have been correct to have this support motivated specifically by regional policy. Then, however, people would be asking why the hardships of regional structural change, which is caused by factors other than climate protection, have not necessitated any special support measures.

Whenever the phase-out of using coal to generate electricity is being discussed, people repeatedly voice the concern that the price of electricity could rise sharply. The **price of electricity** is mainly affected by the power plant capacities remaining in the system, future commodity and carbon prices, the progress made in expanding the use of renewable energy, and developments in the European electricity market. Given the higher prices in the EU ETS and the increase in commodity prices, prices on the electricity exchanges would probably continue to rise even without the phase-out of fossil fuels (Agora Energiewende and Aurora Energy Research, 2018). Any accelerated phase-out of using coal to generate electricity could raise prices on the electricity exchanges by an additional €4 per MWh by 2030 (Agora Energiewende and Aurora Energy Research, 2018; Aurora Energy Research, 2019).

However, this increase could be offset or even more than compensated for by an **accelerated expansion of renewable energy as stipulated under the German government's coalition agreement** (Agora Energiewende and Aurora Energy Research, 2018). Conventional electricity producers charging higher prices in the electricity market will be displaced by the renewables offered at a lower marginal cost (merit-order effect; GCEE Annual Report 2016 item 893). If the target of expanding renewable energy so that it accounts for 65 % of electricity generation by 2030 is not achieved, however, and the **price of gas** relative to coal rises more sharply than expected, the price of electricity might even increase by as much as €14 per MWh as a result of the phase-out of fossil fuels (Aurora Energy Research, 2019).

In addition to the level of electricity prices, **security of supply** also plays a key role in the phase-out of fossil fuels. In order to ensure this supply going forward, it is especially important to continue expanding the grid. Alongside additional gas-fired power stations, part of the power plant capacity being shut down could also be compensated for by improved demand management and by stronger integration of the European electricity market (Agora Energiewende and Aurora Energy Research, 2018). It will probably be necessary to import electricity from neighbouring countries especially in order to cover peak demand (Aurora Energy Research, 2019).

An emissions trading scheme does not really require any separate intervention or subsidised phase-out of fossil fuels. This **phase-out would happen anyway over the medium term as the price of carbon rises** – possibly even sooner than currently planned, depending on the marginal avoidance cost. Although there are objectives other than environmental protection that are associated with the phase-out of fossil fuels, sufficient certificates must be removed from the emissions trading scheme in order to enable the phase-out to make a contribution to climate policy. This has been allowed since the EU ETS directive was amended. Otherwise the emissions reduction bought at great expense by the phase-out of fossil fuels will be offset by an increase in other member states.

Edenhofer et al. (2019) estimate that, in the absence of any supplementary measures, the phase-out of fossil fuels might even cause EU-wide carbon emissions to increase. One reason for this would be the rise in electricity prices, which makes the generation of electricity from coal more profitable (**rebound effect**). In addition, the EU ETS price is likely to fall owing to the unused emissions, which in turn raises carbon emissions in the EU ETS sectors (**waterbed effect**). The second effect occurs if the MSR is not sufficiently able to remove from the market the surplus certificates arising from the phase-out of fossil fuels. Whether and, if so, to what extent the phase-out causes a waterbed effect will depend largely on the future calculated surplus in the EU ETS and potential adjustments to the MSR as part of the planned revisions (Agora Energiewende and Öko-Institut, 2018). If, when the coal-fired power stations are shut down, the surplus of certificates in the EU ETS has already been substantially reduced and the MSR is therefore no longer being replenished, the waterbed effect might continue (Edenhofer et al., 2019). The phase-out of fossil fuels would then cause fewer certificates from the MSR to be cancelled, which means that total emissions in the EU ETS would ultimately actually increase. Any cancellation of certificates would probably be accompanied by a loss of government revenues. Edenhofer et al. (2019) emphasise that setting an EU ETS-wide minimum price might be a more attractive option for the German government because the loss of revenues resulting from the cancellations would then be borne by several countries.

Although the Commission on Growth, Structural Change and Employment has been calling for coal-fired power stations to be shut down in consultation with their operators, a phase-out might ultimately be settled by regulatory means. In this event, however – similar to the phase-out of nuclear power – we could expect to see constitutional disputes between power plant operators and the German government (Büdenbender, 2019). If the carbon price in the EU ETS were higher, power plant operators would need to consider from a business perspective whether it still made commercial sense to continue operating their plants given the higher costs involved. Such a higher price would arise, for example, from integrating the non-EU ETS sectors or from a carbon tax, which would ensure a fairly high minimum price in the EU ETS. If it no longer made commercial sense to operate their power plants, the operators would not be entitled to receive any compensation. In the event that a minimum price was set only nationally in the form of a carbon tax, one possible alternative would be to offer power plant operators the option of either deciding to accept a shut-down settlement or, instead, agreeing to pay a carbon tax (Büdenbender, 2019).

67. A further objective of Germany's climate and energy policies is to **reduce primary energy consumption**. After this consumption had grown over the period from 2014 to 2017, it decreased last year (German Environment Agency, 2019c). ↘ CHART 8 LEFT Efficiency gains and the fact that renewable energy accounted for a larger proportion of electricity generation are likely to have played a major part here (AGEB, 2019). At the same time, output in particularly energy-intensive sectors has been below average in 2018, which is likely to have contributed to the relatively sharp decline in primary energy consumption. ↘ CHART 8 RIGHT

Some sectors actually reported very significant falls in output. The **low level of water** in the Rhine probably played a role in the chemical industry, at coking plants and in oil processing. This sectors are especially reliant on freight navigation (Ademmer et al., 2018). As things stand, however, the target of cutting primary energy consumption by 20 % by 2020 compared with 2008 levels – as stipulated by the German Energy Concept 2010 – is likely to be missed. So far a total reduction of only 10 % has been achieved (German Environment Agency, 2019c).

68. A further key element of Germany's national measures is the technology-specific **support given to renewable energy**, the aim of which is to increase the proportion of electricity generated by solar and wind power in particular. Before Germany's Renewable Energy Sources Act (EEG) came into effect in 2017, a predefined amount was paid for electricity generated in this way. Since the **EEG was amended in 2017**, the amounts paid for the generation of renewable energy have generally been determined by invitations to tender (BMWi, 2019b). The money is therefore paid to the operator who generates renewable energy the most cost-effectively.

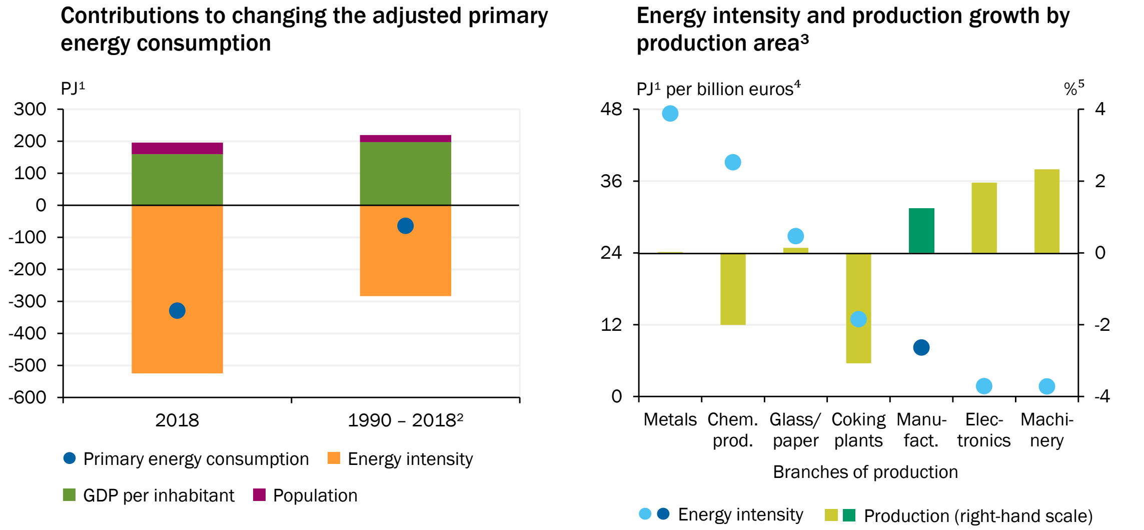
69. Roughly a quarter of the newly installed output from **solar panels** has been auctioned since the EEG was amended, while the rest of this output continues to be entitled to receive the legally stipulated payments (BMWi, 2019a). The recent

invitations to tender for solar power generation have been characterised by a high level of bids, and the **capacity of newly installed panels continues to increase**. One benign factor impacting on the price of solar energy is likely to be that a growing proportion of panels comes from China and other Asian countries, where they can often be produced more cheaply than in Germany (Fraunhofer ISE, 2019).

70. In contrast to solar power generation, the **invitations to tender for land-based wind turbines have recently been undersubscribed**. All bids submitted in the last three rounds of the invitations to tender in 2018 were successful (Bundesnetzagentur and Bundeskartellamt, 2019). The area capacity available in Germany for these turbines is limited. Even a minimum distance of 1,000 metres to residential areas would reduce the potential area available for expanding land-based wind turbines by between 20 % and 50 % (Plappert et al., 2019). If expansion continues in line with current plans, renewable energy will probably only account for 54 % of total electricity generation by the year 2030, and the **German government's target of expanding renewable energy so that it accounts for 65 % of electricity generation** by 2030 could be **at risk** (BDEW, 2019).

71. At the same time, expansion of the grid and storage infrastructure is making only slow progress, which is making it more difficult to **integrate electricity from renewable sources into the grid**. This is problematic given the **weather-related volatility of renewable energy**. Whether or not the targets for expanding renewable energy use are achieved is likely to largely depend on the extensive modernisation and nationwide expansion of the grid infrastructure (Agora Energiewende, 2018).

↘ CHART 8
Energy consumed in Germany in 2018



1 – Petajoules. 2 – Average annual change. 3 – According to the Classification of Products by Activity, edition 2008 (CPA 2008) or the Classification of Economic Activities, edition 2008 (WZ 2008). Chem. prod.: chemical products; Glass/paper: glass and glass goods, ceramics, processed stones and soil as well as paper, cardboard and goods made from these; Coking plants: coking and oil products; Manufact.: manufacturing industry as a whole; Electronics: IT equipment, electronic and optical products as well as electrical equipment. 4 – In 2016. 5 – Change compared with 2017.

Sources: Federal Statistical Office, Working Group of Energy Balance, own calculations

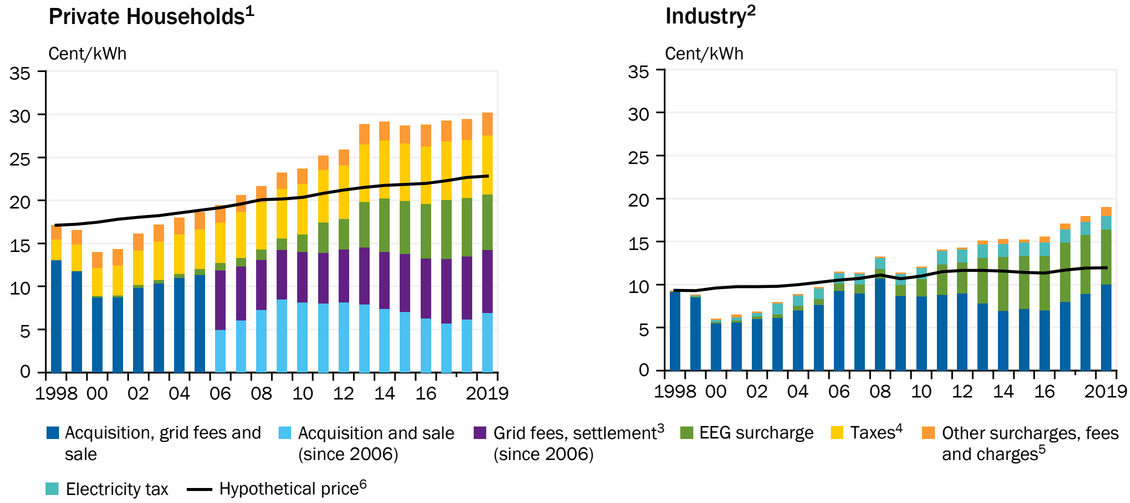
One point of controversy is the extent to which generated electricity should and could be stored in future and what impact this will have on the economic viability of renewable energy (Sinn, 2017; Zerrahn et al., 2018). Smart grids could help here to strike a physically necessary **balance between electricity generation and consumption** (GCEE Annual Report 2016 box 31). This would, however, require households and companies to be comprehensively re-equipped accordingly.

72. The expansion of renewable energy is being funded by the **EEG surcharge** and so the cost is being borne by electricity consumers. This surcharge – alongside the cost of procurement, charges and distribution – has a significant impact on electricity prices. Although it increased until 2017 it has fallen slightly since then, which is related to the transition towards invitations to tender. ↘ CHART 9 At the same time the downward trend in other price components has reversed, which can be largely attributed to higher commodity prices and price rises in the EU ETS. Going forward the EEG surcharge is likely to fall on the back of a higher carbon price because the prices of generating electricity from fossil fuels on the one hand and from renewable sources on the other are converging.

Overall the amounts paid to operators minus the proceeds from the sale of EEG electricity over the period from 2000 to 2019 are likely to total almost €222 billion (BMWi, 2018a). This amounts to roughly 6.5 % of GDP in 2018. The financial cost of the EEG surcharge is borne by companies and households, whereas the support provided for renewable energy does not impose any costs on Germany's public finances. Furthermore, because the government has no control over the financial flows under the EEG, the European Court of Justice ruled in 2019 that a feed-in tariff system such as the EEG does **not constitute a**

↘ CHART 9

Electricity prices and their components for households and industrial customers



1 – For an annual consumption of 3,500 kWh. 2 – Medium-voltage supply; consumption 100 kW / 1,600 h to 4,000 kW / 5,000 h. 3 – Including metering and meter operation. 4 – Sales tax and electricity tax. 5 – Concession fee, surcharge for the Combined Heat and Power Act (KWKG), surcharge under section 19 of the Electricity Grid Fee Ordinance (StromNEV), an offshore grid surcharge (offshore liability surcharge until 2018) and a surcharge for interruptible loads. 6 – For private households: 1998's electricity price updated in line with increases in the consumer price index. For industry: 1998's electricity price updated in line with increases in producer prices of commercial products excluding electricity, gas and district heating.

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

government subsidy (CJEU, 2019).

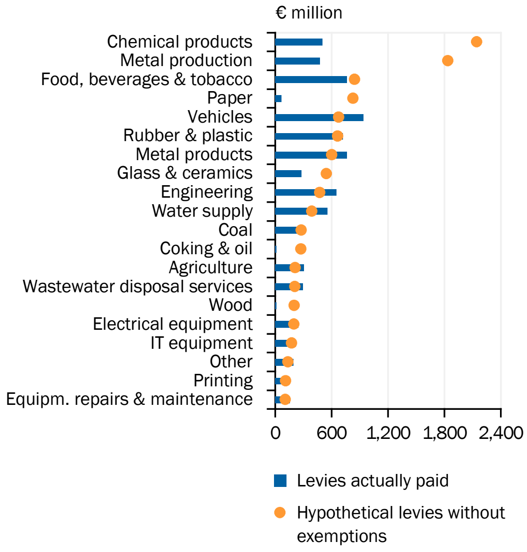
73. The annual financial cost of the **EEG surcharge** for households and companies amounts to between €22 billion and €24 billion (BMWi, 2018b). In 2016, roughly 36 % of this cost was borne directly by households, around 28 % by industry and approximately 19 % by the service sector (BDEW, 2017). The remaining almost 17 % was attributable to public-sector entities, agriculture and transport. The **financial cost** for individual households and industries **varies considerably**. The absolute cost for households increases as their incomes rise ↘ CHART 10 RIGHT because wealthier households consume more electricity. The cost relative to household incomes falls as incomes rise, however, because the proportion of other goods and services in a basket of goods increases. The EEG surcharge therefore has a **regressive** effect.

74. Comprehensive exemptions from the EEG surcharge are granted to **energy-intensive industrial companies** under the special compensation arrangement, which means that these companies 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 10 LEFT Under this scenario the EEG surcharge would be divided equally among all electricity consumers, so the surcharge per

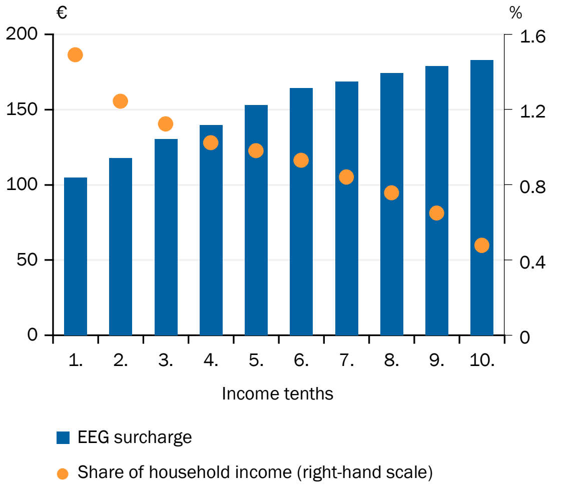
↘ CHART 10

EEG surcharge for companies and households

Actual and hypothetical[1] EEG surcharge by production area in 2015[2]
in 2015



Households' average EEG surcharge by income decile in 2013[3]
in 2013



1 – 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. 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. 2 – According to the Classification of Products by Activity, edition 2008 (CPA 2008). 3 – The sample survey of income and expenditure (EVS) reveals only the absolute level of spending on electricity. It is assumed that all households paid 29.24 cents per kWh in 2013 regardless of their annual consumption. According to the Federal network agency (Bundesnetzagentur), this is the average electricity price for consumption volumes of between 2,500 and 5,000 kWh a year as at 1 April. The EEG surcharge amounted to 5.28 cents per kWh in the same year.

Sources: BMWi, Federal network agency, RDC of the Federal Statistical Office and Statistical Offices of the Länder, Einkommens- und Verbrauchsstichprobe 2013 Grundfile 5 (HB), own calculations kWh would decrease by roughly 29 %. Consumers that are not privileged at present would pay lower charges (roughly one-third lower in the case of households). However, the exemptions granted to energy-intensive companies must be seen and judged within the context of their international **competitiveness** (GCEE Annual Report 2013 items 788 ff.). ↘ ITEMS 171 FF.

75. Although the EU ETS sectors are already covered by the EU ETS and emissions are falling in line with its limit, Germany has saddled itself with expensive projects that are motivated more by **industrial policy rather than climate policy**. Both the phase-out of fossil fuels and the expansion of renewable energy would eventually be achieved anyway by a carbon price, although in this case it would happen when it was economically efficient to do so. Although commitments undertaken in the past must be honoured, going forward, however, the EEG could be abolished and we could simply rely on the effectiveness of the carbon price – possibly in conjunction with accompanying measures (Board of Academic Advisors to the Federal Ministry for Economic Affairs and Energy, 2019).

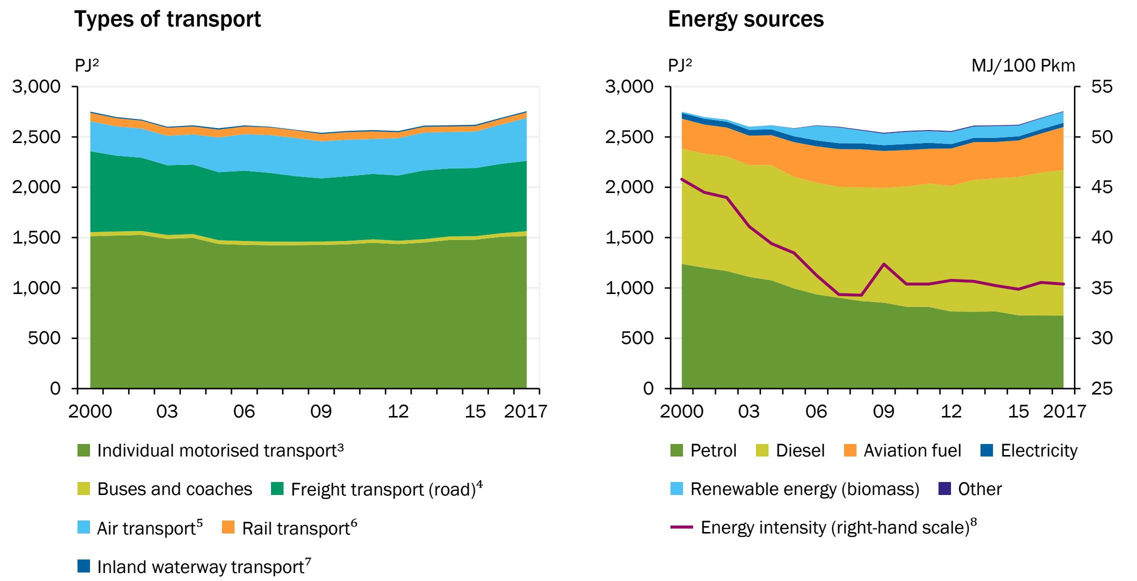
3. Non-EU ETS sectors: patchwork of measures

76. Sectors not included in the EU ETS comprise transport, buildings and agriculture. In Germany these sectors are responsible for roughly 18 %, 14 % and 8 % of greenhouse gas emissions respectively, while slightly more than 58 % of emissions can be attributed to the industrial and energy sectors, which – with just a few exceptions – are included in the EU ETS (German Environment Agency, 2019a). The remaining emissions are generated, for example, in the waste management and recycling sector or in plants that are too small to be included in the EU ETS. Unlike in the industrial and energy sectors, no market-based instrument is currently used for the transport, buildings and agriculture sectors. Instead, the non-EU ETS sectors are subject to a **number of targets and measures** at various levels (GCEE Annual Report 2016 items 867 ff.). Some of these targets are likely to be missed. These include the binding EU target to cut greenhouse gas emissions in the non-EU-ETS sectors by 2030. ↘ ITEMS 49 F.

Various sectors facing specific challenges

77. The **transport sector** faces the challenge of cutting its greenhouse gas emissions while total traffic volumes are likely to continue to grow. The emissions in this sector were broken down as follows in 2016: passenger cars 60.6 %, commercial vehicles 35.3 %, domestic aviation 1.4 %, coastal shipping and inland navigation 1.2 %, diesel locomotives 0.6 % and other forms of transport 0.9 % (BMU, 2019b). Road traffic therefore accounts for the majority of carbon emissions in the transport sector. ↘ CHART 11 LEFT Per person-kilometre (pkm), however, aviation is responsible for the most greenhouse gas emissions. It emits 201 g/pkm; by comparison a passenger car emits 139 g/pkm and a long-distance train emits only 36 g/pkm (German Environment Agency, 2018b).

↘ CHART 11
Energy consumption in the transport sector[1]



1 – Domestic use. 2 – Petajoules. 3 – Cars, motorbikes, mopeds. 4 – Trucks, articulated lorries, tractor, and other motor vehicles. 5 – International aviation in the EU ETS since 2012, although flights to and from third countries are currently excluded. 6 – Railway, underground train, and trams. 7 – Including port and coastal shipping. 8 – Ultimate energy consumption in transport in megajoules per 100 person-kilometer.

Sources: BMVI, Working Group of Energy Balance

78. The **transport volumes** of trucks – measured in tonne-kilometres – **grew** by 42 % in Germany between 2000 and 2017. Traffic volumes in passenger transport increased by almost 15 % over the same period. The **growth in economic output**, which is closely related to the volume of freight transport in particular, is a key factor here. In addition, the deeper integration of value chains and the eastward enlargement of the EU are likely to have contributed to the increase in traffic volumes (Obermüller et al., 2019). Germany's Federal Office for Freight Transport has forecast, for example, that foreign trucks will probably account for slightly more than 44 % of trucks' total transport volume in 2020 (BMVI, 2018a).

Energy consumption per person-kilometre (pkm) has stagnated in recent years after significant **efficiency gains** were achieved until the recession of 2008/09. ↘ CHART 11 RIGHT Possible reasons for this could be the lower capacity utilisation of vehicles or the higher proportion of short-distance journeys undertaken by heavy trucks as a result of the construction boom (Obermüller et al., 2019).

79. **Freight transport volumes** are expected to grow by a further 48 % by 2050 compared with 2015 levels, whereas passenger transport volumes could remain largely stable against a background of demographic change and a declining total population (Boston Consulting Group and Prognos, 2018). There are four options for cutting emissions in the transport sector:

– **Efficiency gains**, for example by making technical improvements to existing propulsion technologies: Although it has been possible to cut new cars' carbon emissions in recent years, the average level of carbon emitted by newly registered vehicles in Germany is still well above the target for 2020

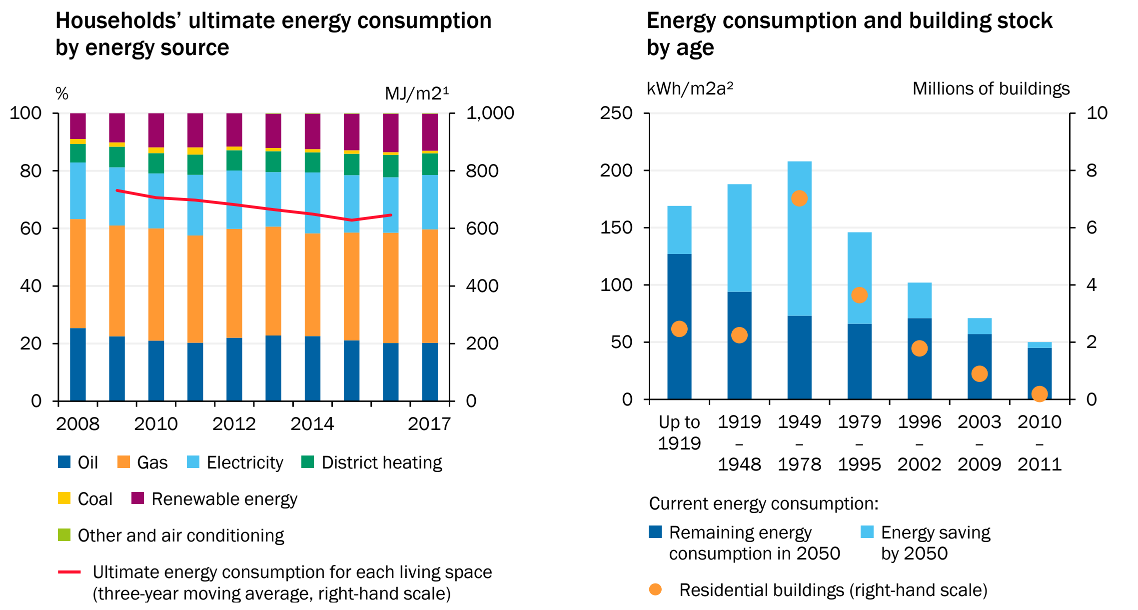
(EEA, 2018). ↘ ITEMS 87 F. The growing demand for larger and more powerful vehicles is a key factor here. This demand has been one reason why the average weight of newly registered passenger cars has not decreased despite the use of lighter materials and improved automotive design (EEA, 2018).

- **Transfer traffic from road to rail**: Rail freight transport emits 80 % less carbon than trucks based on the same transport volume in tonne-kilometres (German Environment Agency, 2018b). However, the various forms of transport differ significantly in terms of their transport routes and the freight transported (Obermüller et al., 2019). Nonetheless, the much larger proportion of rail freight transport in other countries certainly suggests that there is further potential for transferring traffic from road to rail in this country (Agora Verkehrswende, 2018). This would, however, require the rail network and transhipment facilities to be expanded.
- **Switching to less carbon-intensive propulsion methods:** Electric cars are failing to achieve greater market penetration because they are more expensive to buy, the infrastructure of electric charging points remains inadequate, and electric vehicles still have relatively short ranges. Although propulsion based on fuel cells and gas still tends to entail high avoidance costs ↘ ITEMS 133 FF., these propulsion methods could increasingly be used in future if there were greater technological innovation, especially in road freight transport (Boston Consulting Group and Prognos, 2018; Fraunhofer ISI, 2018).
- **Running vehicles on synthetic and biological fuels:** Petrol and diesel continue to account for the lion's share of the fuels used in transport. ↘ CHART 11 RIGHT Using alternative fuels could help to cut emissions in the transport sector. If biofuels are used, it is necessary to consider the indirect impact on land use, land prices and food prices (Edenhofer et al., 2019). In future, however, the addition of synthetic fuels in particular could play an important role. One option, for example, would be to generate electricity cheaply at sunny locations outside Germany, convert it there into liquid or gas fuels and then use them here in vehicles (Obermüller et al., 2019).

80. The number of **air passengers** worldwide rose to 4.1 billion in 2017. The volume of freight also continues to increase (ICAO, 2017). The **aviation industry** accounted for **2 % of global carbon emissions** in 2017. The International Civil Aviation Organization (ICAO) – a specialised agency of the United Nations – expects civil aviation to continue to grow to 10 billion passengers by 2040 (ICAO, 2018). The shipping industry is facing similar climate policy challenges. In the absence of any further measures, the carbon emitted by the maritime sector is likely to increase by between 50 % and 250 % by 2050 (IMO, 2015).

81. The sixth monitoring report on the transformation of Germany's energy sector has found that the **emissions from heating used in buildings** are likely to be only around 12.5 % lower in 2020 than they were in 2008 (BMWi, 2018b). Because it is only possible for people to adjust their heating behaviour to a certain extent, the most effective ways of cutting emissions in buildings are to introduce **energy-efficiency measures** and **switch to less carbon-intensive fuels.** ↘ CHART 12 LEFT Heat pumps can play an important part here. At

↘ CHART 12
Energy consumption and age of the building stock



1 – Megajoules per square metre. 2 – Kilowatt-hours per square metre per year.

Source: BMWi

present, however, it is not very cost-effective to use them owing to the relatively heavy taxation of electricity compared with heating oil and natural gas (Board of Academic Advisors to the Federal Ministry for Economic Affairs and Energy, 2019). Because roughly three-quarters of all residential property in Germany was built before the first Ordinance on Thermal Insulation came into effect, there is significant potential for saving energy in older buildings (BMWi, 2015). ↘ CHART 12 RIGHT

82. In the **buildings sector** there are three challenges: lengthy refurbishment cycles, consideration for the landlord-tenant relationship, and limited capacity in the construction industry. Energy-efficiency measures are especially cost-effective if general refurbishment work is due to be carried out at the same time (Henger and Schaefer, 2018). The **building refurbishment cycles** for technical installations and equipment, however, amount to 30 years. This cycle is as much as 50 to 55 years for external parts of a building such as the roof (Fraunhofer IBP, 2013). New heating systems are installed in around 2 % of residential property every year on average (Henger and Voigtländer, 2012). In the absence of any additional measures the buildings sector is therefore likely to make a steady but slow contribution to cutting emissions in future.

83. Given the large **proportion of rented accommodation in Germany**, any pricing must be determined by whether the relevant price incentives actually encourage landlords to introduce energy-efficiency measures, because these measures will ultimately lower tenants' incidental costs. Tenancy law restrictions could make it additionally unattractive for landlords to invest in energy-efficiency measures for their properties (Henger and Schaefer, 2018). Supplementary measures are therefore advisable in this area. ↘ ITEMS 245 FF.

Part of the cost of any modernising maintenance or basic modernisation not requiring any repairs **can be passed on to tenants** (section 559 German Civil Code [BGB]). If this merely involves modernising maintenance of the heating system, however, the cost incurred must be reduced by the amount that would have been incurred by pure maintenance (section 559 (2) BGB). Preventive measures involving wearing parts or the replacement of defective components are classified as maintenance and do not justify passing on the costs incurred to tenants (sections 555a and 555b BGB).

Since 2019 it has not been possible to pass on more than 8 % of any modernisation-related costs to tenants (section 559 BGB). Funding costs and any costs subsidised by public funds can never be passed on to tentants (section 559a BGB). The allocation of modernisation costs is also subject to an absolute limit that is determined by the dwelling's price per square metre (section 559 (3) BGB). Incentives to modernise heating appliances and to allocate costs change fundamentally if the landlord has outsourced the operation of the heating system to third parties (**heating contracting**). In this case the heating is operated, maintained and supplied by a commercial provider.

84. Limited capacity in the construction industry presents a further obstacle to energy-efficiency measures being carried out swiftly (German Environment Agency and BMU, 2011; Pfnür and Müller, 2013). It is estimated that around 100,000 additional skilled workers are needed in order to achieve the climate targets set for the buildings sector by 2030 (Kenkmann and Braungardt, 2018). The growing demand for accommodation especially in towns and cities combined with more stringent energy-efficiency requirements is likely to further exacerbate what is already a challenging situation in the housing market. Given the **supply-side restrictions**, subsidy programmes might not achieve the desired effect (Kenkmann and Braungardt, 2018).

85. In addition to carbon dioxide, **agriculture** produces further greenhouse gases such as methane and nitrous oxide. These are emitted by the **keeping of livestock** (methane), the storage and spreading of livestock manure (methane and nitrous oxide) and by emissions from agricultural land owing to the use of **nitrogen fertiliser** (nitrous oxide) (Lünenbürger et al., 2013). The biggest individual emitters of methane are dairy cows.

The German government's target is to cut greenhouse gas emissions in this sector by between 31 % and 34 % by 2030 compared with 1990 levels (German Environment Agency, 2019d). By 2017, however, emissions had been reduced by only 17 %. This target, which is stipulated in the German Climate Action Plan 2050, is unlikely to be achieved, however, purely by measures taken in fertiliser management and in arable and livestock farming (German Environment Agency, 2019d). Because the technological possibilities for cutting emissions in livestock farming are, by its nature, limited in contrast to other sectors, the only option would be **reduce the numbers of animals kept**.

Regulatory efforts at European level

86. **Regulatory approaches** to limiting Europe's carbon emissions are primarily being used in the non-EU ETS sectors at European level. These include, for example, manufacturer-specific emissions limits for **passenger cars and light commercial vehicles**. These measures often involve very strong interventions in individual markets. Empirical studies have shown that the cost of avoiding emissions through regulation – for example in the form of standards in the transport sector – is several times higher than the cost imposed by a carbon price (Edenhofer et al., 2019; Board of Academic Advisors to the Federal Ministry for Economic Affairs and Energy, 2019).

87. Already in 1995 the European Commission launched a strategy to cut carbon emissions from passenger cars. This strategy initially stipulated a **voluntary commitment** by manufacturers to mitigate carbon emissions. The strategy then evolved in 1999 into a voluntary commitment by carmakers to limit carbon emissions to 140 g CO2/km by 2008 (1999/125/EC). When these **voluntary commitments proved not to be very effective**, in 2009 the European Commission created the first **legally binding framework** imposing **manufacturer-specific limits** on the average emissions levels of the relevant fleets of new cars (Regulation (EC) No. 443/2009). This arrangement was intended to cut average emissions to 130 g CO2/km by 2015.

88. The **targets and framework conditions** of these regulations were **adjusted** and **expanded** in 2014. A target of 95 g CO2/km was set for 2021, for example, and the relevant **sanctions** were **significantly tightened**. Whereas until the end of 2018 the sanction amounts were initially staggered, a penalty of €95 per gram per vehicle is now payable as soon as the target is exceeded by just one gram.

The latest **amendment** to this regulation in 2019 now stipulates that carbon emissions should be reduced in two stages by 15 % to approximately 80 g CO2/km by 2025 and then by 37.5 % to around 59 g CO2/km by 2030. In addition, the introduction of the Worldwide Harmonized Light-Duty Vehicles Test Procedure (**WLTP**) is intended to provide a test procedure that better reflects vehicles' actual driving performance. An **interim assessment** of the latest regulation's effectiveness is due to be carried out in 2023. Based on this evaluation the European Commission reserves the right to adjust the emissions limits if necessary and to extend them to the period from 2035 to 2040.

89. The amendment of Germany's Federal Immission Control Act (BImSchG) in 2007 changed the way in which **biofuels were encouraged** into a mandatory **minimum quota that had to be added** to fossil fuels. Instead of a fixed biofuel quota, a **greenhouse gas quota** has been used since 2015 to encourage the reduction of carbon emissions in the transport sector. These are national measures to implement the **requirements of the European directives** on fuel quality (98/70/EC) and renewable fuels (2003/30/EC).

90. The quota obliges companies that introduce new fuels to achieve annual reductions of greenhouse gases relative to their total consumption of petrol and diesel

fuel. At present the **annual mitigation target** is **4 %**, and it will rise to 6 % from 2020 onwards. Companies must comply with the quota by introducing biofuels in the same year. If the greenhouse gas quota commitments are not met, the companies concerned must pay **fines** in proportion to the amount by which they miss their targets. If any targets are exceeded, the companies concerned can have the relevant amount credited to the following year.

91. In some respects the greenhouse gas quota is similar to the EU ETS. Companies can transfer to third parties their commitment to introduce biofuels. As with the EU ETS it is therefore possible to **trade the quota commitments**. In particular the quota creates an **implicit price** for cutting carbon emissions **in the transport sector**. This implicit price is partly determined by the mitigation target of the greenhouse gas quota and by the biofuels' potential for cutting emissions. If the latter increases, the relative need for biofuels to meet the greenhouse gas quota targets will decrease.

92. The EU has provided the **heating and refrigeration sector** with roughly €166 million up to 2020, which has so far been used primarily to fund research and development projects and the implementation of Smart City projects in Europe (European Commission, 2016). In the **agriculture sector** the EU is funding many businesses in Europe through the Common Agricultural Policy, although these payments are only partially being used for the sustainable development of agriculture. A policy of greening has often seen public funding tied to environmental projects and the protection of nature. 30 % of the direct payments made for greening purposes are tied to environmental projects, with funding being awarded to projects that encourage land use in the interest of the environment, promote crop diversification and maintain permanent pastures.

Support measures and taxes indirectly relating to carbon emissions

93. The German government's energy concept in the non-EU ETS sectors comprises several action plans and support measures aimed at achieving its individual targets. The sixth monitoring report on the transformation of Germany's energy sector lists **190 individual measures** (BMWi, 2018b). Many of them concern the use of renewable energy and the improvement of energy efficiency. Funding of €1.8 billion was set aside in 2018 purely for the KfW development bank to support the introduction of energy-efficiency measures in buildings; €650 million was earmarked for the energy efficiency fund, and approximately €300 million each was budgeted for both the national climate action initiative and for individual measures concerning the use of renewable energy (BMF, 2017).

94. Regulatory requirements are also intended to help cut emissions. The German Energy Saving Ordinance (EnEV), for example, defines structural and energy-efficiency requirements for new and existing buildings. The regulations include **specific requirements for heating and refrigeration systems** and pursue the objective of reducing buildings' energy consumption and improving efficiency. In certain circumstances, for example, the EnEV bans the use of older oil- and gas-powered heating systems.

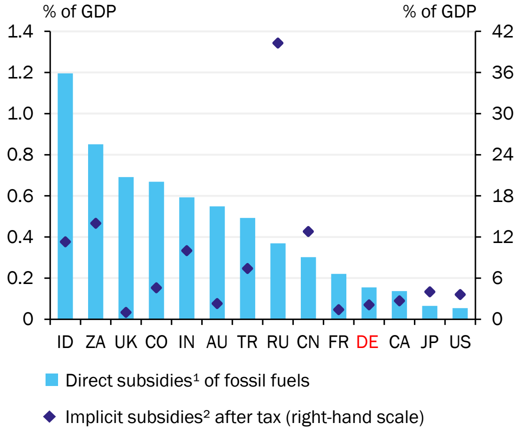
95. Alongside the subsidies given to renewable energy and low-emission technologies, **fossil fuels receive what amount to indirect benefits** in Germany, for example when most federal states choose not to levy mining royalties or water abstraction charges in the lignite mining industry and the non-energy-related use of fuels is exempt from energy tax (Köder and Burger, 2017). This means that the polluters do not have to bear some of the incurred costs themselves. This reduces the incentive to use energy efficiently and sparingly. A study by the International Monetary Fund (IMF) – which, in addition to direct subsidies, factors in external costs arising from the harm caused by energy consumption – estimates the scale of such implicit subsidies in Germany to have been 2.1 % of gross domestic product (GDP) in 2015 (Coady et al., 2019). ↘ CHART 13 LEFT

Worldwide, however, fossil fuels receive implicit subsidies amounting to 6.3 % of global GDP. In China, for example, conventional fuels receive considerable implicit subsidies amounting to 12.8 % of GDP. The direct subsidies provided here are much smaller. ↘ CHART 13 LEFT The increasing spread of subsidies worldwide places the focus on **international coordination** in reducing subsidies and transitioning to a **lower-emission energy system**.

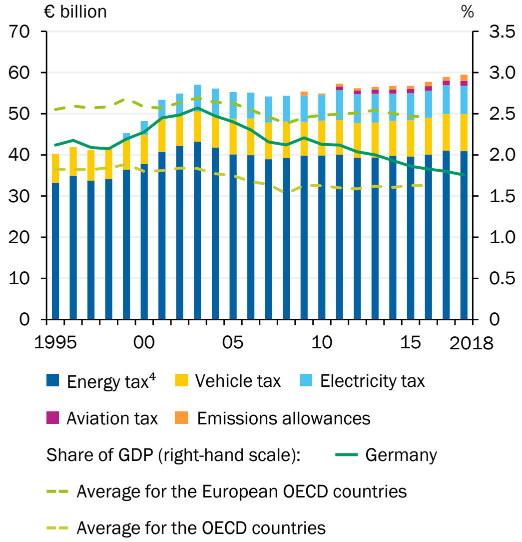
96. Furthermore, there are **already several environment-related taxes** in Germany. ↘ CHART 13 RIGHT However, these are based only **indirectly on carbon emissions**. Reforms are therefore needed irrespective of what form of carbon pricing is chosen in future.

↘ CHART 13
Subsidies and taxation

Direct[1] and implicit[2] subsidies of fossil fuels compared with other countries[3]



Environmental tax revenue in Germany



1 – This includes direct subsidies and tax breaks but no measures to lower the national prices of fossil fuels in general. 2 – Implicit subsidies are defined as the difference between the actual price of fossil fuels and a hypothetical price that would factor in both the opportunity cost of provision and the environmental costs. 3 – For 2015. ID-Indonesia, ZA-South Africa, UK-United Kingdom, CO-Colombia, IN-India, AU-Australia, TR-Turkey, RU-Russia, CN-China, FR-France, DE-Germany, CA-Canada, JP-Japan, US-USA. 4 – Mineral-oil tax until 2006.

Sources: Coady et al. (2019), Federal Statistical Office, OECD, own calculations

97. The rates of tax on energy and electricity have remained constant in nominal terms in recent years. **Environmental tax revenue as a share of GDP is falling continually**. This tax revenue as a share of GDP has fallen by more than 0.6 percentage points since 2003. ↘ CHART 13 RIGHT In 2016 this tax revenue amounted to 1.9 % of GDP, which was slightly above the OECD average of 1.6 % of GDP but below the average for the European OECD countries. ↘ CHART 13 RIGHT

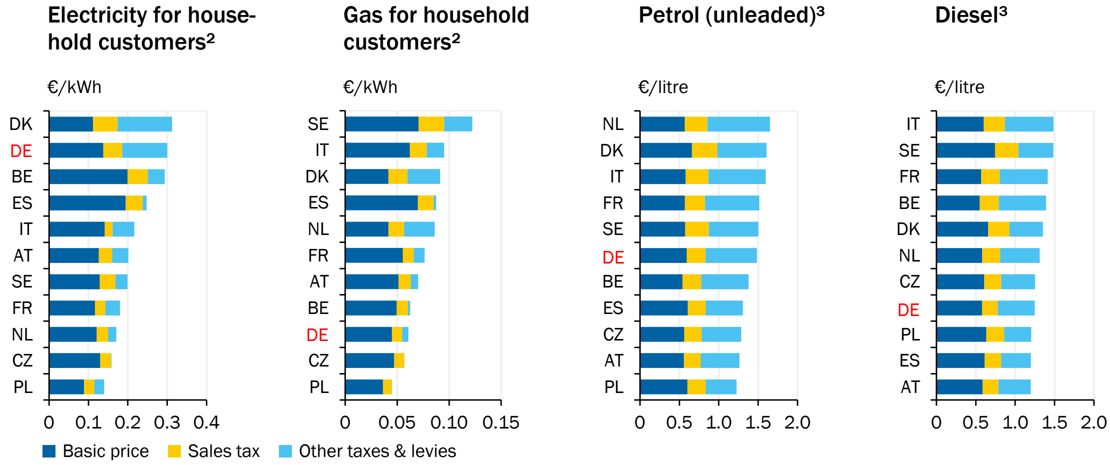
98. Since 2009 the amount of **vehicle tax** has been determined not just by engine size and exhaust emission standard but also by carbon emissions. Since last year the level of emissions in newly registered vehicles has been measured by a new test procedure (WLTP) as part of a standard test cycle. Although this increases the average tax burden, the amount of tax is not affected by the **actual use of the vehicle**. So although this tax might offer incentives to purchase a vehicle that creates lower emissions per kilometre, the actual level of emissions arising from the intensity of use is not taken into account. If emissions were taxed at a standard rate, carbon emissions could be ignored as a factor in assessing vehicle tax. This would also reduce the complexity of calculating taxes on newly registered vehicles at least. In order to offer incentives to buy lower-emission vehicles there have been proposals to introduce a system of credits and debits in conjunction with a registration tax when new cars are first registered (Agora Verkehrswende, 2018).

An **energy tax** is currently levied on **fuel consumption**. Although the amount of this tax varies from one type of fuel to another, the tax rate is only very loosely based on the relative impact that these fuel types have on the climate. The tax on petrol, for example (65.45 cents per litre), is higher than that on diesel (47.04 cents per litre). Depending on the emissions factor used, this results in an implicit price for CO2 equivalents of more than €250 per tonne for petrol compared with only €150 per tonne for diesel (Edenhofer et al., 2019). Emissions were not originally regarded as the factor that should determine the level of the respective tax rates. Rather, energy taxes were supposed to address other externalities such as local air pollution, traffic congestion, road accidents and a fair, user-based system of infrastructure funding (Coady et al., 2018). When calculating implicit tax rates, the Board of Academic Advisors to the Federal Ministry for Economic Affairs and Energy (2019) therefore only includes the ‘environmentally motivated energy tax’ and ignores the former mineral-oil tax. The implicit tax rates calculated in this way then amount to €64 per tonne for petrol and €58 per tonne for diesel.

In order to help fund infrastructure, the German government had decided to introduce a new infrastructure levy (**road toll for passenger cars**) on trunk roads in Germany, but the European Court of Justice recently ruled that this form of toll was illegal. Rather than being based on the distance travelled, this toll was to be paid by all vehicle owners for one year at a time. As in the case of vehicle tax, the price would have been determined by engine size and environmental factors. In return, the German Motor Vehicle Tax Act would have granted tax relief at the same time. However, the European Court of Justice ruled that this compensation constituted indirect discrimination against owners of vehicles registered in other countries.

↘ CHART 14

Basic prices and tax burden on various energy sources across several European countries[1]



1 – AT-Austria, BE-Belgium, CZ-Czech Republic, DE-Germany, DK-Denmark, ES-Spain, FR-France, IT-Italy, NL-Netherlands, PL-Poland, SE-Sweden.
2 – Data as at 31 December 2018. 3 – Data as at 1 January 2019.

Sources: European Commission, Eurostat, own calculations

99. Thus there remain **two sources of revenue for the German government** which, in different ways, use the transport sector to fund infrastructure while at the same time – in some respects, at least – pursuing incentive objectives. In principle it would be advisable to **pursue these objectives separately** by implementing comprehensive reforms. ↘ ITEM 127

100. A comparison of the tax burden on the purchase and ownership of vehicles shows first of all that the usage-based taxes levied in Germany and other European countries account for a fairly small proportion of total taxes (Kunert, 2018). Germany's taxation of diesel in particular is fairly low **compared with other European countries.** ↘ CHART 14 Compared with **non-European countries** such as Canada, the United States, Brazil and Russia, however, the effective tax rates on petrol and diesel are very high in Germany (OECD, 2018).

101. The energy tax also covers **heating fuels** whose implicit carbon price is much lower (Edenhofer et al., 2019). It is also significant that coal and heavy heating oil – two not very environmentally friendly fuels – have been fully exempted. This is encouraging the adoption of more environmentally harmful fuels. Furthermore, a number of exemptions have been granted for sectors such as industrial companies and for agriculture and forestry.

102. The current energy tax rates are well above the **minimum rates** set by the Council of the **European Union** in 2003 (Directive 2003/96/EC). Back in 2011 the European Commission put forward proposals for the directive to be revised. These proposals would have based taxation on the energy content of fuels (European Commission, 2011). However, the European Parliament rejected these plans. Because such directives must be unanimously approved, it is questionable whether agreement could even be reached in future. This is particularly the case with higher minimum tax rates, which could create a stronger incentive effect.

103. The law introducing Germany's ecological tax reform of 1999 gradually increased the rates of tax on diesel, petrol, heating oil and gas and also introduced an **electricity tax**. Here too there are exemptions that are problematic from an incentive perspective. Night-storage heaters and public transport, for example, are not adversely affected. More serious, however, is the fact that the taxation takes no account of how the electricity is generated. Because only generated electricity is taxed, this happens regardless of whether the electricity has been produced by regenerative technologies or by coal (Linscheidt and Truger, 2000a). What's more, the EEG surcharge makes it much more expensive to buy electricity, irrespective of its generation mix. One particularly notable feature is the high tax burden on electricity for household customers in Germany compared with other European countries. ↘ CHART 14

104. Flights that take off in Germany have been subject to an **aviation tax** since 2011. This tax is levied not on kerosene but on the each ticket. The German government initially discussed the option of introducing an ecological aviation levy that was supposed to create an incentive effect commensurate with the environmental harm caused by aviation, but it then thought that it would not be feasible to implement such a tax to reflect the actual level of carbon emitted by aircraft (Bundesregierung, 2010; Deutscher Bundestag, 2010). It therefore implemented a tax that is determined by the number of passengers transported and is loosely based on the distance to the destination concerned. The aviation tax is only levied on the commercial transportation of passengers and does not cover air freight or private aviation (BMF, 2011). The total cost imposed on aviation by the aviation tax and the EU emissions trading scheme should not exceed €1 billion. If the expenditure anticipated for both instruments exceeds this amount, the tax rates will be lowered accordingly. This happened most recently at the beginning of this year (LuftVStAbsenkV, 2019).

105. Furthermore, the **tax system** contains **elements** that could be **problematic** from a **climate policy perspective**. The tax allowance for commuters, for example, could offer incentives to travel further distances than necessary. Privately used company cars also benefit from favourable tax treatment. The German Council of Economic Experts has proposed in some of its previous annual reports that these tax privileges should be either abolished or restricted (GCEE Annual Report 2012 item 365; GCEE Annual Report 2011 item 360).

106. The reforms undertaken with the ultimate goal of carbon pricing – irrespective of the solution eventually chosen – should therefore be grasped as an opportunity to **overhaul** and, where possible, simplify **the tax system**. The energy tax – the largest tax in Germany – is likely to become less significant, especially if we manage to cut the emissions generated by transport and buildings. At the same time the revenue raised by the electricity tax is likely to increase, although this tax is problematic in its current form. ↘ ITEM 103 The funding of road infrastructure could rely more heavily on the vehicle tax and a system of road pricing, whereas local externalities could be more effectively addressed through local measures such as congestion charging. ↘ ITEM 127

IV. PATHS TOWARDS SYSTEMATIC CARBON PRICING

KEY POINTS

- Applying a price to CO_2 emissions can efficiently coordinate the individual decisions of households and companies and is therefore preferable to small-scale regulatory measures.
- The primary goal should be to extend the EU ETS to all sectors. Possible transitional solutions are a separate emissions trading scheme or a carbon tax for non-EU ETS sectors.
- For reasons of efficiency, coordination should be sought with the largest possible coalition of member states.

107. **Prices** play a central role in markets: They send **signals**, in response to which economic agents adapt their individual actions, thus ensuring that all individual decisions are **coordinated**. In functioning markets, they also ensure that the overall result is achieved **efficiently**: Achieving the same result in terms of volume through any other allocation of individual decisions would require a greater use of resources. It is generally welfare-enhancing to organise exchange by means of a market, when coordinating the actions of multiple decentralised participants. The **government** can ensure the functioning of markets by providing a stable framework for market development, without getting involved in individual decisions.

This basic concept also extends to the exchange of **property rights**. In this sense, a **uniform carbon price** can be understood as the price of a property right: Those who pay this price acquire ownership of a small section of the **global disposal space for greenhouse gases**. This price can be used as the central coordination signal for allocating individual decisions about selecting avoidance options and thus ensure an efficient overall result. First, it creates incentives to reduce the consumption of CO_2-intensive products and services. Second, it increases the return on investment in low-carbon technologies, such as renewable energy or low-carbon mobility concepts. Third, it provides incentives for innovation in the field of CO_2-saving technologies (Edenhofer et al., 2019).

108. A uniform carbon price can accomplish this task: at the level of individual decisions, it ensures that carbon would never be emitted if avoiding emissions was cheaper than its price. **Small-scale sectoral targets** may hamper an efficient solution. This is because, from a climate protection perspective, individual sectors only represent parts of the overall economic activity that generates carbon emissions. From this perspective, there is no meaningful distinction between the CO_2 emissions from different sectors. Therefore, the avoidance options open to all sectors should be considered together. A **functioning market** for these ownership rights to the disposal space does not simply arise by itself; it must be created through **government action**. Several

systems have already been successfully established for this purpose, in particular the EU ETS.

In order to achieve a uniform price of carbon emissions that covers all climate-relevant activities, as part of a rational German and European climate policy, the **expansion of the EU ETS** to all sectors should be the primary objective and be implemented as soon as possible. As a **transitional solution**, **separate pricing in the non-EU ETS sectors** is advisable. In this way, at least the objectives within these sectors can be achieved efficiently during the transitional period. Separate pricing could be realised through separate emissions trading or by applying a carbon tax to these sectors. Both approaches should be coordinated with the largest possible coalition of EU member states. However, even if the approaches are only implemented at national level, pricing is likely to be far superior in terms of cost-effectiveness to a policy purely based on regulatory measures.

1. Carbon pricing: more effective than a regulatory approach

109. There are **several means** of bringing about a targeted reduction in emissions: **Regulatory measures** can be used to achieve small-scale control. Alternatively, specific instruments can be used to organise the reduction of emissions on a market-based basis. **Market-based measures** include **price instruments**, which can be implemented either by taxing emissions or by subsidising emission reductions. The government then only indirectly controls the amount of emissions resulting from the price.

The alternative option is **quantity instruments**. In this case, the government issues a certain quantity of tradable emission rights, but only controls their price indirectly: The price is generated as a result of the interplay of demand and supply of emission rights due to market developments. Such rights can be freely assigned, sold or auctioned by the government. In the same way as with the tax solution, the government can receive revenues that it can use, for example, to redistribute or reduce distorting taxes. The different possibilities for reducing emissions can in principle be used in parallel.

110. Under strong assumptions, in particular the presence of complete information and the lack of uncertainty, price and quantity instruments would be equally suited to achieve the **desired goal with minimal social costs** (Weitzmann, 1974). However, these assumptions are not met in reality. The advantages of the different instruments depend not least on which evaluation criteria are used and how they are weighted. They can also be determined by **path dependencies**, that is, by the routes previously taken in the implementation of climate policy.

111. Price and quantity instruments both lead to a price for emissions, thus creating incentives for measures to reduce emissions, where abatement costs are lower than this price. In terms of **cost-effectiveness**, these instruments are superior to a regulatory approach. A policy of conditions and requirements can achieve the reduction target through heavy intervention, but rarely allows differences in

the **costs of avoidance** between polluters to be taken into account, if at all. To achieve an efficient solution, the regulator would have to know the costs of each polluter and prescribe an individual code of behaviour. This is not practical in reality. Market-oriented instruments make it possible to achieve the goal at lower overall societal costs.

112. Quantity instruments by means of emissions trading achieve high **accuracy** with respect to the **targeted reduction in emissions.** This is because the total amount of emissions is **set by the government** and the price results from the trading of emissions certificates that can only be issued by the government. In contrast, price instruments do not guarantee that the objectives will be achieved, since the regulator usually does not know the abatement costs of the next greenhouse gas unit, nor therefore how the market participants will respond. Price instruments are therefore a less suitable means of achieving politically predetermined quantitative targets accurately. However, the optimal amount is also difficult to determine since the relationship between emission levels and temperature increases and the consequential costs of climate change can only be determined with uncertainty.

One argument in favour of quantity instruments could be the possible avoidance of **tipping points** that are associated with major effects on the climate. ↘ ITEM 24 Quantity instruments are more likely to prevent an overshooting of values (Board of Academic Advisors to the Federal Ministry for Economic Affairs and Energy, 2019). However, determining these tipping points is also associated with great uncertainty and their exact location is unknown.

113. On the positive side, by **setting a price trajectory,** a carbon tax essentially offers more **planning certainty** with regard to the prices of emissions compared to an emissions trading system. This aspect is likely to be relevant to investors in general, and especially for individual decisions on investment goods with long investment cycles such as heating systems or buildings. However, the **taxation of carbon emissions** must be designed as a learning system if it is to achieve the climate policy goals: To address the problem of limited accuracy, the government would need to respond to any deviations from an internationally binding emission reduction target and **gradually adjust** the tax rate over time. Discretionary adjustments are thus an integral part of the mechanism. If the response in quantitative terms is overestimated when the carbon tax rate is initially chosen, the tax rate must be raised accordingly. Hence, initially unexpected tax increases cannot be ruled out.

The set quantitative targets cannot be met if **necessary tax increases are not implemented for political reasons**. There is then a risk that policymakers will instead resort to regulatory measures that unnecessarily increase the cost of climate protection compared to carbon pricing. In addition, assessing the appropriate tax is a more difficult task for citizens than assessing the appropriate quantitative path in an emissions trading scheme, which can be derived directly from the policy objective.

114. However, the problem of **credibly signalling** a binding price of carbon emissions, with a path that is considered by the market participants to be

reliable, also applies to quantity instruments by means of an emissions trading system, albeit to a lesser extent. Renegotiation of the originally desired emission path cannot be ruled out, for example because complying with the path in practice turns out to be unexpectedly expensive. However, if quantity instruments are implemented in a group of several European countries, modifications may be more challenging than for a tax that can easily be changed unilaterally. Addressing this problem by setting a **maximum price** (Edenhofer et al., 2019) would create a hybrid price-quantity system that would limit the achievement of objectives. Ultimately, the success of any system depends on **the ability of policymakers to make credible binding commitments**.

2. Three options for carbon pricing

115. Nevertheless, the question remains how these abstract considerations can be translated into practical climate policy action. A particular challenge arises from the fact that climate policy reforms must be discussed not least with regard to their interaction with the **existing mix of measures**. After all, the EU ETS already functions as an emissions trading system at European level for a significant proportion of emissions. This opens up three functional basic options in the direction of comprehensive carbon pricing:

(1) Sectors that are not yet subject to the EU ETS could be included in the trading system. All sectors would thus be subject to uniform pricing. ↘ ITEMS 116 FF.

(2) The pricing in non-EU ETS sectors could be organised through a separate trading system for emission certificates, which would in the future be merged with the EU ETS. ↘ ITEMS 121 FF.

(3) In the non-EU ETS sectors, an additional carbon tax could be introduced, also linked with the aim of setting up a comprehensive emissions trading system in the future. ↘ ITEMS 125 FF.

The advantages of the individual options differ depending on which criterion is used for the evaluation. There is no clear frontrunner when weighing up the two options (2) and (3) that serve as intermediate steps towards option (1), a comprehensive emissions trading system. Overall, however, all three options are preferable to a regulatory approach. ↘ TABLE 1

116. There are already over **50 different carbon pricing systems** in force **worldwide**, covering around **15 % of global emissions**. ↘ CHART 15 LEFT On average, the price of carbon emissions currently stands at US$2 per tonne of CO2. However, it is much higher in individual systems. ↘ CHART 15 RIGHT In some states that participate in the EU ETS, a tax is also levied on energy sources outside the emissions trading scheme.

↘ TABLE 1

Evaluation[1] of different options for carbon pricing

	Incorporating additional sectors into the EU ETS	Separate emissions-trading system for non-EU ETS sectors	Carbon tax for non-EU ETS sectors	Memorandum item: regulatory law
Achieving the 2021-2030 targets under EU Effort Sharing Regulation	no more national targets needed	when retaining the path for issuing allowances	regular readjustment necessary	challenging, small-scale readjustment necessary
Cost efficiency	cross-sector and EU-wide	within the system boundaries	within the system boundaries	low
Administrative feasibility	medium effort (monitoring)	medium effort (monitoring)	relatively little effort	medium effort (enforcement necessary)
Timely political feasibility	medium term, EU negotiations	short to medium term	short term	short term
Revenue for redistribution	additional revenue	additional revenue	additional revenue	no additional revenue
Reaction to changes in economic conditions	endogenous reaction	endogenous reaction	readjustment difficult	readjustment difficult
Planning reliability for actors	price corridor possible at expense of target achievement	price corridor possible at expense of target achievement	fixed price path only without readjust-ments	depends on design
European link possible	joint EU instrument	linking possible	coordinated tax rates possible	low

1 – green = Option largely meets criterion, yellow = neutral red = option unlikely to meet criterion.

In 1991, for example, Sweden opted for a tax on fossil fuels. France introduced a carbon tax in 2014 (World Bank, 2019). In addition to applying a national carbon tax, Switzerland also operates its own emissions trading system. This system will be linked to the EU ETS under the bilateral agreements (BAFU, 2019). In 2013, the United Kingdom introduced a national minimum price for EU ETS certificates (Edenhofer et al., 2019).

Option 1: Incorporating all sectors in the EU ETS

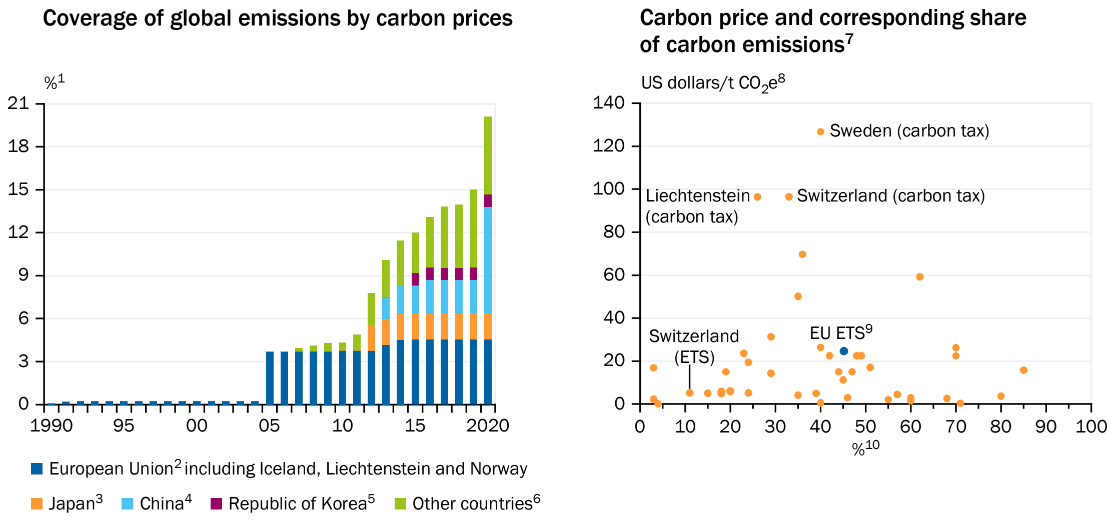
117. Extending the EU ETS to include non-covered sectors in all member states would result in a **uniform, cross-sectoral price within the EU.** ↘ TABLE 1 This should be the **primary goal of all climate policy efforts**. German policymakers should work together with their European partners towards finding majorities in Europe and reforming the EU ETS framework accordingly.

If this action is initially not feasible with all member states, the EU ETS regulations allow other sectors in the member states to be integrated into the emissions trading sector via an opt-in. This integration could take place in a coalition with other member states. A process could thus be initiated that would gradually expand this circle (Edenhofer et al., 2019).

118. By expanding the EU ETS, emission reductions would be made where they are cheapest within the EU ETS, regardless of the sector or member state. **National targets** for the non-EU ETS sectors would **no longer be relevant** as emissions are capped at aggregated level. Even if, due to higher abatement costs,

↘ CHART 15

Carbon price for emissions trading and carbon taxes



1 – Share of global carbon emissions covered by carbon emission trading and carbon tax, respectively, for the year 2012. Before the introduction of the EU ETS in 2005, carbon taxes in Finland, Norway, Poland, Slovenia and Sweden are taken into account. These covered a share of 0.25 % of the global emissions in 2012. 2 – Carbon taxes in Denmark, Estonia, Finland, France, Ireland, Latvia, Poland, Portugal, Slovenia, Spain, Sweden, United Kingdom and EU ETS (including Iceland, Liechtenstein and Norway). 3 – Carbon tax in Tokio and Japan and Saitama ETS. 4 – Pilot ETS in the provinces of Beijing, Chongqing, Fujian, Guangdong, Hubei, Shanghai, Shenzhen, Tianjin and China ETS. 5 – Korea ETS. 6 – Carbon taxes in Argentina, Australia, Canada, Chile, Columbia, Mexico, Switzerland, Singapore, South Africa, Ukraine, USA and ETS in Australia, Canada, Kazakhstan, New Zealand, Switzerland, United States. 7 – Status as at: 1 April 2019. The chart shows individual pricing systems, serveral of which exist concurrently in some countries. 8 – Tonnes CO_2 equivalents. 9 – Including Iceland, Liechtenstein and Norway. 10 – Share of carbon emissions covered by carbon emission trading and carbon taxes within the scope.

Sources: World Bank, own calculations

individual sectors initially contributed less or nothing to the overall CO2 reduction, ↘ ITEMS 132 FF. this would not be a problem. In fact, the specific advantage of this system would be its ability, by means of the uniform price signal, to steer the investment decisions of the market and thus realise an economically efficient reduction path.

Meanwhile, this comprehensive emissions trading scheme would have the advantage that the carbon price would adjust endogenously as the economic situation changes. ↘ TABLE 1 Carbon pricing via an emissions trading system would require a reform of the German tax and levy system, at least in the foreseeable future. Climate change reform may even act as a lever for launching such an already imminent fundamental fiscal reform. ↘ ITEM 126

119. While **extending emissions trading** to previously non-included sectors is not uncontroversial from a legal point of view, it is possible in principle (Büdenbender, 2019). The relevant legislation here is **EU ETS Directive 2003/87/EC**, which was last amended on 14 March 2018. Article 24 of the Directive provides for a unilateral extension of emissions trading to include activities, installations and greenhouse gases not listed in Annex I to the Directive (**opt-in**). The EU Effort Sharing Regulation states, in parallel, that emissions from a member state in the non-EU ETS sectors can be transferred via an opt-in to the EU ETS, thus eliminating the **national target** for these sectors.

The European Commission would have to review a member state's request to include its non-EU ETS sectors. However, the Council and the European

Parliament can oppose a positive decision. There could be **resistance** to some requests, for example, since the price of carbon may rise if additional sectors with higher abatement costs are incorporated (Edenhofer et al., 2019). This is likely to make the short-term implementation of this option considerably more difficult. ↘ TABLE 1

+

While in the past it has often been assumed that the opt-in of individual member states to the EU ETS is legally possible in theory (European Council, 2014; German Environment Agency, 2014), the Federal Ministry for the Environment considers a national opt-in to be legally inadmissible without an amendment of the Directive, with reference to a decision of the European Court of Justice (BMU, 2019c). In particular, the current directive does not allow an upstream or midstream approach because the polluters involved, such as fuel suppliers, do not themselves issue emissions. A downstream approach is also problematic because the directive's definition of installation is based on fixed installations. At the same time, such a downstream approach, starting with the vehicle owner, for example, would require enormous effort to be implemented in practice (BMU, 2019c). ↘ ITEM 119 The question of whether the current directive precludes extending the EU ETS to cover other sectors is disputed. In a midstream system, for example, road users would be liable to pay a charge. However, they would be represented by the fuel vendor for practical reasons. This type of representation rule would be legally permissible since these obligations are not highly personal (Büdenbender, 2019). Concerns that national inclusion does not correspond to the idea of an EU-wide climate change policy (Büdenbender, 2019), could be addressed by having the largest possible coalition of states jointly submitting their non-EU ETS sectors for inclusion in the European emissions trading system. Due to the different legal assessments, a **thorough legal review** is likely to be required. It would also be necessary to clarify how the revenue from expansion is distributed among the member states. The distribution ratio for the auction rights would also possibly have to be renegotiated. In principle, the directive could ultimately be amended. The Council and the European Parliament would have to agree to this: the Council would not require unanimity, but only a qualified majority.

120. Integrating additional sectors in the EU ETS raises issues of practical implementation. The current EU ETS regulates the emission rights for the combustion of fuels in industry and the energy industry. This is a **downstream approach**. ↘ ITEM 58 If the transport and the buildings sector were included in the EU ETS, vehicle owners would have to acquire ownership rights at this level of regulation, for example in the transport sector. This would require disproportionate effort and thus be hardly feasible in terms of practical implementation. Moreover, this may not comply with the current EU ETS definition of emissions, which is based on emissions from stationary installations. ↘ ITEM 118

Meanwhile, an **upstream approach** would apply to mining companies and fuel importers. In this case, the administrative effort would be comparatively low, since the number of potential market participants is likely to be manageable. However, it would be necessary, in particular for a sector-separated emissions trading system, ↘ ITEMS 121 FF. to differentiate between the fuels according to their purpose, in order to avoid imposing a double burden. Recording the actual emissions from a hybrid upstream and downstream system would pose practical challenges. The further upstream the certificate obligation takes effect, the more cost pass-through must be considered, for example, for the effects of pricing.

Alternatively, a **midstream** approach could offer a middle way. Under this approach, fuel suppliers would bear the burden of emissions. For road traffic, these suppliers would mainly comprise petrol stations, bus companies or freight forwarders. The regulatory approach for the energy tax would apply. The European Commission would have to specify the rules in the case of an opt-in to the EU ETS. To avoid imposing double burdens, refund regulations could be introduced under the energy tax (Edenhofer et al., 2019).

121. Edenhofer et al. (2019) emphasise the risks involved if, for example, in the event of rising certificate costs and subsequent political pressure, **political renegotiation** could bring about an increase in the cap on emissions trading. Achievement of the objectives would thus no longer be guaranteed. However, since a similar risk also applies to other climate policy measures, ↘ ITEM 113 the GCEE does not regard this problem as one that is specific to emissions trading and that would require emissions trading to be accorded particular forbearance when considering climate policy instruments. ↘ TABLE 1 Regardless of the choice of specific instruments, it is important that policymakers manage to create a credible system.

Option 2: Separate trading system as a possible transitional solution

122. Extending the EU ETS to include all sectors or agreeing on an opt-in to the EU ETS may prove slow to implement politically. One means of achieving comparatively rapid carbon pricing in the non-EU ETS sectors would be the temporary establishment of a **separate emissions trading system for the non-EU ETS sectors**. The establishment of a separate national trading system is legally possible according to the EU ETS Directive (Büdenbender, 2019). Volumes would be determined on the **basis of the German targets** in the EU Effort Sharing Regulation. This step could also be coordinated in a coalition with other states. These certificates should be auctioned off in order to **redistribute** the additional revenue. ↘ ITEMS 216 FF.

123. However, with the implementation of this type of separate trading system, **cost efficiency** would only exist **within the system boundaries**. For this reason, a single system should be introduced for all of the non-EU ETS sectors, if possible. Separation into different sectors prevents emissions from being reduced where a reduction is most cost-effective. The separately operating emissions trading systems each comprise only parts of the demand for the carbon disposal space. The total reduction therefore first would have to be split between the trading systems in a discretionary fashion. Problems can also arise if a downstream and upstream approach are combined and different points of reference arise. ↘ ITEM 119

124. Nevertheless, such a system could be a **transitional solution** to the expansion of the EU ETS envisaged in the medium term. The greater the divergence

between the prices, the more difficult it is likely to be to subsequently incorporate such a separate system. For instance, the prices in a trading system relating only to transport and buildings could rise rapidly due to the high abatement costs to be assumed in these sectors. A **maximum price** could thus be required to prevent arbitrary political interventions, among other things (Edenhofer et al. 2019, Board of Academic Advisors to the Federal Ministry for Economic Affairs and Energy, 2019). ↘ ITEM 147 However, in this scenario, it would not be possible to guarantee the achievement of the objectives for the non-EU ETS sectors. Nevertheless, in the case of a sector-specific EU ETS that is designed as a transitional solution, a maximum price should be considered in order to avoid extreme price fluctuations. In the medium term, the intended emission reductions would then be achieved more cost-effectively by incorporating the system into the EU ETS.

125. The existing administrative infrastructure for energy taxes could simplify and expedite the **practical implementation** of this new system, since fossil fuels are already recorded (Edenhofer et al., 2019). However, this is a novel instrument which would also be time-consuming to design with legal certainty. Ultimately, all national solutions face complex administrative issues in order to avoid a double burden from the EU ETS and the separate ETS or from the carbon tax (Edenhofer et al., 2019). According to Joas and Flachsland (2016), administrative costs for all pricing options are likely to be relatively similar and therefore irrelevant in the comparison of options.

Option 3: Carbon tax as a possible transitional solution

126. Another transitional solution and an alternative to the temporary establishment of a separate emissions trading system would be a **tax on carbon emissions** in the transport and buildings sectors. This would be comparatively easy to implement if it were based on the existing energy tax. The various tax rates would simply need to be adapted. Companies in the manufacturing sector already benefit from tax concessions arising from the energy tax, which helps them to maintain their international competitiveness. Moreover, no financial market or state aid issues would need to be addressed (Edenhofer et al., 2019). As in the case of an auction of emissions certificates, additional revenue would be available for **redistribution** measures. ↘ ITEMS 216 FF. The tax revenue could be estimated with more certainty than the revenue from an auction of certificates.

127. Essentially there are two options for adapting energy tax rates to the carbon content of the energy sources. The existing tax rates could be taken as a given and an **additional charge could be implemented based on the carbon content**. The various implicit prices of carbon emissions that already exist would then however still be important elements of the carbon tax. Moreover, legal concerns could arise if this option were implemented as part of the existing energy tax (Büdenbender, 2019). In the buildings sector, at least, the tax rates should be aligned solely with the carbon content. ↘ ITEM 100 Alternatively, **comprehensive reform** could be a preferable option. Such reform would

mean that the energy tax would be based solely on the carbon content of the relevant energy source.

If this option is chosen, the **tax rates for fuels would have to fall significantly**. In any case, the objective of these tax rates – to finance the transport infrastructure – could be achieved more effectively with a **distance-related toll** (SRU, 2017). Externalities, such as local air pollution and traffic congestion, would be accounted for in a more targeted fashion with local levies such as a **city congestion charge** (Loeschel et al., 2019; GCEE Annual Report, 2018, Items 30 f.). The **vehicle tax** could then also be levied independently of carbon emissions. With such comprehensive reform, **sustainable financing for the Federal Government** would be supported: the revenue from the energy tax, an important federal tax, could be expected to fall in the long term in the absence of any changes. Such an adjustment to the tax and levy system would have to be made anyway at least in the long term (Edenhofer et al., 2019). This also applies if a carbon price is introduced via emissions trading systems.

128. The **carbon tax amount** and the tax rate trajectories would have to be specified on an ongoing discretionary basis, depending on technological and economic development. As radical changes could become **necessary for readjusting** the tax in order to reach the targets, the question arises of how **planning certainty** could be signalled to the affected taxpayers through credible political commitment. For example, an independent institution could propose a fixed trajectory for the tax rates (Edenhofer et al., 2019). However, the Parliament cannot be denied an opportunity to adjust the tax rates in a tax system once it has been established. Other drawbacks of a carbon price set by carbon taxes are that it does not adapt automatically to economic developments and cannot guarantee that the objectives will be reached.

129. If this option (or option 2) is chosen, efforts should be made to **subsequently incorporate** the taxed sectors **into the EU ETS**. With this goal in mind, the tax could be aligned with the existing price in the EU ETS. However, this would not necessarily correspond to the price that would materialise in a comprehensive emissions trading system and would therefore possibly contribute little to achieving the objectives in the non-EU ETS sectors. A direct connection to the price in the EU ETS through a variable rule, linked to the emission certificate prices, may be constitutionally questionable (Büdenbender, 2019). A common approach with a **coalition of member states** would be possible with this option, whereby these states would agree on minimum rates or standardised tax rates for the energy tax. Full harmonisation, however, might lead to a situation whereby the respective targets agreed at European level in the non-EU ETS sectors would not be met in all member states.

3. Challenges facing implementation

Common approach with other member states

130. Even if advantages could be gained as a result of higher cost efficiency by pricing carbon emissions solely at a national level instead of maintaining the current approach, coordination with the largest possible **coalition of member states** would be advisable. A comprehensive price in a bigger market more effectively exploits the opportunities offered by a division of labour in the reduction of emissions and leads to more efficient achievement of the objectives. Due to the Single Market, the risk of carbon leakage and negative effects on the competitiveness of companies in the EU is particularly large if national solo efforts are attempted. ↘ ITEMS 128 F. These negative effects could be reduced by adopting a common approach.

131. Efforts to persuade the other member states to work together towards an ambitious goal – the expansion of the EU ETS or coordinated taxation, for example – could be better enforced by consistently prioritising the principle of **reciprocity** and providing a systematic regime of access to common funds within the EU. By contrast, the chances of reaching agreement on an ambitious joint effort are likely to be slimmer if German climate policy aspires to a pioneering role by overreaching some of the targets defined at European level.

At the European level, the structural and investment funds could act as a suitable **common fund**, access to which could be linked closely to the implementation of an ambitious pricing system for carbon emissions. In the current multi-annual financial framework (2014–2020), these funds have a total budget of around €460 billion and represent the main instrument for promoting investment in the EU member states.

Around 25 % of the available funds have already been allocated to mitigate the consequences of climate change. Objectives include safe and affordable energy as well as sustainable energy generation and consumption. The funding stream for supporting a low-carbon economy (in the areas of energy efficiency, renewable energy and sustainable mobility) currently amounts to around EUR 45 billion. The accumulated total budget that has been allocated in the current financial framework varies according to member state, including national co-financing, from roughly €12 billion for Poland, to roughly €6 billion for Spain and Italy, and roughly €63 million for Malta.

132. Instead of granting transfers, some member states could benefit during the initial allocation of allowances in an expanded emissions trading system from a disproportionate allocation of emissions certificates. This would effectively separate the issue of efficiency from the issue of burden sharing. For example, member states with energy production that currently relies heavily on fossil fuels could be granted a higher initial allocation of allowances. In the case of an opt-in into the EU ETS, in the current legal situation, not all auction revenue would accrue to Germany. Instead, only revenues equivalent to the **normal auction share** may accrue (Edenhofer et al., 2019). With such an arrangement, there

could be less resistance from other member states if Germany were to opt for the inclusion of additional sectors. That being said, this might also reduce their incentive to take part in a common opt-in.

Uncertainty about abatement costs in individual sectors

133. The **costs of avoiding** greenhouse gas emissions in the various sectors **cannot be observed directly** and must be estimated. While the available studies assume that abatement costs in the **transport and buildings sectors** are on average **higher** than in industry and the energy sector (McKinsey, 2007; BCG and Prognos, 2018), the differences between and within the sectors are difficult to quantify. In particular, future technological developments are hard to predict. It is thus not surprising that before environmental regulations were introduced in the past, abatement costs had often been estimated incorrectly in advance (Harrington et al., 2000; Kesicki, 2010; Vogt-Schilb et al., 2013).

Calculations of abatement costs are by their nature fraught with great uncertainty: they are based on a plethora of assumptions and projections, such as future price trajectories for carbon and fossil fuels, the lifespan of capital goods, learning curves for various technologies or the discount interest rate. These estimates of marginal abatement costs should therefore be interpreted with caution (Kesicki and Ekins, 2012; Taylor, 2012; Ward, 2014).

134. It is precisely for this reason that the introduction of **uniform pricing of carbon emissions** is likely to achieve results. The uniform price of carbon emissions **reveals** the **actual abatement costs** through the avoidance observed in the individual sectors. Only then would it becomes clear which particular measures taken in which particular sectors to reach the reduction targets are associated with the lowest abatement costs. As longer investment cycles are a characteristic feature of non-EU ETS sectors and the conversion of capital stock takes time because of long-term price expectations, a slow but credible increase in the necessary price of carbon emissions would be advisable. In the case of a carbon tax, this could be ensured via a corresponding price path or in an EU ETS via a slower decline in the quantity of certificates. Otherwise, the burden would increase dramatically and households, for example, would not be able to adjust their carbon emissions in the short term (Board of Academic Advisors to the Federal Ministry for Economic Affairs and Energy, 2019).

135. Abatement costs can be roughly divided into three areas (BCG and Prognos, 2018; Agora Energiewende and Agora Verkehrswende, 2019): first, **unexploited potential**, i.e. abatement measures that are cost-effective but have not yet been used and are associated with negative abatement costs; second, **market-based potential** that can be leveraged with comparatively low abatement costs of less than €100; and third, **innovation potential** with higher abatement costs, which is likely only to be exploited in the medium to long term. Various factors determine the reduction in emissions that is ultimately achieved at a particular price. In addition to the **technical options** for replacing carbon-intensive energy sources and the changes that occur to

these over time, social norms and **changes in behaviour** undoubtedly also play an important role.

136. In order to achieve climate neutrality in the long term, measures will have to be implemented that may currently be associated with relatively high abatement costs, such as in transport for example. However, it would be misguided for two reasons to advocate for the establishment of separate, sector-specific systems with the aim of setting incentives now for corresponding investments. First, it is reasonable to first implement the most economically efficient avoidance options **based on the current state of technological development**, in order to allow time for technical progress that will facilitate further economically efficient avoidance options.

137. Second, when making their investment decisions, market participants take into account their **expectations** about future **technological** progress – and do so in conjunction with their **expectations** about planning certainty regarding the framework conditions set by **climate policy**. Once again, the ability of policymakers to credibly commit to a **reliable system of pricing carbon emissions** is key. If this happens, no further measures will be necessary to set incentives for investments in lower-emission capital goods. If market participants do not consider the pricing of carbon emissions to be credible (Vogt-Schilb et al., 2013), or if they get an incorrect price signal through separate pricing systems, substantial misallocations can occur, particularly in long investment cycles.

138. According to BCG and Prognos (2018), the highest abatement costs are incurred in the **transport sector**; the costs are considerably lower in **industry**. Abatement costs vary significantly within the **energy sector** – they are quite high in the case of photovoltaics. According to simulations performed by Agora Energiewende (2017), in most of the scenarios reviewed, an electricity system with a share of 95 % of renewable energy has almost the same cost or even less than a system based on electricity generated from fossil fuels. Coal- or gas-based electricity systems would only be cheaper if prices of carbon emissions were relatively low (Agora Energiewende, 2017).

Global price trends in fossil fuels and carbon, which are difficult to estimate, play a key role in the energy sector. In addition, the expansion of renewable energy is highly dependent on progress in **network and storage expansion** and on flexibility in electricity demand. ↘ ITEM 70

139. Uniform pricing, with supporting measures if applicable, ↘ ITEMS 242 FF. would be associated with lower economic costs than the imposition of different pricing according to sector (Edenhofer et al., 2019). If necessary, distorted investment and consumption decisions could be adjusted more effectively using **complementary instruments**. There are also political and economic reasons why non-uniform pricing should not be implemented: in a sector-specific system, it is not the most cost-effective technologies that carry the day but rather those whose interests are represented most strongly. The German Renewable Energy Sources Act (EEG) has shown how this can be intermingled with industrial policy. In the case of uniform pricing, sectoral hardships can be better

cushioned by free allocation or temporary tax exemptions (Edenhofer et al., 2019).

140. As a result of the assumed difference in abatement costs, the inclusion of the transport and buildings sectors in the EU ETS would be likely to increase the price in the trading system. In the case of a separate pricing system, the price would also be correspondingly higher. However, the expected certificate prices cannot be reliably predicted due to the considerable uncertainty involved. If there is a desire to consolidate the systems in the medium term, the prices may converge relatively quickly due to the expectations of the market players, who can observe the prices in both emissions trading systems and have the option of "banking and borrowing" as soon as politicians announce the merging of the systems. In order to limit the uncertainty around potentially very high prices, acatech et al. (2015), Edenhofer et al. (2019) and the B Board of Academic Advisors to the Federal Ministry for Economic Affairs and Energy (2019) propose introducing a maximum price or a **price corridor** in the expanded EU ETS and in the separate system.

Minimum and maximum prices: a useful addition?

141. The necessity of introducing a **minimum price** is currently discussed for various reasons. For one thing, specifying a minimum price could increase certainty for investors and prevent the devaluation of investments made in abatement technology. For another, according to Edenhofer et al. (2019), the political interventions of recent years, motivated by political and market developments, could diminish the credibility of the EU ETS. In the past, for example, policymakers reformed the EU ETS in response to market developments. This can bring about regulatory uncertainty, in particular regarding the emissions cap, and create the expectation of a price reduction caused by regulatory intervention (Koch et al., 2016; Salant, 2016).

142. These considerations in turn reveal the **importance of a forward-looking approach on the part of market participants**, depending on their expectations of future developments. If they doubt the **credibility** of the long-term, binding emission cap, this may have a negative effect on current prices, since fewer certificates would be held than would otherwise, as a matter of precaution, be the case. Interventions such as the **market stability reserve** (MSR) can certainly counteract this trend by retiring excess certificates. The price increase noted in the last two years points to the fact that market participants expect a relative shortage of certificates in the future due to the MSR.

It is unclear, however, whether the MSR mechanisms will be sufficient to prevent a future fall in prices in the EU ETS, as was observed in the past, for example as a result of the Great Recession of 2008/09. Nevertheless, the price adjustment has a stabilising effect in times of cyclical fluctuations and for this reason is an advantage of this system. Moreover, the MSR will be regularly reviewed – the next review will take place in 2021 – with the result that some **regulatory uncertainty** must be reckoned with.

143. Another reason for introducing a minimum price could be the **obligation**, set out in international negotiations, to introduce such a price. ↘ ITEM 39 Moreover, a minimum price could also prevent a sharp reduction in the emission certificate price as a result of additional national measures that are implemented but not accompanied by a simultaneous cancellation of certificates (Edenhofer et al., 2019). This could prevent the 'waterbed effect', which invalidates, from a climate policy point of view, national measures such as the phase-out of coal. In climate policy terms, buying up emissions certificates as required or eschewing these measures completely would be just as effective as imposing a minimum price. ↘ ITEM 65 Ultimately, a price corridor consisting of a minimum and maximum price could facilitate the future merging of the EU ETS with a temporary, separate emissions trading system, if abatement costs in the non-EU ETS sectors considerably exceed those in the ETS. ↘ ITEM 130

144. In principle, an excess of certificates could be reduced by an **open market policy**, supporting the price (Weimann, 2017). The MSR intervenes in the market as soon as the number of certificates in circulation exceeds a certain threshold. In the case of a minimum price, emissions certificates would be taken off the market if the emission allowance price fell below the minimum price. An alternative possibility would be to establish an independent institution, similar to a **central bank**, which would regularly intervene in the market in order to guarantee compliance with emissions targets (GCEE Annual Report 2013, Item 814).

145. In principle, various options are available for implementing a minimum price (Edenhofer et al., 2019). An auction reserve price could be specified by the **member states**. The price on the secondary market could be below this minimum price. Its effectiveness in relation to mitigation targets would thus depend on the extent to which certificates that were not auctioned due to the minimum price could be cancelled.

A member state that specifies an auction reserve price would probably miss out on **auction revenue**, as market participants might switch to the secondary market. However, should a larger group of states introduce such a minimum price, that would reduce the alternatives and the revenue of the participating states could even rise due to the higher price. However, it is currently almost impossible for states in the EU ETS to withhold or retire certificates unless these become available through the decommissioning of power capacities. ↘ ITEM 63

146. Alternatively, a minimum price could be implemented by introducing a **Carbon Price Support**. In the United Kingdom, for example, fossil fuels used to generate electricity are also subject to a Climate Change Levy. This corresponds to the difference between the desired minimum price and the expected future ETS price. The actual minimum price may therefore differ from the intended price, depending on price development in the ETS. In contrast to an auction reserve price the state receives additional revenue in any case.

While an automatic adjustment of the levy amount to the EU ETS price might prove constitutionally problematic in Germany, a desired minimum price could be implemented in the form of a workaround by means of tax-reducing offsetting of expenses for ETS certificates (Büdenbender, 2019). It would not make sense to introduce a minimum price by this means in Germany only or in several member states without appropriate countermeasures, as only the EU ETS price would be reduced for the other member states and more emissions would be saved in Germany but not EU-wide.

147. It is not clear how high a potential minimum price should be. The current ETS price of around €25 could serve as a starting point. It would also have to be clarified how a minimum price should develop over time and in particular how high it should rise. In addition, emissions trading would lose its character as a purely quantity-based system and would transition into a **hybrid price-quantity system** if a minimum price were introduced. It also remains to be seen whether the price signal in the ETS is really too weak. The low price could simply be a reflection of the low abatement costs that had to be accepted to achieve the upper limit of emissions set in the affected sectors (Weimann, 2017). According to Weimann (2017), the EU ETS would therefore not need to be reformed in order to strengthen a price signal that might be considered too weak; instead this could be achieved by changing the specified emissions cap.

148. In addition to the minimum price, the discussion also sometimes focuses on how to secure a **maximum price**. Since abatement costs could prove not only to be lower but also considerably higher than originally thought, this could risk the acceptance of the established trading system in practice and prompt the intervention of policymakers. If prices suddenly rocketed, policymakers may be tempted to relax the cap or even dismantle the entire emissions trading system. Since market participants are likely to spot the possibility of such a development, this would increase the uncertainty and possibly weaken the price signal. In the case of a maximum price, it should be noted that compliance with the reduction targets is no longer guaranteed. Due to fewer adjustment options in the non-EU ETS sectors, a maximum price could make sense for these sectors if they are moving towards a pricing system.

149. The combination of a minimum and maximum price creates a price corridor, which, depending on how narrowly it is structured, makes an emissions trading system increasingly similar to a tax. Edenhofer et al. (2019) discuss various **options for structuring such a price corridor**. These cover the setting of entry prices and price trajectories that manage to avoid price volatility. However, while companies in other markets might well adjust to volatile prices, this is likely to be more difficult for households in the non-EU ETS sectors.

Challenges in aviation, shipping and agriculture

150. The options mentioned for pricing the non-EU ETS sectors relate primarily to pricing in the buildings and transport sectors, which in 2017 accounted for approximately 64 % of emissions in the non-EU ETS sector (Agora Energiewende and Agora Verkehrswende, 2018). These are already covered by the energy tax, and a trading system would be comparatively easy to implement in these sectors. Truly comprehensive pricing, however, would also have to include the **remaining sectors** in which the challenges facing the

implementation and impact of pricing are more significant for various reasons. For example, in aviation, shipping or agriculture, the risk of **carbon leakage** is greater than in the buildings and transport sectors.

151. **Aviation** has been included in the EU ETS since 2012. ↘ ITEM 57 In November of the same year, however, the European Commission decided to temporarily exclude flights to and from third countries. This is still the situation today. In Germany there is also a ticket tax. ↘ ITEM 103 Negotiations are currently ongoing regarding a global market-based procedure to reduce emissions (DEHSt, 2017). According to the Chicago Convention, which codifies civil aviation rules, participating countries are responsible for the emissions of national flights, while the ICAO covers **emissions from international flights**.

In 2018, the ICAO member states concluded an agreement intended to counter rising aviation emissions (**CORSIA**). During the monitoring phase (2019 and 2020), the airlines must report their emissions to the national environment agencies. Starting in 2021, carbon emissions that exceed 2019 and 2020 levels will have to be offset by project credits and emission allowances (DEHSt, 2019b). Participation in this system is on a voluntary basis up to 2026. To date, 78 countries, which account for roughly three-quarters of aviation emissions, have confirmed their participation. The effectiveness of CORSIA, however, remains a contentious issue, particularly because it **only monitors the growth in emissions**.

152. **Shipping,** which accounted for roughly 2.6 % of global carbon emissions in 2012, is not included in the EU ETS. A global emissions reduction regime, comparable to that in aviation, does not exist. The slow progress made by the International Maritime Organization (IMO) in negotiating a strategy to reduce emissions in this sector led to the intervention of the European Commission. To date, however, its 2013 strategy has only established a **monitoring** framework and emissions reports. Concrete measures to reduce emissions have not yet been developed.

In 2018, reduction targets were defined. These envisage a 50 % reduction in carbon emissions by 2050 compared to 2008 levels and a reduction in carbon emissions per transport service by 40 % by 2030. The European Commission will review potential measures to be taken by the IMO up to 2021 with regard to the targets and if necessary decide additional measures from 2023 on (Deutscher Bundestag, 2018d; European Commission, 2019c).

Due to the global dimension of aviation and shipping, even measures that are taken at European level are limited. It is conceivable that shipping could be covered by the EU ETS, in the same way that aviation is already covered. Experience has shown that negotiation processes in international aviation and shipping tend to be rather protracted (SRU, 2017). Nevertheless, the EU should advocate global pricing of carbon emissions in both of these sectors at international level.

153. **Agriculture** is not covered by the EU ETS either. Due to the large number of businesses (just under 300,000 in Germany alone) and the various greenhouse

gas emissions in this area, pricing of emissions is difficult. The **high transaction costs** in particular may hamper the integration of agriculture in emissions trading (German Environment Agency, 2013, Scientific Advisory Boards of to the Federal Ministry of Food and Agriculture, 2016). In view of the substitution options for food imports, a review should also be carried out on how to avoid **carbon leakage**. These **issues should be clarified** before agriculture is included in emissions trading.

154. The EU's **Common Agricultural Policy** (CAP) could offer an alternative approach to reducing greenhouse gases in agriculture. The extensive payments made to farmers under this policy could provide powerful leverage in stimulating lower-emission agriculture. This would require an agricultural policy that focuses on reducing greenhouse gas emissions (Lünenbürger et al., 2013; Scientific Advisory Boards of to the Federal Ministry of Food and Agriculture, 2016; Grosjean et al., 2018).

In addition, possibly misguided tax incentives in agriculture could be eliminated. One measure could be to abolish the preferential treatment of agricultural diesel under the fuel tax system in the entire EU (Lünenbürger et al., 2013). The **taxation** of animal products at the full VAT rate may also be considered in principle; but distribution effects would have to be considered (German Environment Agency, 2013; Scientific Advisory Boards of to the Federal Ministry of Food and Agriculture, 2016). An alternative consideration could be to improve consumer education regarding a healthier and more climate-friendly diet (Lünenbürger et al., 2013; Scientific Advisory Boards of to the Federal Ministry of Food and Agriculture, 2016).

V. CO_2 EMISSIONS IN GERMANY: A SNAPSHOT

KEY STATEMENTS

- On the production side, more than three-quarters of CO2 emissions are generated by companies. Roughly 70 % of emissions from domestic consumption can be attributed to households.
- Although companies' carbon intensity varies considerably across industries, this provides only a small part of the explanation for the substantial differences across regions.
- Households' carbon consumption rises exponentially in their income but increases less than proportionally in household size. The degree of urbanisation plays only a minor role.

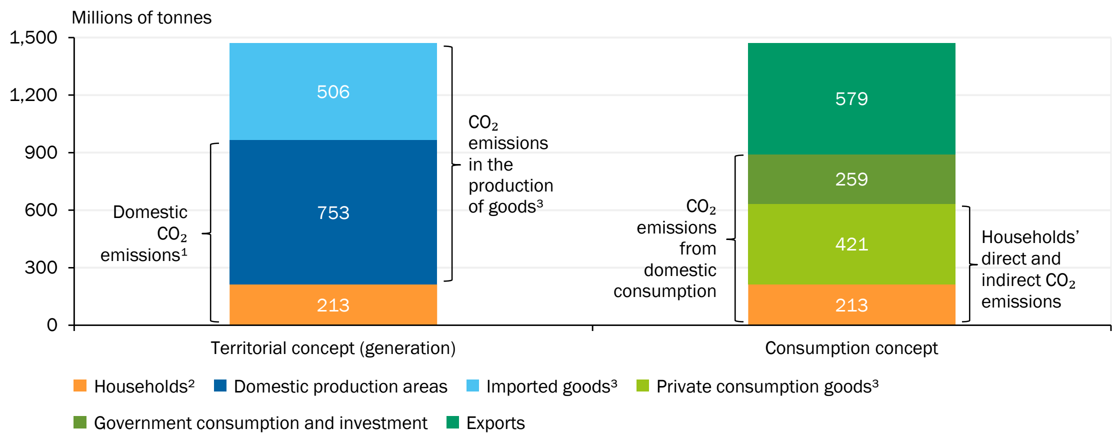
155. A uniform price for greenhouse gas emissions will ensure that the **reduction of emissions** needed to meet a prescribed target is achieved **economically efficiently**, i.e. with the smallest possible use of economic resources. There are therefore strong arguments in favour of pursuing this climate policy route. But this raises further economically relevant questions: Who has to pay this price, who has to bear the adverse consequences of this price (which is by no means the same thing), and what adjustments in behaviour will carbon pricing cause? These questions relate not just to the sectors outside the EU ETS but also – owing to the anticipated rise in prices within the EU ETS – the actors already covered by this scheme (Edenhofer et al., 2019). In order to answer these questions we need to consider:

- where **CO2 emissions** occur in Germany, who is responsible for their emission and what activities they are undertaking to cause the emissions,
- what mechanisms and market conditions explain that those having to pay carbon prices and those having to bear the adverse consequences of these prices may not be the same people, and
- how many CO2 emissions are caused by households' consumption and investment decisions and how these emissions are **distributed.**

1. Exported and imported CO_2 emissions

156. The **System of Environmental Economic Accounting (SEEA)** provides a quantitative overview of the links between economic activity and environmental consumption. It is primarily represented in the form of input-output tables. **CO2 emissions** can be recorded on the production side and consumption side in line with the national accounts. ↘ CHART 16 On the **production side** a distinction is made between emissions from the production of goods and direct emissions from households. The domestic production of goods generated CO2 emissions of 753 million tonnes in 2015. A further 506 million tonnes can be attributed to imported goods. Households emitted around 213 million tonnes of CO2 from heating and transport.

↘ CHART 16
Direct and indirect CO_2 emissions in Germany in 2015



1 – Excluding emissions from residents' transport services abroad. 2 – Includes households' direct emissions from transport and buildings.
3 – Includes goods and services.

Source: Federal Statistical Office

157. The emissions recorded in the **consumption account** are broken down into domestic consumption of goods, exported goods, and households' direct emissions. 680 million tonnes of the total CO2 emissions from the production of goods are attributable to domestic consumption, while 579 million tonnes can be attributed to exports. These are supplemented by households' direct emissions, which amount to 213 million tonnes.

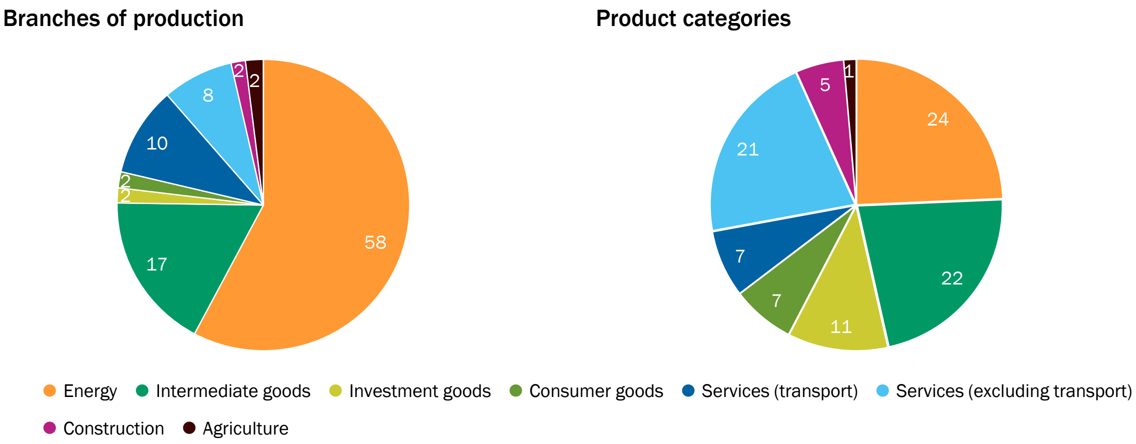
In addition to their direct emissions, **households** cause indirect emissions as a result of their consumption decisions. According to the consumption account, roughly **70 % of** emissions **from domestic consumption** can be attributed to households. The remaining emissions from domestic consumption are attributable to fixed capital formation, government consumption, private organisations' consumption, and stockpiling.

2. More than three-quarters of emissions generated by companies

158. More than 75 % of the CO2 emissions occurring in Germany are generated by companies. The majority of these can be attributed to industry and the energy sector. ↘ CHART 17 LEFT Although these sectors are already covered by the **EU ETS**, its **potential extension to other sectors** and the more demanding **reduction factor in the EU ETS** ↘ ITEM 62 could mean that industry faces the challenge of higher carbon prices. This could confront the workers and regions affected with considerable challenges. There is also a risk that certain energy-intensive sectors might cut back on their production in Germany and offshore it to other countries. ↘ ITEMS 180 FF. The potential adverse impact of a higher carbon price would depend, however, on the extent to which the higher costs could be passed on to other companies and to consumers. ↘ ITEM 173

↘ CHART 17

CO_2 emissions and carbon content by branches of production and product categories in 2015[1]
Shares (%)



1 – According to the Classification of Economic Activities, edition 2008 (WZ 2008) or the Classification of Products by Activity, edition 2008 (CPA 2008). Classification differs slightly from the usual classification owing to lack of disaggregated data. Discrepancies in the totals due to rounding.

Sources: Federal Statistical Office, own calculations

159. From the perspective of companies, a distinction can be made between the **direct CO2 emissions from production** and the **implicit carbon content of goods** including the emissions caused throughout the supply chain of intermediate goods. The majority (58 %) of direct CO2 emissions occurring in 2015 was caused by **energy generation**. ↘ CHART 17 LEFT A further 17 % was caused by the production of intermediate goods such as raw materials and chemical products. By contrast, the remaining sectors of the economy account for only around a quarter of direct emissions.

However, an analysis of the implicit carbon content of goods reveals a different picture. Whereas energy accounts for only just under one quarter of emissions here, other industrial goods' share of total emissions rises from 21 % to 40 % ↘ CHART 17 RIGHT Services account for 28 %of emissions in terms of consumption compared with 18 % in terms of production. Because some goods **require intermediate goods** that are produced with a high energy intensity and because they also use **large amounts of electricity**, these goods' implicit carbon content is several times higher than the amount of emissions caused by their production. For example, the implicit carbon content of machinery and vehicles is approximately ten times higher than the direct emissions caused by their production.

160. In addition to the absolute quantities of emissions, the **carbon intensity of the value-adding process** is a key metric for assessing the impact that higher carbon prices could have on companies. Because this metric measures the CO2 emissions in relation to the gross value added, it helps to assess companies' additional costs better. In addition to energy supply, coking plants and oil processing, shipping and aviation services are especially carbon intensive. ↘ TABLE 2 The manufacture and production of glass, metals, wooden goods and paper are also highly carbon intensive.

↘ TABLE 2

The 10 economic sectors with highest carbon intensity in 2015

Economic sector[1]	Carbon intensity	Gross value added
	Tonnes of CO_2 per € million gross value added	€ billion
Energy supply	8,718	45
Manufacture of coke and refined petroleum products	4,337	6
Water transport services	4,281	6
Air transport services	3,076	9
Manufacture of other non-metallic mineral products	2,370	17
Manufacture of basic metals	1,924	22
Manufacture of paper and paper products	993	11
Manufacture of wood and of products of wood and cork, except furniture	862	7
Agriculture	827	16
Mining and quarrying	656	5

1 – According to the Classification of Economic Activities, edition 2008 (WZ 2008).

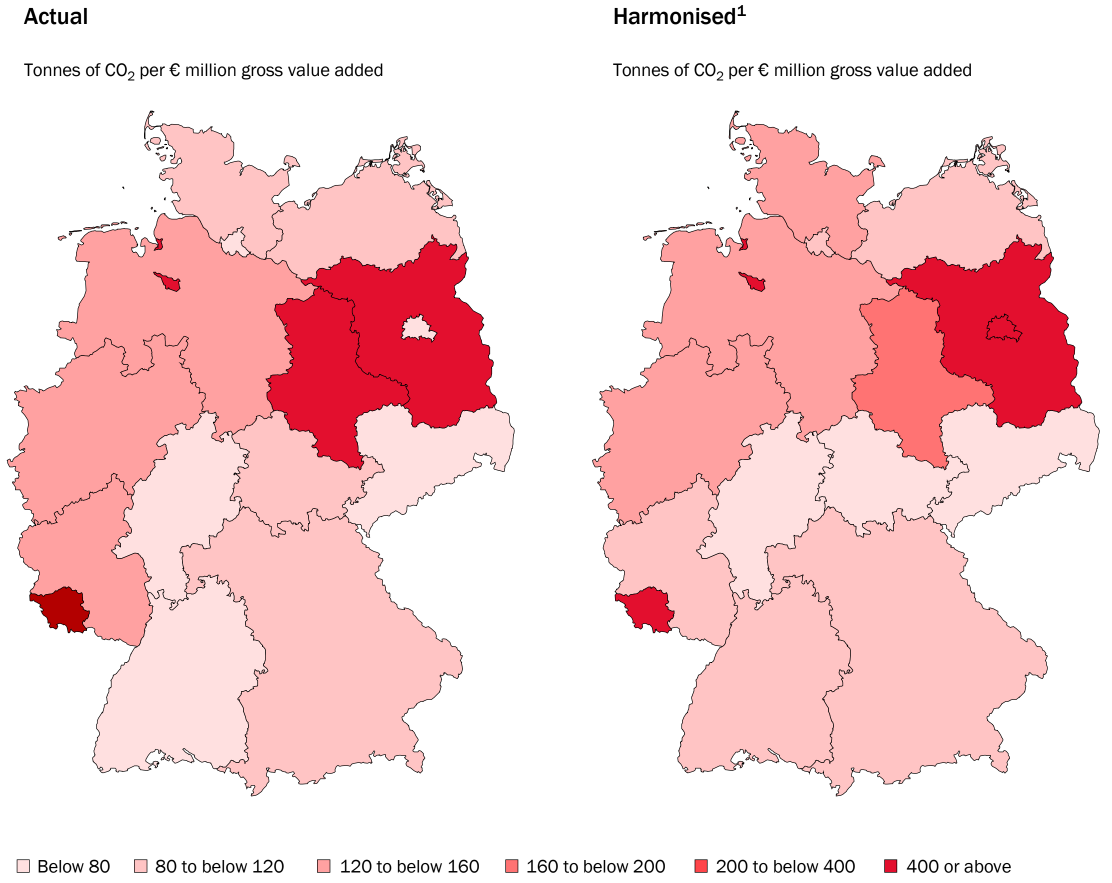
Sources: Federal Statistical Office, own calculations

161. The production-related **generation of emissions** also reveals significant **variations between the German regions**. A particularly high level of carbon intensity can be found in Bremen, Brandenburg, Saarland and Saxony-Anhalt. ↘ CHART 18 LEFT One likely reason for this is that these federal states feature high concentrations of especially carbon-intensive industrial sectors such as, for example, **steel production** or **coking plants and oil processing**. Ready access to cheap sources of energy near coalfields and ports in particular has historically encouraged such energy-intensive industries to locate in these regions (Gutberlet, 2012; Chatterji et al., 2014; Glaeser et al., 2015). Eight out of ten of the biggest carbon polluters among the German industrial plants covered by the EU ETS, for example, are located near coalfields (DEHSt, 2019c).

162. Furthermore, variations in carbon intensity among federal states could be due to differences in the region-specific carbon intensities of the sectors concerned. **Decomposition analysis** can be used to determine whether this factor or the different economic structure is more important. In order to calculate a hypothetical harmonised carbon intensity, this analysis assumes that all regions have the same economic structure. Remaining differences in the **carbon intensity** calculated in this way thus merely reveal to what extent the various sectors (agriculture, mining, ten subcategories of manufacturing, water supply and disposal, construction and services) in these federal states possess varying **region-specific carbon intensities**.

Despite having been adjusted for differences in economic structure, most of the variations across regions remain: roughly 80 % of them are explained by the region-specific carbon intensities of the sectors concerned and only 20 % are explained by the economic structure. This is illustrated by the significant

↘ CHART 18
Carbon intensity by federal state for all sectors except energy in 2014



1 – For the purposes of this calculation it is assumed that the economic structure in all federal states corresponds to the economic structure of Germany as a whole and that only the region-specific emissions intensities of the individual sectors differ.

Sources: Environmental-Economic Accounts of the Länder, Federal Agency for Cartography and Geodesy, Federal Statistical Office, National Accounts of the Länder, own calculations

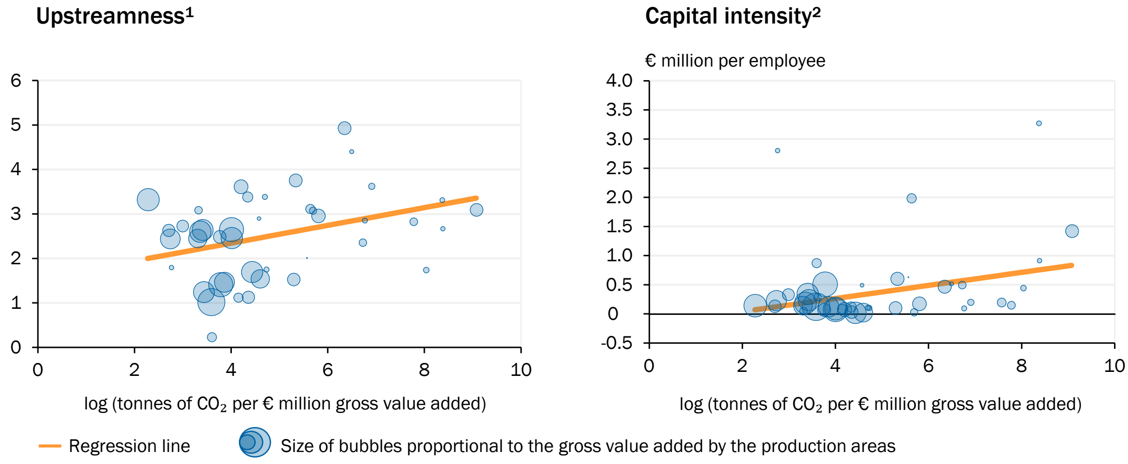
remaining variation in the colouring used to represent harmonised carbon intensity. ↘ CHART 18 RIGHT

163. Energy supply has been excluded from this analysis because the strong **regional concentration of the conventional generation of electricity from coal** and its very high carbon intensity would otherwise conceal the variations in the other sectors. The differences in the sectors' region-specific carbon intensity expressed in these harmonised calculations can partly be explained by the fact that within the individual sectors there are substantial differences between the industries combined therein. Federal states with a higher proportion of companies engaged in basic chemicals or refineries, for example, reveal a much higher carbon intensity in the fields of "chemical products, coking plants and oil processing".

An analysis of companies in the manufacturing sector shows that there are **significant variations** in carbon intensity even **within narrowly defined industries**. This is consistent with findings for the United States (Muehlegger and Sweeney, 2017). Calculations based on AFiD-data for Germany reveal that

↘ CHART 19

Carbon intensity and industry characteristics



1 – Average number of further processing steps until the final use (Antras et al., 2012). 2 – Value of equipment relative to the number of employees.

Sources: Federal Statistical Office, own calculations

roughly half of the differences in carbon intensity in the manufacturing and mining sectors can be explained by the level of heterogeneity within the 255 industries, while the other half can be attributed to differences between the industries (Research Data Centre (FDZ) of the Federal Statistical Office, 2019). This heterogeneity is partly due to the fact that different production methods are used within the industrial sectors. Steel production using the electric-arc furnace process, for example, generates just one quarter of the CO2 emissions – per tonne of crude steel – that are generated by production in traditional blast furnaces (Zuliani et al., 2010).

164. Carbon-intensive companies often manufacture important **intermediate products for other industries**. An industry's importance for downstream sectors can be measured in terms of its upstreamness (Antràs et al., 2012). This measure indicates how many downstream sectors an industry's goods pass through before they are consumed as part of an end-product. Most industries with high levels of direct CO2 emissions can be found at upstream stages of the value chain and are thus characterised by a high degree of upstreamness. ↘ CHART 19 LEFT This means that the total carbon intensity of goods in downstream sectors – the calculation of which must include the CO2 emissions generated by the production of intermediate goods – often turns out to be much higher than its direct carbon intensity.

In addition, carbon-intensive sectors are characterised by a **high level of capital intensity**. ↘ CHART 19 RIGHT These sectors typically require large amounts of capital equipment for production purposes; the energy intensity of existing plant and equipment can be assumed to remain unchanged (Atkeson and Kehoe, 1999). The associated very lengthy investment cycles, which are especially typical of the basic-materials industries, restrict any potential emissions-avoidance strategies (Boston Consulting Group and Prognos, 2018).

3. Carbon consumption rising in income

165. On the consumption side, **households are the largest generators of CO2 emissions**. As with companies, households are highly heterogeneous in this respect because they vary substantially in terms of their consumption behaviour and the associated quantities of emissions. A carbon price would accordingly impact individual households in different ways.

Using the currently available data from the survey of income and expenditure (EVS) and the System of Environmental Economic Accounting (SEEA), we can calculate that **German households** emitted an average of around **13.4 tonnes of CO2** in 2013. However, this presumably underestimates average carbon consumption. Based on the absolute figures of the SEEA and the population statistics, consumption amounts to 16.7 tonnes of CO2 per household in 2013. This discrepancy is, however, of a methodological nature. ↘ BOX 3

↘ BOX 3

Using the EVS and the SEEA to determine CO_2 emissions for households

As proposed by Wier et al. (2001) and Gill and Moeller (2018), two data sources are used to determine a household's CO_2 emissions. Information on households' consumption behaviour is obtained from the survey of income and expenditure (EVS), which provides consumption-related information on more than 52,000 households every five years. The System of Environmental Economic Accounting (SEEA) can be used to determine the CO_2 emissions per euro spent for 52 different groups of goods and for households' direct energy consumption and then to combine this data with the information obtained from the EVS. Other greenhouse gases are not considered here.

One caveat worth mentioning here is that the two data sources are subject to different types of classification. The EVS classifies households' consumption according to the purpose for which it is used, whereas the SEEA classifies it according to groups of goods. It is therefore necessary to transform the data from the SEEA by using correspondence tables and a weighting algorithm. For simplicity's sake it is assumed here that the individual goods within the 52 groups of goods generate identical CO_2 emissions. Because of the aforementioned transformation, 5 % of the total CO_2 emissions cannot be considered. These primarily include emissions from biomass and other renewable energy. Taken together, the CO_2 emissions per euro spent can be determined for 46 different uses.

One important limitation arises from the fact that differences within individual consumption categories have to be neglected as they are not identified in the EVS. It must be assumed here that the relative composition of the basket of goods within each of the categories is independent of the households' socio-demographic characteristics. Furthermore, where households have not given any information about their heating costs it is necessary to reconstruct the missing values by means of imputation. In addition, it must be assumed that the quarterly consumption data recorded in the EVS is representative of the entire year. On the whole, the relative distribution of emissions according to consumption category can be compared with other calculations (German Environment Agency, 2018c). However, carbon consumption tends to be underestimated here. But, despite these limitations, the EVS makes it possible to analyse all household spending consistently with a sufficiently large sample and, in addition, to be able to draw on various household characteristics.

Multiple regression models can be used to relate the heterogeneity within cumulative carbon consumption and within the consumption categories of energy, transport, and other goods and services to key socio-demographic variables. Based on simplifying assumptions, this allows to identify households that would be particularly adversely affected by carbon pricing. ↘ TABLE 3

↘ TABLE 3

Regression analysis of the factors explaining household's CO_2 consumption

	Total	Energy	Fuels	Other products and services[1]
Dependent variable: Annual CO_2 consumption (in logged tonnes) by spending category[2]				
Net equivalent income[3] (in €100)	0.020 ***	0.007 ***	0.021 ***	0.021 ***
	(0.000)	(0.000)	(0.000)	(0.000)
Urbanisation of place of residence (reference: town)[4]				
Agglomerations[5]	– 0.020 ***	– 0.014 **	– 0.144 ***	0.045 ***
	(0.004)	(0.005)	(0.007)	(0.004)
Rural area[6]	0.006	– 0.010	0.046 ***	– 0.007
	(0.005)	(0.008)	(0.010)	(0.005)
Number of household members (reference: one person)				
2 persons	0.398 ***	0.288 ***	0.414 ***	0.343 ***
	(0.004)	(0.005)	(0.007)	(0.004)
3 persons	0.594 ***	0.404 ***	0.703 ***	0.508 ***
	(0.005)	(0.007)	(0.010)	(0.006)
4 or more persons	0.744 ***	0.503 ***	0.872 ***	0.659 ***
	(0.005)	(0.007)	(0.010)	(0.005)
Constant	1.862 ***	1.309 ***	0.337 ***	1.087 ***
	(0.006)	(0.007)	(0.010)	(0.006)
Quarter fixed effects	yes	yes	yes	yes
Number of observations	48,714	48,714	48,714	48,714
Adjusted R^2	0.583	0.201	0.349	0.547

1 – Total of CO_2 consumption arising from food, goods and services. 2 – The logarithmic function would remove from this analysis households that do not report any spending in the category concerned. 1 is therefore initially added to the dependent variable and only then is it logarithmised. 3 – Monthly household income is weighted according to the OECD scale. 4 – Place of residence with the high-density population that lacks a surrounding regional centre. 5 – Regional centres (towns with more than 100,000 inhabitants) or densley populated places of residence with regional centre nearby. 6 – Place of residence with a low population density.

Robust standard errors in parentheses.
***, ** and * constitute a significance at the 1 %, 5 % and 10 % level

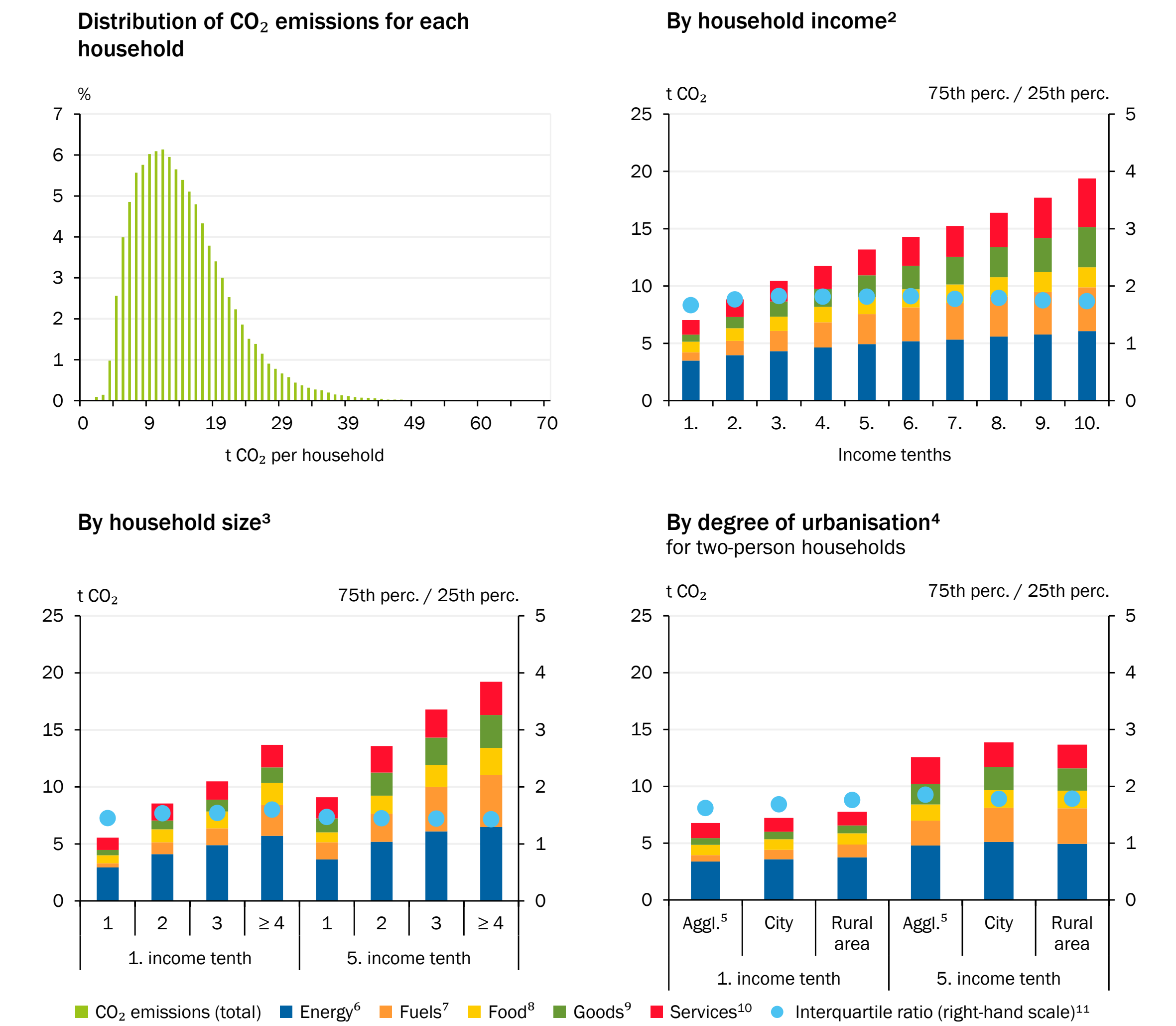
Sources: Federal Statistical Office, RDC of the Federal Statistical Office and Statistical Offices of the Länder, Einkommens- und Verbrauchsstichprobe 2013 Grundfile 5 (HB), own calculations

It is evident that carbon consumption in the form of energy is highly heterogeneous. Whereas, in the other consumption categories, the coefficient of determination suggests that at least one third of heterogeneity can be explained by only three variables, the explanatory power of income, household size, and degree of urbanisation within energy consumption is very small. This explanatory power is only significantly increased if the heating system and the dwelling size are taken into account.)

166. Despite their methodological limitations, the calculations indicate the differences in **emissions** across households. ↘ CHART 20 TOP LEFT The main reason for these differences is the **disposable household income**. Whereas a household in the bottom income decile emitted an average of 7.0 tonnes of CO2 in 2013, a household in the fifth income decile generated almost twice the amount of carbon. This quantity is almost three times as high in the top decile. ↘ CHART 20 TOP RIGHT However, this increase in CO2 emissions is less than proportional to income. The EVS shows that the average net equivalent income in the top income decile is almost six times as high as in the bottom decile. If regression

↘ CHART 20

Households' average CO_2 emissions in 2013[1]
by purpose of use and household characteristics



1 – Data weighted using extrapolation factors. 2 – Equivalence-weighted net household income. Average values for income tenths. 3 – Number of household members. 4 – Classified as either agglomerations, urbanised areas or rural regions. Agglomerations are regions with a population density greater than 300 inhabitants per square kilometre or otherwise they are residential areas with a nearby regional centre that has more than 100,000 inhabitants. Urbanised areas are lower-density residential areas, possibly with a regional centre in the vicinity. Rural areas are residential areas with a low population density and without any regional centre nearby. 5 – Agglomerations. 6 – Emissions caused by electricity and heating. 7 – Emissions caused by fuel consumption. 8 – Emissions caused by food, beverages and tobacco products. 9 – Emissions caused by spending on clothing, fixtures and fittings, and other goods. 10 – Emissions caused by spending on services for healthcare, communication, education, catering and other services. 11 – Relationship between the 75th percentile and the 25th percentile within the group under consideration.

Sources: Federal Statistical Office, RDC of the Federal Statistical Office and Statistical Offices of the Länder, Einkommens- und Verbrauchsstichprobe 2013 Grundfile 5 (HB), own calculations models are used to control for other socio-demographic characteristics, annual CO2 emissions will rise by an average of 2.0 % for every €100 of disposable monthly income. ↘ TABLE 3

167. However, the **heterogeneity** between income deciles is not just reflected in the absolute amount of carbon consumed. In the bottom income decile almost half of emissions are caused by heating and electricity consumption. Individual mobility and the consumption of goods and services are less important. **Only in higher income groups do consumer goods and fuel consumption** assume greater importance. ↘ CHART 20 TOP RIGHT

168. There is also **considerable heterogeneity within the income deciles**. The third quartile in terms of CO2 emissions within an income decile, for example, is roughly twice as high as the corresponding first quartile. ↘ CHART 20 TOP RIGHT This heterogeneity can partly be explained by further household characteristics. These factors significantly reduce the ratio between quartiles and, therefore, the distribution if we control for household size. This is because carbon consumption rises sharply as the number of household members increases. ↘ CHART 20 BOTTOM LEFT Nonetheless, this increase is less than proportional as a result of returns to scale. ↘ TABLE 3

169. The **degree of urbanisation of the place of residence** explains the heterogeneity between households to only a small extent. ↘ CHART 20 BOTTOM RIGHT Households in agglomerations – i.e. regions that constitute a major centre or are located near such a centre – emit 2 % less carbon per year on average than households in urbanised or rural regions. This is partly due to their often more carbon-efficient heating and partly because of their lower vehicle density (Gill and Moeller, 2018). The differences between urbanised and rural areas are fairly small and mainly relate to their fuel consumption. ↘ TABLE 3

170. These calculations based on the EVS and the SEEA are largely consistent with the findings of the international literature (Druckman and Jackson, 2016). Disposable **income** and **household composition** are always identified as the **driving forces** behind household-specific CO2 emissions. It also becomes clear that food assumes a much greater importance as soon as other greenhouse gases are included in the calculation.

VI. MAINTAINING COMPETITIVENESS, PROMOTING INNOVATION

KEY STATEMENTS

- The burdens on companies vary considerably from one industry to another, depending on their energy intensity and the extent to which they can pass the costs on to consumers.
- A border tax adjustment could be considered if the free allocation of allowances is no longer sufficient to mitigate negative effects on industry competitiveness.
- Innovations are crucial to achieving the climate goals. In addition to the pricing of CO2 emissions, a technology-neutral promotion of basic research is indispensable.

171. An expansion of carbon pricing leads to additional burdens on companies and households. However, the burden does not necessarily have to be borne by the market participants who generate the emissions. The actual **burden depends largely on the extent to which costs can be passed on**. Companies competing internationally, in particular, can often pass on only a smaller share of their costs. Furthermore, carbon pricing can lead to companies in some industries transferring operations to countries with lower carbon prices **(carbon leakage**). In order to maintain the **competitiveness** of these economic sectors, a **reduction in existing taxes and charges** can be considered in addition to the free allocation of allowances in the EU ETS.

172. The carbon price also has an impact on **growth and employment**. On the one hand, higher energy prices could reduce incentives for investment in Germany and thus slow down growth of the capital stock. On the other hand, a carbon price provides incentives for research into more efficient technologies. Their development could mitigate the negative macroeconomic impact in the long term. Government research funding that ensures competition between **technologies** therefore has an important role to play.

1. Estimate of the burden on enterprises

173. The **financial burden on** households and companies resulting from a carbon price or an additional increase in that price can be **estimated** in the short term, assuming stable production and consumption structures. However, carbon pricing has an explicit steering function: **adjusting the behaviour** of households aims to bring about a **substitution** towards consumer goods and consumption with lower emissions. The idea is for companies to use inputs and technologies that are less emissions-intensive. The changes in behaviour depend to a large extent on whether alternative goods and technologies are available. The larger the changes, the smaller the financial burden of the carbon price. In the medium term, households are likely to purchase more **low-emission consumer goods**

and companies to invest in **more energy-efficient machinery, equipment and production processes** in order to reduce the burden of carbon pricing at a given price signal.

Companies are only burdened if costs cannot be passed on in full

174. A quantitative analysis of the burden's effects is generally hampered by the fact that the actual economic burden **(incidence)** is not always borne by those market participants who, in practice, must initially pay the carbon price. Rather, part of the burden is usually **passed on to other market participants**. Price elasticities and the intensity of competition play a key role in the extent to which costs can be passed on. The degree to which supply or demand reacts to price changes depends on **price elasticities**. In addition, the **intensity of competition** influences the extent to which companies can adjust their price mark-ups as a result of cost increases and thereby change the degree to which costs can be passed on. Furthermore, institutionally induced market rigidities can limit cost pass-through and avoidance reactions.

Many studies have researched cost pass-through and avoidance reactions particularly in relation to taxes, energy-price increases and the effects of the EU ETS in the energy sector. ↘ BOX 4 Studies indicate that **a high percentage of the carbon price** is likely to be passed on to **end consumers**.

↘ BOX 4

Companies' cost pass-through of energy taxes

The scientific literature on cost pass-through deals primarily with the question of which **price adjustments** companies make towards **their customers** as a result of cost increases. In perfect competition, cost pass-through depends exclusively on **supply and demand elasticities**, since – unlike in the case of imperfect competition – there are no mark-ups that could be adjusted by the companies (Jenkin, 1872; Weyl and Fabinger, 2013; Ganapati et al., 2019). Therefore, in this case the more strongly the supply – or the more weakly the demand – react to price changes, the bigger is the share of the burden that must be borne by the demand side. However, **imperfect competition** is observed in many markets, for example in the form of monopolies or oligopolies, making it possible for companies to demand a mark-up on their marginal costs. In this case, companies will bear a larger share of the tax burden because their mark-ups are reduced (Deltas, 2008; Goldberg and Hellerstein, 2013).

Estimates of the degree of cost pass-through are available for **individual raw-material-intensive sectors of the economy** with otherwise low inputs of intermediate goods, such as the energy supply (e.g. for the costs of EU ETS allowances), oil refineries and filling stations. For the Spanish **electricity market**, Fabra and Reguant (2014) estimate that **energy suppliers** pass on 100 % of costs in periods of high demand and 60 % in periods of low demand. It has been estimated for the German electricity market that a total of about 100 % of the costs of EU ETS allowances was passed on (Hintermann, 2016). It is therefore assumed in the EU ETS that electricity producers can in principle pass on the costs in full, and no allowances have been allocated to them free of charge since 2013. The resulting burdens on electricity-intensive industrial companies in Germany are reduced by electricity price compensation. ↘ ITEM 188

For **petrol stations** in the USA, Deltas (2008) estimates a medium-term cost pass-through of about 95 % in the most competitive regions and about 85 % in the least competitive regions. Marion and Muehlegger (2011) show for the USA that 100 % of changes in fuel taxes on diesel and gasoline are passed on. Lower rates of cost pass-through can be observed in times of limited supply, which have the same effect as greater market power and therefore, taken alone, lead to comparatively high prices. In Spain, the average cost pass-through for tax increases on fuel also amounts to 100 % (Stolper, 2016). However, the rate of cost pass-through varies quite widely – from 70 % to 120 % – between individual filling stations. Unlike the results of the studies for the USA, a higher degree of cost pass-through can be observed there in regions with greater market power.

Muehlegger and Sweeney (2017) study the cost pass-through of higher crude-oil prices by **oil refineries** in the USA. The figures show that industry-wide cost increases are almost completely passed on, whereas this is not the case with refinery-specific increases. A simulation on the introduction of a carbon tax including a border adjustment estimates the cost pass-through of the entire industry at 95 %; refineries that are more carbon-efficient pass on much more, and less efficient refineries significantly less. Without a border tax adjustment, however, only around 35 % of the costs would be passed on due to international competition. Overall, in the observed industries with predominantly local or national demand, the degree of cost pass-through is close to 100 %, while industries competing internationally can only pass on a smaller portion of the costs.

Ganapati et al. (2019) have estimated the pass-through of energy-cost increases at the company level in the USA for various sectors of the economy with homogeneous products, such as **cement or concrete**. For most of the industries considered, the degree of cost pass-through is between about 70 % and 100 %. Since the **cost increases** used for the estimate are **region-specific**, these results represent a lower estimate of the extent of cost pass-through when a national carbon price is introduced, taking the findings of Muehlegger and Sweeney (2017) into account. For, in the case of regional cost shocks, consumers can switch to products from other regions whose costs and prices have not increased. This restricts the ability of firms affected by the regional cost shock to pass costs on.

In the case of **national cost shocks**, these avoidance reactions are greatly reduced, and a larger proportion of the costs can be passed on. The extent to which more costs are passed on in the event of national shocks depends on how easily the products can be traded over longer distances. In Germany, the degree of cost pass-through has been estimated for different production factors in individual energy-intensive sectors (Alexeeva-Talebi, 2010). Energy costs in particular can be passed on almost completely in most industries.

Most studies therefore suggest that the **bulk of a carbon price** is likely to be **passed on** to final consumers, with the extent of cost pass-through varying according to the competitive situation and the area where the price applies.

Large differences in the scale of the burden

175. Pricing CO2 emissions would affect the various economic sectors differently. The burden on individual sectors of the economy depends on the input-output structure and the extent to which costs are passed on along the entire value chain to the final consumer. The **possible range of the total short-term burden** on each sector of the economy can be calculated for the assumed carbon price on the basis of Germany's system of environmental economic accounts.

This analysis assumes a **static production structure** and does not take into account the possibility of substituting intermediate goods with a lower carbon content. Since companies have different options for reducing the resulting burden, the **actual burden** on the economic sectors will generally differ from the calculations made here. However, such possibilities for adjustment exist mainly in the longer term. ↘ITEMS 178 F. To do the calculation, the imputed carbon price is multiplied by the carbon content of the goods in their final form as used by the consumer, only taking into account emissions from domestic producers. This approach is in line with the assumption that all cost increases along the value chain can be passed on to subsequent sectors of the economy. The actual burden on one sector of the economy will be higher, the smaller the cost pass-through to the subsequent sectors. On the other hand, the actual burden will be lower if upstream industries can only pass on a smaller share. In this analysis companies that sell **directly to end users** and companies that **export** their goods have to bear the **burden** of cost increases.

176. The analysis calculates the **total burden** and does not take into account the fact that almost half of German emissions are already recorded and priced in the EU ETS (DEHSt, 2018, 2019c). The **additional burden** of a cross-sector carbon price will be correspondingly **lower**. However, if additional sectors were to be integrated into emissions trading, an increase would certainly be expected in the price of allowances, thus placing an additional burden on the sectors already integrated into the EU ETS. Greater electrification in the buildings and transport sectors could also be reflected in higher ETS prices via a higher demand for allowances (Board of Academic Advisors to the Federal Ministry for Economic Affairs and Energy, 2019).

The estimate considers two different scenarios. ↘ CHART 21 In both cases it is assumed that no cost transfer is possible for export goods. This would be the case if German companies acted as **price takers on the world markets** and were therefore unable to pass on the costs of a carbon price. However, many companies, especially those operating in niche markets where they have a certain amount of market power, are likely to be able to pass on their higher costs, at least in part, to foreign customers. In this respect, the assumption made here represents a lower limit for the extent of cost pass-through. The first scenario considers the burden that would arise if the cost increase could not, furthermore, be passed on to domestic consumers. In the second scenario, on the other hand, it is assumed that the additional burden can be fully passed on to domestic consumers.

177. In both scenarios, **a carbon price of €35 per tonne** is assumed as an example. In purely arithmetic terms, the burden in the first scenario for most industries corresponds approximately to the direct payments to be made for the EEG surcharge in 2015. ↘ ITEM 72 The reduction of the burden when the cost is fully passed on to domestic consumers is proportional to the economic sector's share of domestic turnover. The burden in industries with a higher share of domestic turnover will then of course be significantly lower. This would apply, for example, to the food industry, water supply and most services. Since competition in the **services sector** is for the most part regionally limited and companies are therefore affected to a similar extent by cost increases, it can be assumed that costs will be passed on at a fairly high rate.

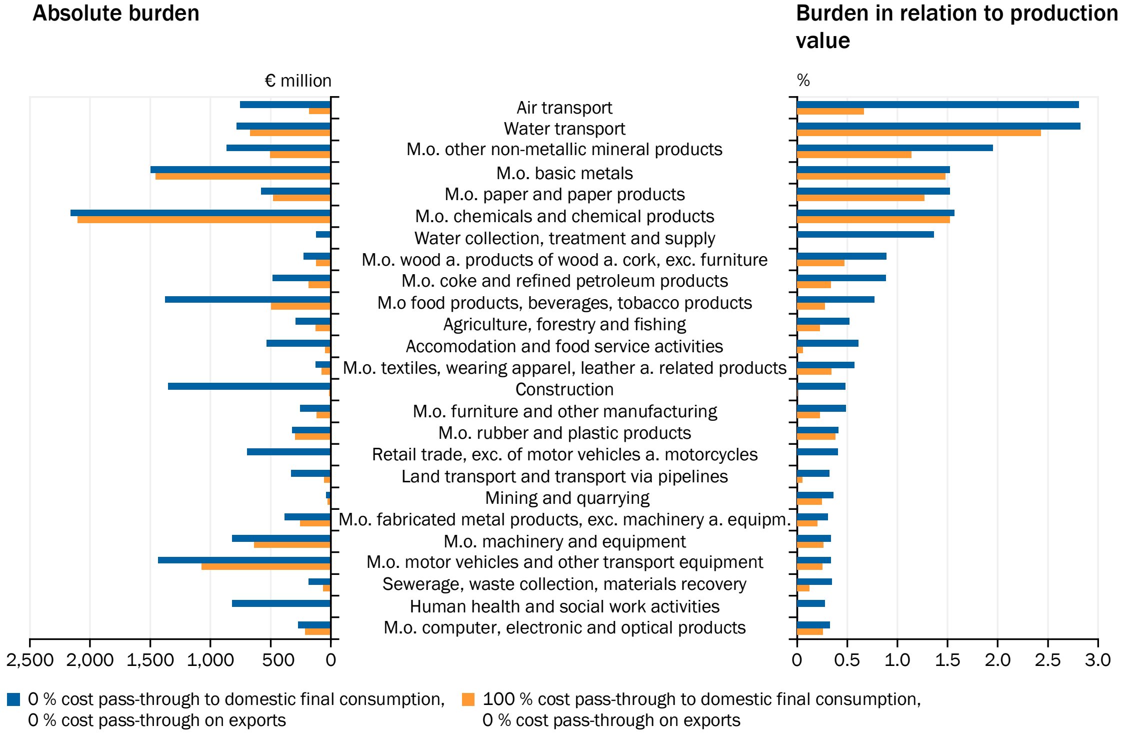
Industries with a strong **export orientation**, on the other hand, will probably find it all the more difficult to pass on the costs of a carbon price, the smaller the number of countries that implement carbon pricing. An **international coordination of carbon pricing** would mitigate possible impacts on these industries.

178. The burden of a carbon price of €35 per tonne would, without special arrangements, amount to less than 3.0 % of the production value in all economic sectors. ↘ CHART 21 RIGHT In this short-term analysis, the calculations are linear and assume a static input-output structure; the burden would thus double at a price of €70 per tonne, for example. **Medium-term adjustments** to the production structure could make production more carbon-efficient. The higher the carbon price, the more profitable such adjustments become. The burden would thus be lower and would increase disproportionately to the price. On the other hand, the higher marginal costs could reduce production in downstream industries all the more, the higher the carbon price. This, in turn, would increase the resulting burden, which could lead to a disproportionate increase in the burden. Which of these two effects predominates depends on the economic sector.

The highest burden relative to the production value would be borne by **energy-intensive industries**. These include, for example, the production of glass and ceramics, the processing of stone and earths, metal production and processing, and some transport services. At first glance, energy-intensive industrial compa-

↘ CHART 21

Burden of a carbon price of €35 per tonne CO_2 on selected economic sectors[1]



1 – According to the Classification of Economic Activities, edition 2008 (WZ 2008). Calculated on basis of the CO_2 emissions and gross production value of economic sectors in 2015.

Sources: Federal Statistical Office, own calculations nies would appear to be burdened much more by a uniform carbon price than by the **EEG surcharge**, where they benefit from **exemptions**. However, these industries often receive **free allowances under the current EU ETS** because their production is energy-intensive and they are subject to international competition, and this reduces their actual burden. ↘ ITEMS 184 FF.

Land transport services such as haulage firms are only slightly burdened in this analysis, as they are predominantly counted as intermediate services for other economic sectors; here, complete cost transfer is assumed. A pricing of direct emissions, for example via fuel consumption, would lead to a burden of just under 0.6 % of the production value if there is no cost transfer to downstream industries.

179. The analysis does not address the extent to which the burden is **passed on within the value chain**. This depends on the **price elasticities** of supply and demand and the **competitive conditions**. **On the input side**, enterprises can pass on their higher costs to labour, as a factor of production, and to the producers of the capital and intermediate goods used. **On the output side**, it is possible that only part of the higher costs can be passed on to downstream industries or consumers via price increases ↘ BOX 4

Determining the degree of cost pass-through is important, as a high degree of cost transfer could make the **free allocation of allowances superfluous**. The almost complete pass-through of costs was, for example, the reason why the free allocation of EU ETS allowances to the energy sector was abolished in 2013.

180. Furthermore, companies can react to carbon pricing by **adjusting their production processes**. If production uses substitutable intermediate goods, companies can reduce their inputs of carbon-intensive intermediate goods whose relative price rises as a result of carbon pricing. However, this possibility does not apply if production uses inputs which are non-substitutable in the short term. Furthermore, the use of machines with a lower carbon intensity can help reduce marginal costs in the long term (Atkeson and Kehoe, 1999).

2. Maintaining the competitiveness of enterprises

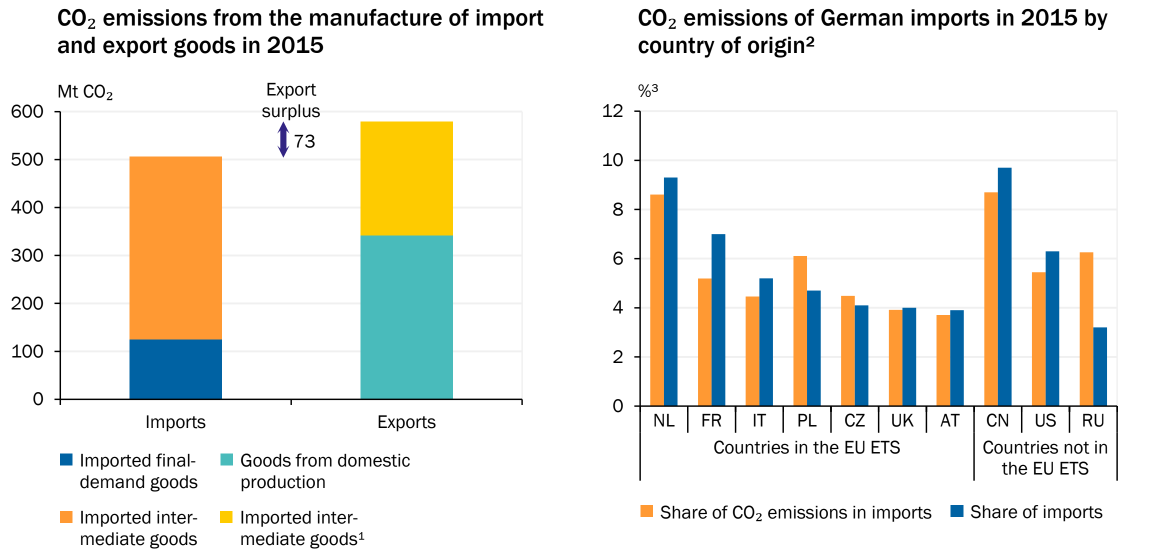
181. International trade is of particular importance for Germany's open economy. As a result of the **large volume of trade**, large quantities of carbon cross the borders along with the goods traded. In 2015, 506 million tonnes of CO2 emissions were ascribed to German imports, of which intermediate goods accounted for a significant share. ↘ CHART 22 LEFT The main countries of origin include some countries outside the scope of the EU ETS ↘ CHART 22 RIGHT At the same time, Germany exported goods containing 579 million tonnes of CO2 in 2015. This means that Germany has an export surplus when it comes to CO2 emissions.

182. Economic **openness** is **relevant** to the **pricing of CO2 emissions**, since, on the one hand, goods produced in Germany compete worldwide with goods pro-

duced outside the scope of the carbon price. On the other hand, domestic consumers have the option of switching to goods produced abroad. These substitution options depend on many factors, for example the tradability of the goods, the opportunities for expanding capacity abroad, and the competitive situation on the respective market.

↘ CHART 22

Imports to Germany and CO_2 emissions



1 – Imported intermediate goods contained in exports. 2 – NL-Netherlands, FR-France, IT-Italy, PL-Poland, CZ-Czech Republic, UK-United Kingdom, AT-Austria, CN-China, US-USA, RU-Russia. 3 – Share of the respective trading partner.

Sources: Federal Statistical Office, own calculations

Carbon leakage threatens competitiveness and climate impact

183. A **carbon price** set at the producer level **raises the price of domestically manufactured goods** whose production generates CO2 emissions. If this results in domestic consumers increasingly resorting to goods produced abroad or in German exporters shifting production processes abroad, CO2 emissions in Germany will indeed fall. At the same time, however, CO2 emissions will be shifted to other countries where production is now relatively cheaper **(carbon leakage**).

In addition, measures that reduce carbon-intensive production in a region can lower the **world market prices for fossil fuels** if resource extraction is not adjusted at the same time (Board of Academic Advisors to the Federal Ministry for Economic Affairs and Energy, 2019). As a consequence, part of the carbon reduction will be cancelled out. In order to reduce global CO2 emissions, a relocation of production could be beneficial if production abroad is more carbon-efficient. If this is not the case, however, there is a risk that the relocation of production will result in even higher global CO2 emissions overall. Regionally limited environmental policy measures could thus not only endanger the **compe-**

titiveness of domestic producers, but even counteract the goal of reducing emissions.

184. Several questions therefore need to be clarified in the discussion on a comprehensive pricing of CO_2 emissions. For industry, it must be examined whether the EU ETS's protection against carbon leakage is sufficient in view of possible **price increases for allowances** and a prospective **extension to other sectors** with a tendency towards higher avoidance costs. If necessary, additional protective measures could be considered in addition to the current free allocation of emission allowances to selected industries. Separate emissions trading for the non-EU ETS sectors could initially protect industries in the EU ETS with a higher carbon-leakage risk from high price increases (Felbermayr et al., 2019). For those sectors that are not yet subject to carbon pricing, the carbon-leakage risk is likely to be lower. ↘ ITEMS 191 FF.

Complex system of free allocation of allowances in the EU ETS

185. Under the EU ETS, companies in industries subject to a carbon-leakage risk are allocated allowances largely free of charge in accordance with uniform Europe-wide allocation regulations. The European Commission draws up a list of economic sectors at risk on the basis of **defined criteria**. The carbon-leakage risk is partly determined at a highly **disaggregated level** using a carbon-leakage indicator. This will be calculated in the fourth trading period (2021-2030) as the product of **carbon intensity** and **the intensity of trade**. Carbon intensity relates direct and indirect CO_2 emissions to the value of production, while trade intensity relates to trade with third countries. If the indicator exceeds a certain threshold value, a carbon-leakage risk is assumed for this economic sector.

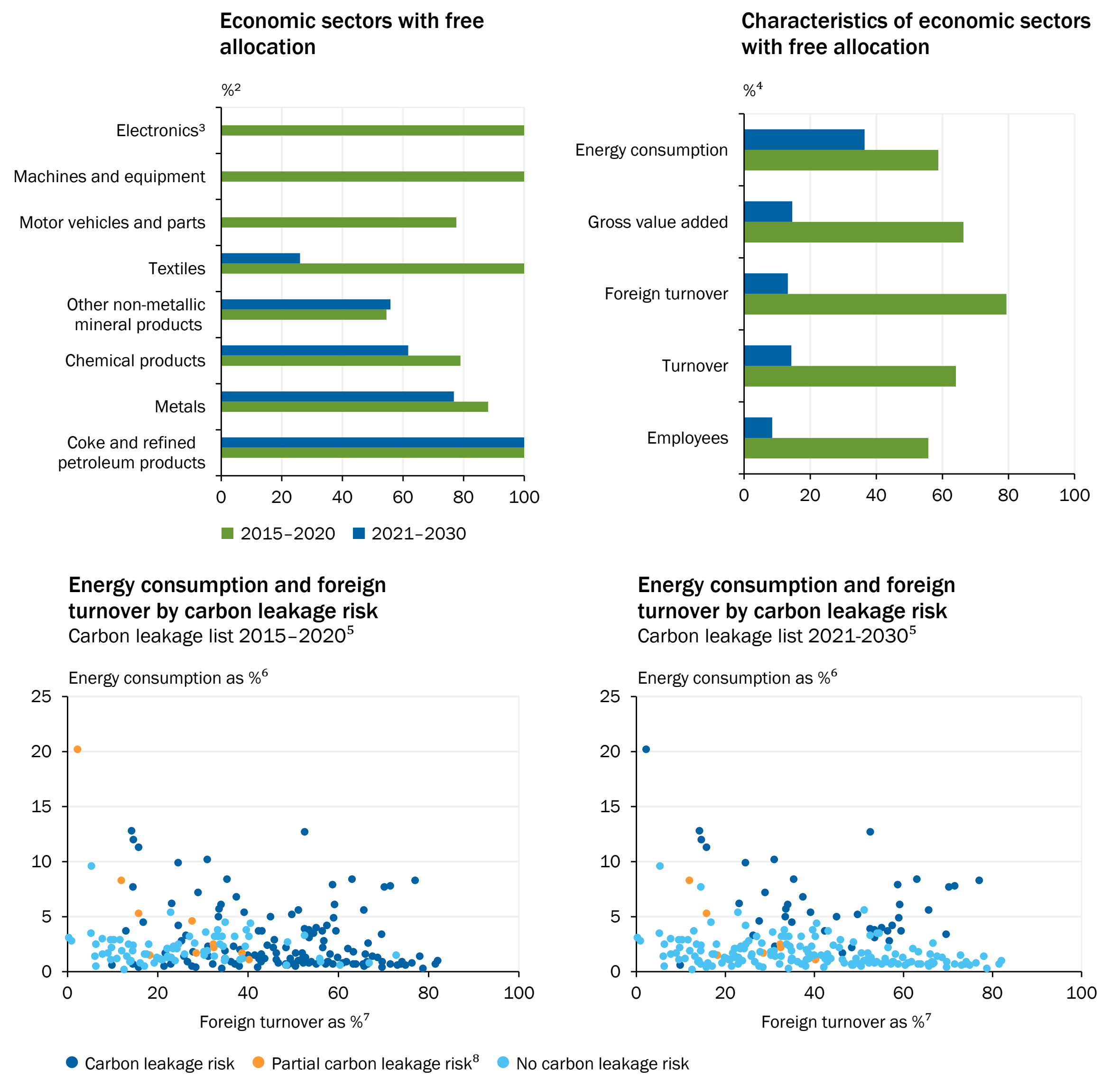
These economic sectors currently include in particular the manufacture of paper, glassware and chemical products as well as coking plants and mineral oil processing. ↘ CHART 23 TOP LEFT These are characterised above all by above-average energy consumption. ↘ CHART 23 TOP RIGHT In the previous trading period, economic sectors, including vehicle construction and mechanical engineering, were also included in the **carbon-leakage list** solely because of their high trade intensity, i.e. the sum of exports and imports in relation to turnover in this economic sector. These industries will no longer be on the list in the future due to their low carbon intensity during production. The new regulation thus takes into account research results according to which an economic sector's carbon-leakage risk depends above all on its carbon intensity (Martin et al., 2014).

186. In the fourth trading period (2021-2030), free allocation to carbon-leakage-prone industries will continue, while the other economic sectors will no longer receive free allowances from 2026 onwards. Compared to the previous list, there is an **increasing restriction** to sectors of the economy presumed to be particularly vulnerable. ↘ CHART 23 BELOW In total, there are now only 63 industries and products on the carbon-leakage list, compared to 175 in the period from 2015 to 2020 (European Commission, 2014, 2019d).

187. The exact quantity of **allowances allocated free of charge** to companies threatened by carbon leakage is mostly based on **product reference values (benchmarks)**. These define how many CO2 equivalents per unit of production are emitted during production by the most efficient plants of an industry. The benchmark value decreases over time, so that even the most efficient producers have an incentive to increase their carbon efficiency. Less efficient companies receive the same number of allowances free of charge as the reference companies in relation to their production volume. On the other hand, they have to buy additional allowances for the additional emissions they cause due to their lower efficiency.

↘ CHART 23

European Commission's carbon leakage list[1]



1 – According to the Classification of Economic Activities, edition 2008 (WZ 2008). Economic sectors considered to be at risk of CO_2 emissions relocation pursuant to Article 10b of Directive 2003/87/EC. 2 – Vulnerable economic groups (3-digit) and classes (4-digit): share of the gross value added of the respective economic division (2-digit) in 2016. 3 – Computer equipment, electronic and optical products and electrical equipment. 4 – Share of the respective characteristic accounted for by covered industries. 5 – Economic sectors (2-/3-/4-digit). 6 – Compared to GPO (gross product originating/gross production value) in 2016. 7 – Compared to total turnover in 2016. 8 – At disaggregated level (6/8 digits).

Sources: European Commission, Federal Statistical Office, own calculations

188. In addition, there is a **cross-sectoral correction factor** (CSCF) which ensures that the sum of allowances allocated free of charge does not exceed a certain proportion of the total EU ETS cap. If this limit is exceeded due to an overly generous allocation of free allowances, the quantity of freely allocated allowances is reduced by the same percentage in all economic sectors. In the current trading period, the correction factor averaged 11 % and was thus significantly higher than expected (BMU, 2018c). In order to avoid the use of the correction factor and the resulting uncertainty for companies as far as possible, in future up to 3 % of the total budget can also be allocated free of charge as a 'safety buffer' (BMU, 2018c).

189. Since 2013, there has been no free allocation in **electricity generation** due to the almost complete cost pass-through ↘ BOX 4; 100 % of the demand for allowances must be covered on the market. There are exceptions for electricity generation in some European transition countries. Member states may, in accordance with European competition law, partially compensate electricity-intensive companies for rising electricity prices. A revision of the corresponding EU directive is planned for autumn 2020 (European Commission, 2019e). Seven member states, including Germany, made use of this option during the trading period from 2013 to 2020. In 2017, German companies received subsidies **(electricity price compensation**) totalling €202 million (DEHSt) 2019d).

190. The empirical literature on carbon leakage found very few to zero negative effects on the **competitiveness and profitability** of companies in the first two trading phases of the EU ETS (Martin et al., 2014, 2016; Arlinghaus, 2015; Dechezleprêtre et al., 2018). Evidence of **production relocations** or changes in trade flows resulting from the EU ETS could not be found either (Moore et al., 2019; Koch and Basse Mama, 2019; Naegele and Zaklan, 2019).

However, it should be borne in mind that allowances were **allocated very generously** in this phase and many companies were able to pass on the costs to consumers (Joltreau and Sommerfeld, 2019). In some cases, the companies even made additional profits **(windfall gains**) through the EU ETS (de Bruyn et al., 2016). It is also conceivable that regulated companies might even gain competitive advantages through the incentive to develop low-carbon technologies (Porter and van der Linde, 1995).

191. Furthermore, it is unclear to what extent comparatively low prices, as in the EU ETS over the past few years, have prompted companies to relocate production to non-European countries. Since energy-intensive industries produce capital-intensively, production relocations are associated with high **fixed costs**. At the same time, other factors play a role in the **choice of location** in addition to energy and carbon costs. After all, due to the long investment cycles, higher energy costs do not have to lead directly to production relocations, which may take some time to occur.

According to surveys, increased investment abroad due to energy policy is currently only an issue for just under 4 % of German industrial companies, while a

reluctance to invest is affirmed by at least around 12 % of companies (Bardt and Schaefer, 2017).

The extent to which **carbon-leakage protection** will prove its worth in the future is an open question. Currently, the EU ETS price of around €25 is significantly higher than in most years since 2005. In addition to more stringent reduction targets and more restrictive allocation rules, an expansion to include the buildings and transport sectors in particular could cause prices to rise further. Although higher prices would increase the value of the freely allocated allowances for the sectors on the carbon-leakage list, the exact numbers of allowances allocated is governed by the product benchmarks. It remains a big challenge to adequately take into account the respective technological possibilities for reducing CO2 emissions when determining these benchmarks.

Emissions relocations of little significance in non-EU ETS sectors

192. In the non-EU ETS sectors, emissions could in theory be relocated as a result of CO2 emissions pricing. National energy taxes can be examined to assess the risk better. These taxes vary quite widely between EU member states. At the end of June 2019, the **price difference for premium grade petrol** was 23 cents between Poland and Germany and 53 cents between the Netherlands and Luxembourg (ADAC, 2019). Such differences can lead to 'fuel tourism', even causing higher emissions overall due to the detours driven. At the same time, this circumvention of carbon pricing would **weaken** its **incentive effect**. Where price differences are particularly large, filling up in a neighbouring country can even make longer journeys worthwhile.

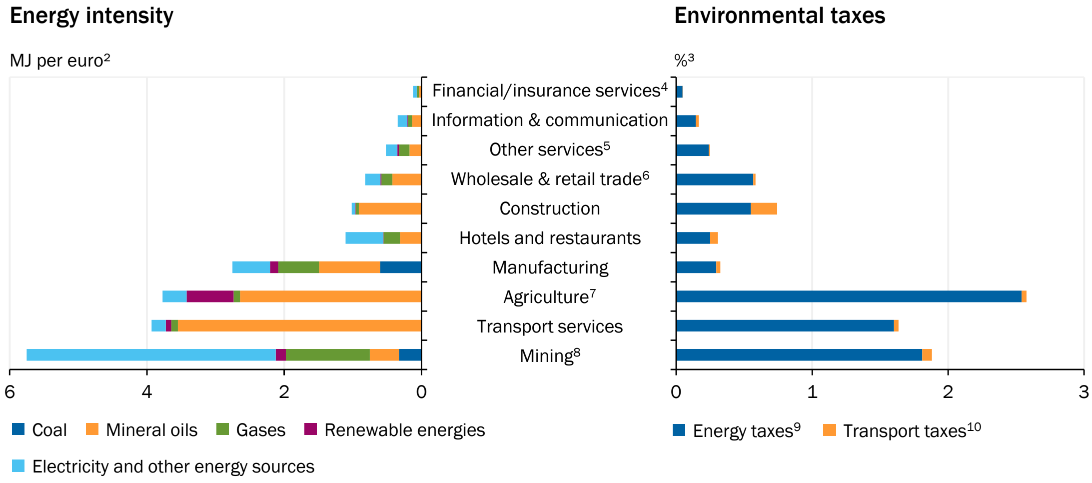
Similar shifts could occur in the buildings sector if, for example, differences in the price of **heating oil** become too large between neighbouring countries. However, these possible emissions relocations are likely to be largely limited to **border regions**.

193. Because of the much lower trade intensity in the **service industry** (GCEE Annual Report 2017 item 668), the risk of carbon leakage as a result of carbon pricing is likely to be relatively limited for most companies. Depending on the competitive situation, they should also be able to pass on the **higher costs** to consumers. Moreover, with the exception of transport services, the service industry is less energy-intensive. ↘ CHART 24 LEFT

These characteristics and the comparatively **limited possibilities for import substitution** in services are likely to be one reason why existing tax breaks, such as peak balancing for electricity tax, are geared to the manufacturing sector. Accordingly, the actual environmental tax burden there is relatively lower than the energy intensity. ↘ CHART 24 RIGHT In the field of transport services, the tax exemption for kerosene in particular should be taken into account. In terms of energy intensity, agriculture is subject to relatively heavy environmental taxes. At the same time, however, it receives substantial state aid at EU level under the Common Agricultural Policy (CAP).

↘ CHART 24

Energy intensity and environmental taxes by economic sector[1] in 2016



1 – According to the Classification of Economic Activities ('Klassifikation der Wirtschaftszweige'), 2008 edition (WZ 2008). 2 – Megajoules per euro of production value. 3 – Relative to production value. 4 – Financial, insurance and real estate services. 5 – Business services, public and other services. 6 – Wholesale and retail trade; maintenance and repair of motor vehicles. 7 – Agriculture, forestry and fishing. 8 – Mining and quarrying. 9 – Energy tax, electricity tax, emission allowances, German National Petroleum Stockpiling Agency, nuclear fuel tax. 10 – Vehicle tax, air traffic tax.

Sources: Federal Statistical Office, own calculations

Various refund options are possible for taxes and levies

194. If an increase in the EU ETS carbon price or the inclusion of other sectors creates additional burdens for energy-intensive companies that jeopardise their competitiveness, these burdens can be reduced, for example, by means of **refund regulations**. This can temporarily follow the existing regulations until a system differentiated by sector has been developed (Edenhofer et al., 2019). In the case of a separate emissions trading scheme for the buildings and transport sector, consideration could be given to a free allocation to certain energy- and trade-intensive industries. Before the introduction of a German ETS for these sectors, the questions regarding state aid should be clarified (Edenhofer et al., 2019). Revenue from carbon pricing can also be used to **reduce the EEG surcharge**, subject to approval by the European Commission under state-aid law (Büdenbender, 2019).

195. Another option for offsetting a carbon tax would be a process-specific tax allowance (Linscheidt and Truger, 2000b). Ideally, this should lead to a **separation of incentive effects from burden effects**. Similar to carbon-leakage protection in the EU ETS, the allowance is only granted to **part of industry**. Criteria could include the energy-tax burden as a percentage of turnover, or competition with foreign competitors (Linscheidt and Truger, 2000b). As with the allocation regulations in the EU ETS, the size of the exemption would be based on a **product reference value**. This would require determining how much energy or CO2 emissions are technically necessary in the various production processes.

196. A cross-sectoral CO2 emissions price of €35 per tonne would generate **additional revenue** of around €19 billion compared to the current EU ETS price of €25

per tonne. The calculation is based on the sector-specific direct CO_2 emissions for 2016 recorded under the system of environmental economic accounts. This also includes emissions resulting from the manufacture of export goods. The free allocation of allowances is not taken into account, which is why the actual additional income is likely to be slightly lower. Around €8 billion comes from revenues from the pricing of direct emissions by private households. Industry and the energy sector would be burdened with an additional €5.7 billion. Companies in **commerce, trade and services** (Gewerbe, Handel, Dienstleistungen, **GHD**), which have not yet been subject to carbon pricing, would also contribute €5.7 billion.

197. If companies are unable to pass on these additional costs, options for reducing the burden would include cutting the **electricity tax to the EU minimum rate** or **lowering the EEG surcharge rate**. Income from the EEG surcharge amounted to around €23 billion in 2018, of which businesses paid around €15 billion. In 2018, businesses also contributed about €4.3 billion to the electricity tax revenue of €6.9 billion. Income from carbon pricing could thus be used to reduce electricity tax to the minimum rate; it could also cover about half of the EEG surcharge.

Those companies that would be most burdened by an extension of carbon pricing, however, are relieved of the EEG surcharge and electricity tax via comprehensive exemptions. Therefore, the abolition of these levies would hardly relieve these companies. On the other hand, the GHD companies would be relieved by these measures, as they have not as yet benefited from exemptions and thus bear a disproportionate share of the EEG surcharge and electricity tax. However, it is likely to be easier to pass on rising costs to consumers particularly in these sectors of the economy due to the regionally limited competition.

Border tax adjustment involves practical hurdles

198. A possible alternative to the measures discussed would be a **border tax adjustment**. Imported goods would be charged according to the emissions involved in their production, while exporters would recover the carbon costs incurred during production at the border. The carbon price for imported goods from countries with no – or a lower – carbon price would be increased, so that **competition neutrality** would prevail between producers at home and abroad in this respect. A border tax adjustment must be distinguished from customs duties, which are levied across the board on goods from countries without a comparable carbon pricing system.

199. While the idea of a border tax adjustment is theoretically attractive and recommended by some economists (Bureau et al., 2017; Econstatement, 2019; Felbermayr et al., 2019; Wissenschaftlicher Beirat beim BMWi, 2019), **its practical implementation involves difficulties** (Tamiotti et al., 2009). These include in particular unequivocally determining the product- and country-specific CO_2 emissions. In the vast majority of cases, for example, the emissions generated during production cannot be determined on the basis of the end product and

must be estimated. In particular, the carbon intensity of production of the same product can vary depending on the country of origin. There are initiatives such as the Carbon Disclosure Project, which summarise the CO2 emissions reported by companies in over 100 countries. However, such calculations would probably have to be carried out far more extensively and systematically for a border tax adjustment. For simplification purposes, a reference value could perhaps be determined on the basis of input-output statistics, and companies could be given an opportunity to prove the actual carbon content (Felbermayr et al., 2019).

More difficulties come with emissions trading, with the **carbon price fluctuating** over time. A further difficulty with a border tax adjustment would be to assess **non-price-based reduction measures** in the countries of origin and to take them into account appropriately.

200. Depending on the design of the carbon pricing system and a possible border tax adjustment, there is a risk that the measures taken could conflict with **European law** and **international trade regulations**, particularly those of the World Trade Organization (WTO). Felbermayr et al. (2019) believe a system that exempts exports and burdens imports, similar to VAT, would be WTO-compliant. Under European law, Articles 30 and 110 of the TFEU result in the **principle of equal treatment of EU imports and domestic goods sales** (Büdenbender, 2019). In particular, domestic and imported products are to be reported at the same stage of the value chain. The levying of a carbon tax should therefore be designed in such a way that domestic goods and imports from the EU are treated equally (Büdenbender, 2019).

Another basic principle of international business law is the equal treatment of domestic and foreign companies, goods and services (Büdenbender, 2019). Article III of the General Agreement on Tariffs and Trade (GATT), for example, stipulates that the same goods must be treated equally in internal taxation and regulation, regardless of whether they originate from domestic production or were imported. Due to the great diversity of options for carbon pricing and the limited experience, there is a **certain legal uncertainty** here (Holzer, 2016), and a large number of issues are the subject of legal debate (Tamiotti et al., 2009).

201. The German economy is particularly dependent on free international trade. Particularly in times of ongoing trade conflicts (GCEE Annual Report 2018 item 7 ff.), the impression should be avoided that disguised discriminatory protectionist restrictions are being enforced via unilateral regulatory measures. The **design of the carbon pricing** should therefore be in **line with international regulations** and rigorously reviewed accordingly. At the same time, it should be noted that a border tax adjustment could possibly trigger countermeasures by trading partners. The **political consequences** of such a measure should therefore be taken into account. If the existing carbon-leakage protection through the free allocation of allowances is no longer sufficient to avoid major competitive disadvantages, a border tax adjustment could be considered jointly with the other EU member states.

3. Macroeconomic impacts and innovation

202. Although the pricing of CO_2 emissions internalises external effects, like other taxes it influences decisions on production, investment, consumption, labour and savings. This can have long-term **impacts on growth and employment**. At the same time, carbon pricing creates incentives to develop production technologies with lower CO_2 emissions that could make a significant contribution to reducing macroeconomic costs. The state has an important role to play in promoting the development of lower-carbon technologies. In this context, the principle of technology neutrality should be respected and competition between technologies ensured.

Impact of a carbon price on growth and employment

203. The effects of pricing CO_2 emissions on growth and employment can be analysed in **intertemporal general equilibrium models**. ↘ TABLE 4 On the corporate side, these models describe input-output relations, the demand for labour and investment decisions. On the household side, the demand structure, labour supply and savings decisions are modelled. The decisions are made by forward-looking, profit-maximising companies and utility-maximising households that adapt their decisions to the long-term path of the carbon prices. These models also take into account the impact of technological progress.

Compared to the global models of climate and macroeconomic interactions (Nordhaus and Yang, 1996), the national models do not take the potential **economic damage** of global warming into account. The analyses below differ quantitatively on the one hand mainly because different carbon prices or price paths are assumed. On the other hand, a wealth of different assumptions are made with regard to substitution elasticities or technological progress. In addition, the form of the assumed use of funds differs.

204. The introduction of a price for CO_2 emissions increases companies' marginal costs for fossil fuels, which leads to a reduction in energy use. As energy and capital are complements, investment – and thus the growth of the capital stock – is reduced. Most studies estimate the resulting long-term **decline in the average annual growth rate** of GDP to be less than 0.1 percentage point. A decline in the growth rate of 0.1 percentage point would mean a 4 % lower level of GDP after 40 years. This does not include welfare improvements from a reduction in negative externalities. However, because of the different structures of production and consumption, the results can only be transferred to Germany and the EU to a limited extent.

All studies come to the conclusion that the long-term effects depend to a large extent on the **concrete design of the reform**. Especially important is how the revenue from a carbon tax or the auctioning of allowances is used. ↘ ITEMS 219 FF. The negative effects on growth and employment are less pronounced in models which assume that revenues are used to reduce other distorting taxes **(double dividend**) and thus to create incentives for investment. In the study by Hebbink et al. (2018) on the effects of a carbon price in the Netherlands, a revenue-neutral cut in capital gains tax or income tax counteracts the negative effect of pricing CO2 emissions. In the case of income tax, it is even overcompensated. By contrast, other studies find bigger effects from a reduction in capital gains tax (Jorgenson and Wilcoxen, 1993; Cogan et al., 2013; Goulder and Hafstead, 2013).

205. The **economic costs** probably also depend on the extent to which companies can adapt their production methods to changes in fossil-fuel prices. It can be assumed that carbon intensity is fixed in the short term, as there is no flexibility with regard to the fuel types and quantities required in a machinery park that is already in use (Atkeson and Kehoe, 1999). In the medium term, companies can invest in new, more energy-efficient capital goods that use lower-carbon fuels. On the basis of energy price developments between 1960 and 1994, Atkeson and Kehoe (1999) calculate for the USA that doubling energy prices as a result of the gradual renewal of the capital stock leads to a long-term decline in economic output of 5.5 %. In terms of average growth, however, this effect is comparable with the above studies. Corporate energy costs in Germany would only double at a price of €140 per tonne of CO2.

206. In addition to the adjustment of capital stock, an increase in energy costs as a result of carbon pricing could have an impact on the **production factor 'la-**

↘ TABLE 4

Macroeconomic effects of a carbon price

Study	Country[1]	Time period	Initial carbon price[2]	Final carbon price[2]	Reim-burse-ment[3]	Change in GDP growth in percentage points[4]	% deviation of GDP level from baseline scenario after 40 years	Change in the volume of work in%
Jorgenson and Wilcoxen (1993)	US	1990–2020	$0	$65	P	– 0.06	– 2.30	
			$0	$65	E	– 0.02	– 0.90	
			$0	$65	K	0.04	1.50	
Jorgenson et al. (2013)	US	2010–2050	$1	$109	P	– 0.08	– 3.00	– 0.70[a]
			$1	$396	P	– 0.20	– 8.00	– 2.70[a]
Smith et al. (2013)	US	2013–2053	$20	$96	E/S	– 0.02	– 0.60	– 1.40
			$20	$1,000	E/S	– 0.09	– 3.60	– 8.30
Goulder and Hafstead (2013)	US	2010–2040	$10	$37	P	– 0.04	– 1.50	
			$10	$37	E	– 0.03	– 1.10	
			$10	$37	K	– 0.02	– 0.70	
Hebbink et al. (2018)	NL	2019–2024	€50	€50	S	– 0.18	– 7.00	– 0.60
			€50	€50	E	0.10	4.10	0.40
			€50	€50	K	– 0.08	– 3.20	– 0.30

1 – US-USA, NL-Netherlands. 2 – Price basis for Jorgenson and Wilcoxen (1993): 1990, for Jorgenson et al. (2013): 2005, for Smith et al. (2013) and Goulder and Hafstead (2013): 2012; Hebbink et al. (2018): Nominal. 3 – E-income tax cut, K-capital tax cut, P-per capita lump sum, S-debt reduction. 4 – The differences in GDP level relative to the baseline scenario without a carbon price reported in most studies were converted for better comparability into a reduction of the average annual growth rate. Approximation errors caused by non-consideration of the growth rate in the baseline scenario amount to less than 5%. a – Average change in level over the period under consideration.

Sources: Own compilation, own calculations

bour'. The reaction of manufacturing companies in Germany to the introduction of a carbon price by the EU ETS has been studied (Petrick and Wagner, 2014). No negative impact was measured on the demand for labour, while emissions in the companies concerned fell significantly. However, only the initial years of the EU ETS were examined, which were characterised by very low allowance prices. ↘ ITEM 60

A study has also been conducted for the manufacturing sector in France on the impact of a 40 % average increase in energy prices between 1997 and 2010 on the factor labour (Marin and Vona, 2017). The elasticity of labour demand in relation to energy prices was estimated at -0.26. A carbon price of €35 per tonne would lead to a 12 % increase in energy costs in Germany, which, given this elasticity, would mean a 3 % **drop in labour demand**. In the case of services, this elasticity is expected to be lower due to the easy tradability of manufacturing goods, thus reducing the decline in labour demand.

207. The long-term effects of pricing greenhouse-gas emissions should lead to a fundamental change in the energy supply, production methods in energy-intensive sectors, and consumer behaviour. Although the impact is rather small overall, the economic effects of a carbon price on GDP estimated in the literature are characterised by a high degree of uncertainty. The estimates of the impact of future increases in carbon price should therefore be interpreted with caution.

Moreover, as in the past, companies and households are likely to be able to adapt to the **structural change**. However, since this nevertheless takes time, it would seem advisable to introduce **pricing** over a longer period of time by means of a **reliable mechanism** and to extend it only gradually ↘ ITEMS 106 FF.

Avoiding CO_2 emissions by means of new technologies and innovations

208. The development of new technologies aiming to largely avoid greenhouse-gas emissions is particularly important in order to achieve the long-term climate targets. The literature describes three factors that lead to innovation: (1) supply-side factors, which include innovation through **research and development**, (2) demand-side factors (market introduction and penetration), and (3) innovations generated by **regulation and policy interventions** (Carter and Williams, 1958; Walsh, 1984; Kleinknecht and Verspagen, 1990). Supply-side innovations play a special role particularly in the initial phase of the product cycle (Rosenberg, 1974; Baumol, 2002), while demand-side innovations by consumers and companies are more important in the diffusion phase (Pavitt, 1984; Rehfeld et al., 2007).

209. However, supply-side and demand-side factors are often insufficient to generate environmental innovation (Rennings, 1998). Regulatory intervention can be justified by **externalities**, particularly if the costs caused by CO2 emissions are not sufficiently internalised by market players due to distortions or false expectations. Furthermore, environmental business activities involve a high degree of

uncertainty for corporate development. For example, Horváthová (2010) shows in a meta-study that the economic profitability of environment-related investments is only positive in half of all cases.

There can also be market failure with regard to **knowledge transfer**. When new technologies are widely available and represent a common good, this can promote innovation. Global provision via new technologies has benefits for society as a whole, but not for the individual inventor (Popp, 2019). Companies therefore have no incentives to carry out sufficient research activities.

210. **Pricing CO2 emissions** aims to replace fossil fuels with low-carbon energy sources. Numerous studies have examined the **effect of rising energy prices on innovation activity** (Jaffe and Palmer, 1997; Brunnermeier and Cohen, 2003). Ley et al. (2016) analyse the effect of sector-specific energy prices on green and non-green innovations in various countries. They show that a 10 % increase in energy prices over the past five years led to a 3.4 % increase in green innovation.

For the **automotive industry**, various studies find price elasticities of innovation activity (measured in terms of energy-efficient patents) in the range of 0.24 to 0.98 (Popp, 2002; Crabb and Johnson, 2010; Aghion et al., 2016). Price elasticity is particularly high for relatively clean technologies such as electric or hybrid cars. On the other hand, government regulations on fuel saving have no influence on the number of patents, while the efficiency of fuel consumption increases as a result of regulatory measures (Knittel, 2011). These studies also document high **path dependencies**. Companies that already have a large knowledge base on relatively clean technologies are more likely to aim for further innovation in this area.

211. The **EU ETS** represents a special form of regulation. A central component is the incentive to move towards low-carbon technologies (Pizer and Popp, 2008; Calel and Dechezleprêtre, 2016). Calculations for the EU show that regulated companies under the EU ETS have produced **more** low-carbon **patents** than non-regulated companies. However, low prices and high **regulatory uncertainty** may have led companies to adopt a wait-and-see strategy in the first trading phase and not to invest enough in **green technologies** (Pontoglio, 2010; Borghesi et al., 2012; Laing et al., 2013; Calel and Dechezleprêtre, 2016).

212. In addition to the EU ETS, specific **regulations and requirements** can create incentives for companies to strive for innovation in their production processes. Regulations can above all have a beneficial effect on product-related environmental innovations on air, water and noise emissions as well as soil pollution. Business surveys show that green innovations are largely generated to save costs. **Customer demand** for green products is another important reason for redesigning products, while government regulations and taxes lead in particular to the adoption of green technologies (Horbach et al., 2012). Veugelers (2012) and Horbach et al. (2012) also stress the importance of state subsidies for reducing CO2 emissions.

213. In addition to the forms of market failure described (such as knowledge diffusion and path dependencies), innovations in the energy sector often involve disproportionately high capital costs (Weyant, 2011). Combined with risk aversion on the part of investors, this can lead to an insufficient supply of capital for investments in renewable energies. These additional externalities could justify introducing **accompanying state measures** on green technologies.

214. Almost US$280 billion was invested in renewable energies worldwide in 2017. ↘ CHART 25 LEFT Up until 2012, a large proportion of this investment took place in Europe. In the meantime, Europe has been replaced by China as the top investor. Global **investment in renewable energies** has stagnated since 2014. However, this does not mean that less is invested in terms of the volume of potential output, since the cost of capital, especially for solar energy, has decreased over the same period. As a result, more gigawatts can be installed for each US dollar invested in a given region (McCrone et al., 2018), whereby the actual output then depends on geographical and technical conditions. At 77 %, the largest share of capital expenditure goes to wind farms, solar parks and other energy systems.

Research and development of new technologies accounts for about 3.9 % of total expenditure, which corresponds to about US$11 billion. The public and corporate sectors are each responsible for around US$ 5 billion. About US$1 billion is provided by venture capitalists.

Designing technology-neutral state innovation policy

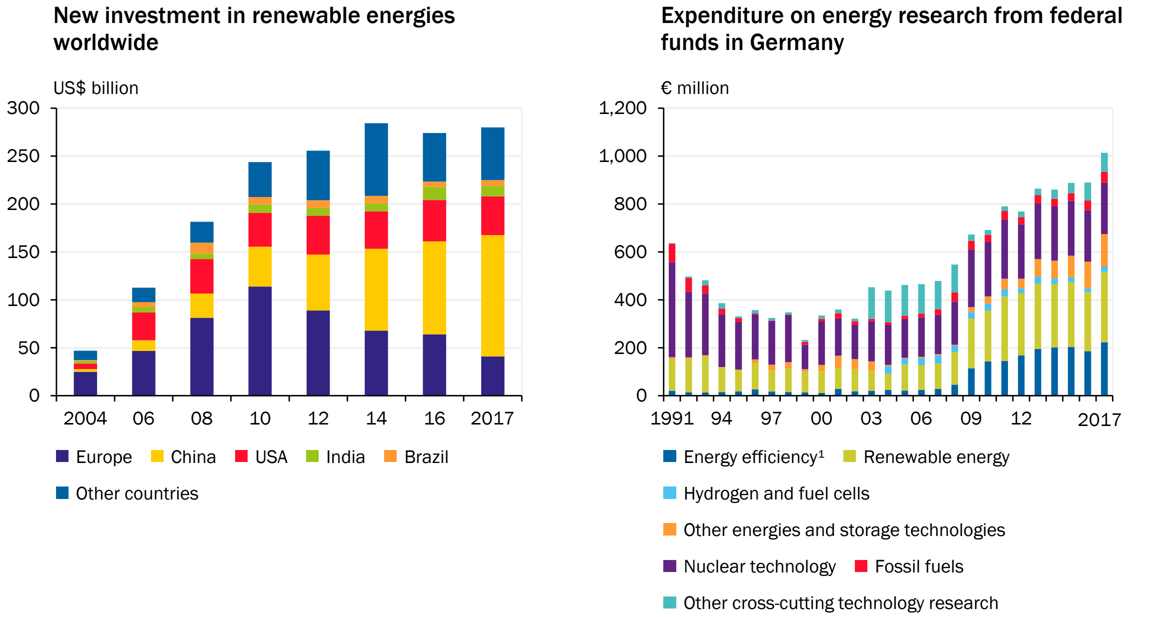
215. **Federal Government spending on research and development in the energy sector** has been rising again in real terms since the early 2000s. In 2017, it accounted for around 0.035 % of economic output, the highest figure since reunification. The research areas of energy efficiency and renewable energies are growing in importance, while nuclear technology's share of total expenditure has fallen significantly. ↘ CHART 25 RIGHT

216. The **effectiveness of** public research-and-development funding in innovation, as measured in patents, has been demonstrated in a number of studies (Peters et al., 2012; Dechezleprêtre and Glachant, 2014; Nesta et al., 2014). Research networks supported, for example, by the EU have a positive impact on coordination, network size and knowledge diffusion between research institutions and private companies (Cantner et al., 2016; Fabrizi et al., 2018). They thus represent an important instrument of research funding.

217. Coherent and predictable signals from politicians are needed because of economic and technological uncertainties, and a path dependency caused by the existing energy infrastructure (Mazzucato, 2013). Long-term, **reliable political framework conditions** can stabilise the expectations of private households and companies, thus reducing uncertainty and increasing the volume of investment in relatively clean technologies (Nordhaus, 2011). Venture capitalists oftendo not enter the market until after a certain period of public investment (Block and Keller, 2011; Lazonick and Tulum, 2011). In addition, due to long in-

↘ CHART 25

Investment in the energy sector



1 – Excluding fossil fuels, hydrogen, fuel cells and storage.

Sources: BMWi, McCrone et al. (2018)

vestment cycles and above-average capital intensity, state-financed investments (Mazzucato, 2018) and financing via development banks (Fried et al., 2012) play an predominant role in renewable energies.

218. The state is taking on an increasingly important role in the generation of **new knowledge through basic research** (Fleming et al., 2019). In addition to a price for CO2, government research funding is a central component of a strategy towards clean energy (Acemoglu et al., 2016). At the European level, **research and development funding** is the third most important item in the EU budget after structural and agricultural funding. The EU's research funding programme 'Horizon 2020' focuses on renewable energies and sustainability in two of the four main fields and is providing €8 billion for the period from 2018 to 2020. This is a relatively large amount per inhabitant compared to German federal funds. Due to economies of scale and positive external effects, funding for basic research at EU level should be stepped up (GCEE Annual Report 2018 item 52).

In addition, in a move to promote decarbonisation, the European Battery Alliance is to press ahead with the development of European battery production. €114 million from the EU's research and innovation programme 'Horizon 2020' has been made available for this purpose (European Commission, 2018b). While research funding for renewable energies and alternative mobility is an important building block for clean energy, concentrating on battery cells is a risk from the point of view of **technology neutrality**, as it is likely to displace alternative technologies. **Competition between technologies** is **indispensable** for leveraging innovation potential.

VII. REDISTRIBUTION OPTIONS FOR HOUSEHOLDS AND ACCOMPANYING MEASURES

KEY STATEMENTS

- The additional revenue from the pricing of CO2 emissions should be redistributed. Possible socially balanced options might be a per-capita lump-sum payment or a cut in electricity tax.
- Targeted accompanying measures, such as premiums for the replacement of heating systems, could facilitate behavioural adjustments.
- Goals of industrial and regional policy should not be intermingled with climate-policy instruments.

219. The aim of carbon pricing is to achieve an **efficient steering effect** to reduce greenhouse gases through behavioural adjustments. Higher prices, be it by auctioning emissions-trading allowances or taxation, would initially generate additional **state revenue**. However, this is not the real aim of such a reform. Rather, suitable political action should be taken to convincingly document that this is not at all about generating state revenue. For example, the reactions to higher carbon prices in France show that such an impression can threaten the **political acceptance** of carbon pricing in view of the socio-political consequences.

On the other hand, people are much more likely to accept a charge for CO2 emissions if the additional revenue generated by this meaningful climate-policy measure is redistributed and the redistribution is handled in a **socially balanced** manner. The analyses in this report of the effects on CO2-emissions avoidance and the financial burden on households are based on a scenario in which all additional revenue is redistributed.

1. Options for redistribution to private households

220. Pricing carbon initially has a regressive effect on private households (Hassett et al., 2009; Grainger and Kolstad, 2010; Edenhofer et al., 2019), because lower income groups would have to spend a higher proportion of their income on carbon pricing. ↘ ITEMS 165 FF. **Some theoretical approaches** suggest that, at least in a situation of perfect information, a compensation mechanism could be designed by internalising climate externalities in such a way that nobody would be worse off (Pareto improvement), and without jeopardising the steering effect generated by the change in relative prices. Bovenberg and Heijdra (1998) discuss how such an improvement can be achieved between generations. Geanakoplos and Polemarchakis (2008), on the other hand, consider possibilities for a Pareto improvement within a static model.

↘ TABLE 5

Evaluation[1] of different options for reimbursement of revenue from carbon pricing

	Payment of a per-capita lump sum	Lower indirect taxes	Increase in means-tested transfer payments	Lower direct taxes or social security contributions
Avoiding a regressive distribution effect	possible	possible	distribution effect limited to transfer recipients	distribution effect limited to tax debtors or employees
Ecological incentive effect	income effect partially counteracts carbon price signal	reduction of charges for electricity also reduces ecological disincentives	price signal for transfer recipients partially or completely reversed	income effect partially counteracts carbon price signal
Incentive effects on the labour supply	depends inter alia on transfer level, burden distribution and elasticities	depends inter alia on level of burden reduction, burden distribution and elasticities	trend is negative depending on transfer level and elasticities	distortion due to taxes are minimised (double dividend)
Visibility among the public (salience)	high – direct information on level of the payout	low	low and limited to specific group	information on level of the reduction possible
Administrative feasibility on introduction	complete register necessary, perhaps recourse to opt-in solution	cut tax rates or surcharges, take into account European minimum tax rates	basic security and housing benefit already available and extendable	adjust tax scale or reduce charges
Dynamic revenue neutrality	temporally variable lump-sum transfer	automatic mechanisms possible, but costly	no revenue neutrality	automatic mechanisms possible, but costly

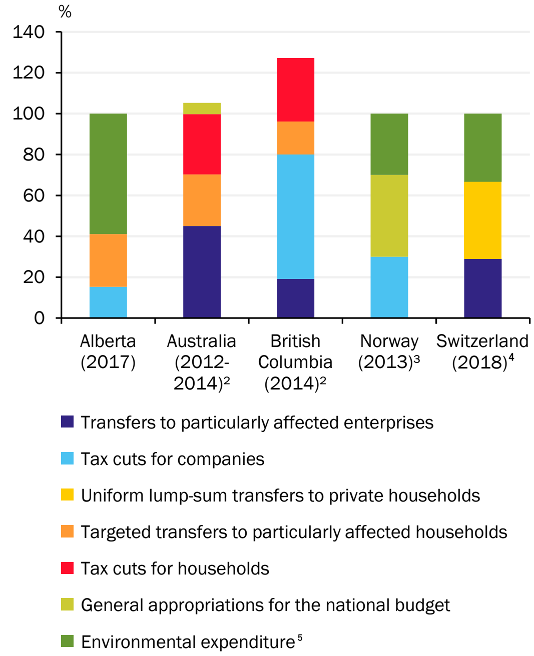
1 – (green) = Option largely meets criterion, (yellow) = neutral (red) = option unlikely to meet criterion.

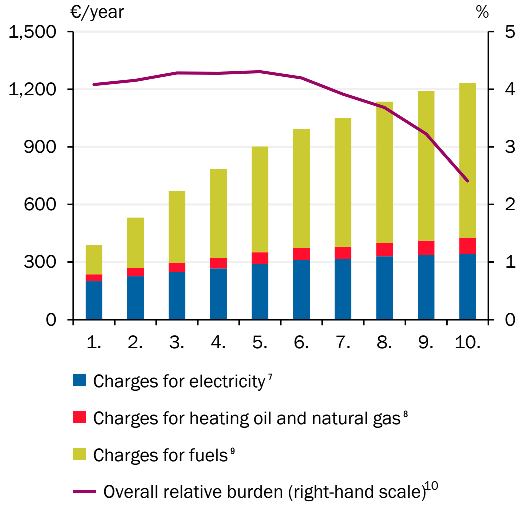
Practical implementation is difficult, however. There is a limit to the extent to which transfers can be organised and targeted in such a way that the money distributed exactly offsets each person's loss of income caused by carbon pricing. Sallee (2019) shows that carbon taxation always ultimately leads to losers and that distribution effects can therefore not be ignored. The reform will therefore have **different incentive and distribution effects** depending on how the revenue is redistributed.

221. When designing the redistribution, questions of **administrative feasibility** arise. It is decisive here, for example, whether new instruments or institutions need to be created. If **long-term revenue neutrality** is to be guaranteed, the chosen instrument would have to be able to adapt to fluctuating revenues from carbon pricing. Conceptually, revenue redistribution can be achieved via four different types of instruments, which can be combined. These instruments differ greatly in their potential for achieving administrative and socio-political objectives. ↘ TABLE 5 An international comparison reveals very different ways in which revenue from carbon pricing is used. ↘ CHART 26 LEFT

↘ CHART 26

Redistribution options in other pricing systems and levies in Germany





1 – Use of revenue as % of total revenue from the carbon price. According to Klenert et al. (2018). 2 – Expenditure exceeds 100% because the regions have committed themselves to additional expenditure. 3 – Estimate. 4 – The redistribution is based on an estimate by BAFU at the beginning of each year. The difference from the actual revenue is settled in the year after next, so that payment does not correspond to the revenue. The total disbursements are therefore standardised at 100%. 5 – Infrastructure, buildings, R&D, renewable energies. 6 – Related to 2013. Only the VAT due on the observed levies is taken into account. 7 – Includes, electricity tax, the allocation under EEG, KWKG, section 19 of StromNev, section 18 of AbLaV, and offshore liability. An average electricity price of 29.38 cents per kWh is estimated. 8 – Average gas prices are estimated at 7.09 cents per kWh and oil prices at 82.9 cents per litre in 2013. 9 – A weighted average price of 146.9 cents per litre and a weighted average tax of 64.3 cents per litre for petrol and diesel are assumed. Households without fuel consumption are taken into account. 10 – Sum of taxes in relation to net equivalised income.

Sources: Alberta Government (2019), BAFU, Bundesnetzagentur and Bundeskartellamt (2014, 2019), Carl and Fedor (2016), Federal Statistical Office, Jotzo (2012), Klenert et al. (2018), Ministry of Finance and Corporate Relations British Columbia (2016), RDC of the Federal Statistical Office and Statistical Offices of the Länder, Einkommens- und Verbrauchsstichprobe 2013 Grundfile 5 (HB), own calculations

Impact assessment analysis

222. To assess the impact of a carbon price on private households, a **reference scenario** is first determined in which the revenue is **redistributed according to a lump-sum transfer per inhabitant**. The data used for this purpose again stem from the and UGR. ↘ ITEMS 164 FF. The initial aim is to identify the demand effects induced by the price signals and to determine the burden at household level ↘ BOX 5 On this basis it can be discussed which distribution effects arise from the option implemented in the reference scenario and, by contrast, from various alternative reimbursement options.

223. The starting point of the model calculation is a **uniform carbon price** for all goods and services. The instrument used to determine this price is not considered. In accordance with Edenhofer et al. (2019) an interval of price elasticities is used to take the considerable uncertainty about the price sensitivity of households into consideration.

↘ BOX 5

Method to determine the tax burden of carbon pricing on private households

The effects of carbon pricing on private households are quantified using consumption data (from the EVS) and CO2 emissions per euro spent (from the UGR - environmental-economic accounts). ↘ BOX 3 The starting point is the assumption that households' expenditure within the 46 consumption categories studied will be increased by a uniform carbon price according to their CO2 emissions. **Price elasticities** are then used to determine how households would most likely adjust their consumption volumes to this price change (Brännlund and Nordström, 2004). The analysis is based on Pothen and Tovar Reaños (2018), who, with the help of the EVS, determine price elasticities for **ten different consumption categories as a function of** households' **spending levels.**

Thereby, the calculations consider that the price elasticities of goods are very heterogeneous and that households' reactions to price changes depend on their consumption budgets. ↘ TABLE 6 For example, **households** react much more sensitively to price changes for leisure goods and services than to price changes in the energy or transport field. In addition, the ability to adjust consumption varies **depending on the budget.** For example, sensitivity to fuel prices decreases in line with the household budget from 0.6 to 0.3. ↘ TABLE 6

↘ TABLE 6

Price elasticities[1] for different consumption categories according to expenditure quartiles as %

	Spending quartile[2]			
	1.	2.	3.	4.
Food	– 0.7	– 0.7	– 0.8	– 0.8
Housing[3]	– 0.9	– 1.0	– 1.0	– 1.0
Energy[4]	– 0.5	– 0.5	– 0.6	– 0.7
Transport[5]	– 0.6	– 0.5	– 0.4	– 0.3
Communication[6]	– 0.7	– 0.7	– 0.7	– 0.6
Leisure[7]	– 0.8	– 0.9	– 1.0	– 1.0
Clothing	– 0.7	– 0.8	– 0.8	– 0.8
Health and education	– 0.8	– 0.9	– 1.0	– 1.1
Appliances[8]	– 0.3	– 0.5	– 0.6	– 0.8
Other services[9]	– 0.9	– 1.1	– 1.1	– 1.1

1 – Price elasticities indicate how the consumption of a good reacts to a one-percent price increase. 2 – Expenditure quartiles split households into four equally large groups according to their total consumption expenditure. 3 – Including maintenance and assumed rents for owner-occupied residential property. 4 – Electricity and heating costs. 5 – Motor vehicles, their maintenance and operation. 6 – Telecommunications and postal services. 7 – Includes various services, electronic devices, durable recreational goods, holiday trips and printed matter. 8 – Including furniture, textiles, glassware and maintenance services. 9 – Financial, insurance and other services.

Source: Pothen and Tovar Reaños (2018)

In addition to the direct burden from the carbon price and the resulting demand effect, the calculations aim to show how the reduction of revenue can reduce the burden on households. However, the income thereby made available is again spent on consumption, which in part counteracts the primary objective of carbon pricing. The calculations of Pothen and Tovar Reaños (2018) are also used to determine the underlying **income effects.**

The model calculation does not offset the imposed carbon price against the current energy or electricity tax. It is therefore implicitly assumed that the carbon price is charged in addition. ↘ ITEM 126 Alternatively, the energy tax could be offset in full or in part (Edenhofer et al., 2019).

Some restrictions must be taken into account when interpreting the results. In general, the **determination of elasticities** is a great challenge and involves **considerable statistical uncertainty.** By definition, they apply to marginal price increases. In the case of carbon prices, however, very strong interventionsin the prices can occur, which could result in demand effects being significantly stronger than expected. In addition, the elasticities used reflect adjustments over a period of five years due to their database. In the **longer term**, higher elasticities can be expected, as it is only here that long-term investments take effect (Edenhofer et al., 2019). In addition, consumers tend to react more elastically to price changes if they are triggered by a change in taxation, as these are noticed more readily by the public. Furthermore, there is a limit to the extent to which the elasticities used can reflect the true heterogeneity of the different consumer goods and the socio-demographic characteristics.

Another necessary assumption for deriving these estimates is that **consumers** bear the **full burden of the tax**. By assumption, producers can pass on the entire carbon price on to consumers. This is a simplification. In the energy and transport sectors, however, it can be regarded as realistic. ↘ BOX 4 This is where the model calculations by Edenhofer et al. (2019) differ, since they exclude the possibility of passing on carbon pricing outside the buildings and transport sector. It is also assumed that the carbon price is levied on every tonne of CO_2, regardless of where it is produced. Imports are therefore also fully included in this model calculation. The resulting burdens on households are therefore an **upper limit**.

Furthermore, the simulation cannot **take into account significant behavioural adjustments**. Should it be possible to introduce a carbon price that takes into account the actual carbon content of each individual product, products within a consumption category will be affected by a carbon price to varying degrees – for example if a producer works very efficiently and the carbon price has a smaller impact on his product than on other identical products. From this perspective, therefore, the model results represent the maximum burden or the minimum carbon saving.

Similarly, substitution with less carbon-intensive goods cannot be taken into account. Instead of reducing the demand for a product category overall, less carbon-intensive goods could be preferentially purchased within the category. For example, the model calculations cannot account for public transport's better carbon-efficiency in comparison to one's own car. Although the carbon price would also burden public transport, the corresponding demand could nevertheless increase due to a high cross-price elasticity.

Despite the far-reaching assumptions, such model calculations can serve to identify the different cost impacts between household types and to recognise cases of hardship. However, because of the great underlying uncertainty, the calculated impacts and carbon savings must **not** be interpreted **either** as a **forecast** or as a **revenue estimate**.

224. The model calculations make it clear that **a higher carbon-price signal** leads to **bigger effects on demand** and that CO_2 emissions are correspondingly likely to fall more sharply ↘ CHART 27 LEFT The savings effects are due in particular to the decline in two consumption categories. Approximately 60 % of the savings are made within the energy category; about 30 % are attributable to fuels. This is largely due to the high commodity-specific carbon consumption of heating media and fuels and to the assumption maintained here throughout that the carbon price will be levied in addition to the current energy tax.

225. The **carbon savings** described involve several elements of uncertainty. For example, the calculation neglects the fact that substitution effects will occur within the consumption categories. Less carbon-intensive goods or services, such as local public transport, become relatively cheaper and are therefore more wi-

dely used. The carbon-saving potential of fuel consumption is thus reduced by the CO2 emitted by the substitute. However, these effects cannot be taken into account in the model calculation.

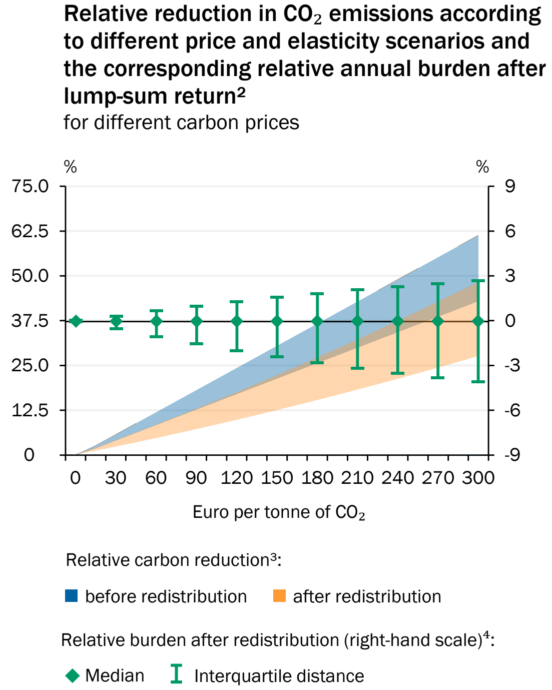
Moreover, the assumed **price sensitivity** of households could be increased, e.g. by accompanying measures ↘ ITEMS 242 FF. Furthermore, the elasticities could be significantly higher at a very high carbon price. The relative reduction in carbon consumption would then increase not linearly but disproportionately with the price.

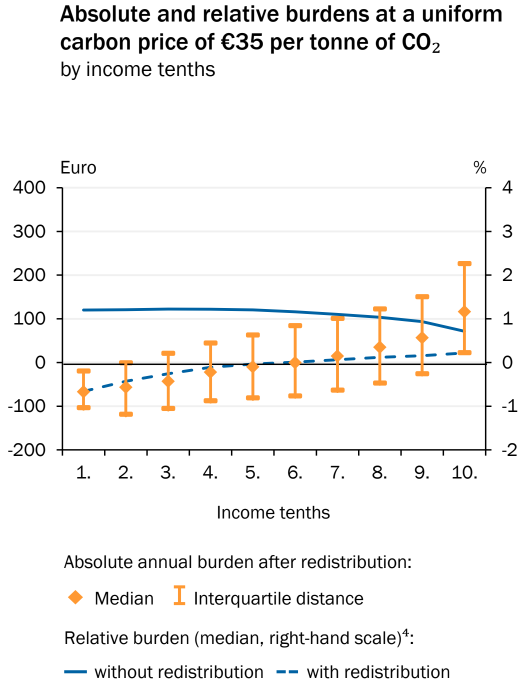
226. Modelling a uniform carbon price of €35 per tonne of CO2 leads to an estimated tax revenue of approximately €11 billion, which is generated in addition to revenue at a hypothetical EU ETS allowance price of €25 per tonne of CO2. This revenue was not initially taken into account when considering demand effects. However, since the estimates are intended to record the effects of carbon pricing assuming **revenue neutrality**, the aggregated revenues are fully redistributed to households in the calculations. The price of €35 per tonne of CO2 is given as an example, as the effects run linear with the price. Although the absolute and relative burdens increase with the price, the distribution effects between the income groups discussed below do not change.

227. An **age-independent per-capita lump sum** is considered as a reference, since it represents the simplest method for ensuring revenue neutrality in terms

↘ CHART 27

Effects of a uniform carbon price on private households' income and carbon consumption[1]





1 – Calculations refer to the base year 2013. 2 – Revenue-neutral lump-sum return. 3 – Upper interval limit determined by 30 % higher elasticities and 10 % higher CO_2 content of goods. 4 – Burden relative to equivalence-weighted disposable income.

Sources: Federal Statistical Office, Pothen and Tovar Reaños (2018), RDC of the Federal Statistical Office and Statistical Offices of the Länder, Einkommens- und Verbrauchsstichprobe 2013 Grundfile 5 (HB), own calculations

of model theory. Revenues above a fixed EU ETS price of €25 are redistributed. This is intended to ensure that the EU ETS revenue already included in the federal budget are not spent twice. In the scenario of a uniform carbon price of €35 per tonne of CO2, the annual lump sum could amount to €140 per person. The fall in excise duties caused by declining demand is not taken into consideration in the fiscal account. Similarly, the turnover tax (VAT) which would be imposed on the carbon price under tax law is also ignored. Furthermore, it is important to take into account the technical uncertainties relating to the extent of the adjustment reactions. ↘ BOX 5

228. The additional income partly counteracts the carbon savings, since it is spent on consumption. Nevertheless, households are reducing their carbon consumption. On the one hand, household-consumption decisions depend on the relative prices of goods. Since emissions-intensive goods become more expensive in relative terms due to the carbon price, emissions are reduced even if income losses are fully reimbursed (Schmitz et al., 2017). On the other hand, the **per-capita lump sum** only covers the average additional expenditure.

229. If, instead of a uniform price, a **diverging price** between the EU ETS and non-EU ETS sectors were charged, this would have an impact on the expected carbon savings ↘ CHART 29 APPENDIX An estimate is documented as an example in which a price of €35 per tonne of CO2 is introduced exclusively in the non-EU ETS sector. Since the average carbon price falls due to this separate pricing, the resulting **CO2 saving effects are lower** than in the scenario of a uniform price. These estimated results are consistent with the results of Edenhofer et al. (2019), who always base their estimates on this alternative.

Flat-rate reimbursement as a climate dividend

230. A direct reimbursement of the income can be achieved through a **lump-sum payment** (climate dividend) to each citizen. This is already being practised in Switzerland. Every citizen, regardless of age, receives a per-capita lump sum. In Germany, such a reimbursement would reverse the initially regressive effect of the carbon price into a progressive distribution effect. ↘ CHART 27 RIGHT The average net burden would thus increase with disposable household income (Wier et al., 2005; Feng et al., 2010; Edenhofer et al., 2019).

Up to the fifth income tenth, the financial burden on households would be reduced, while households above the median net equivalised income would have to pay more. ↘ CHART 28 LEFT Likewise, some households that can be assigned to the lower income tenths and have a relatively high carbon consumption would be worse off as a result of carbon pricing. In the second income tenth, for example, a quarter of all associated households would pay more in net terms. ↘ CHART 27 RIGHT The **net burdens** would therefore be **very heterogeneous** within certain income groups. This observation is reinforced for higher carbon prices. ↘ CHART 30 APPENDIX Bach et al. (2019), Gechert et al.(2019), and Zerzawy and Fiedler (2019) come to a similar conclusion when they consider an energy tax reform in connection with the payment of a climate bonus.

231. Apart from the average burden, it is also shown that the unweighted per-capita lump sum could **cushion hardship** very well. If cases of hardship are defined as households whose burden would make up more than 1.5 % of their net equivalised income in the scenario of a €35 net carbon price, they make up an average 0.9 % in the lower three income tenths in the case of a per-capita lump sum. This indicator only rises slightly in higher income tenths.

The most important **factor explaining** why some households have to spend a relatively high proportion of their income on paying the carbon price is a **carbon-intensive heating** system. Carbon pricing would burden heating systems that use fossil fuels significantly more than district heating. Furthermore, lump-sum reimbursement would place a higher average burden on single persons. A large living space and high fuel costs also increase the probability of having to pay particularly high charges. A discussion on how carbon pricing would affect specific households can be found in Frondel (2019) and the 'CO2-Abgabe' association (2019).

232. If household size were taken into account, there would be more relief for single people in particular. For example, if the lump-sum payment for children were lower than for adults, the funds released could be used to increase the adult lump sum. The ratio between the lump sums for children and adults could be based, for example, on the ratio used for the subsistence minimum in the income-tax and child-benefit systems. It is currently 54 %. According to the model calculations, such a scheme would have little influence on the average distribution effect. However, the **proportion of heavily burdened households** would **decrease** from 1.1 % to 1.0 % on average. ↘ CHART 28 LEFT

233. The reimbursement of revenue could further be based on the **degree to which people are individually affected**, although this would simultaneously reduce the effect on emissions savings. The French Conseil d'analyse économique (Bureau et al., 2019), for example, proposes specific support for lower-income households and targeted transfers that are dependent on the place of residence and decrease with income. Bach et al. (2019) and Gechert et al. (2019) discuss, for example, a mobility allowance designed to relieve commuters irrespective of their tax liability.

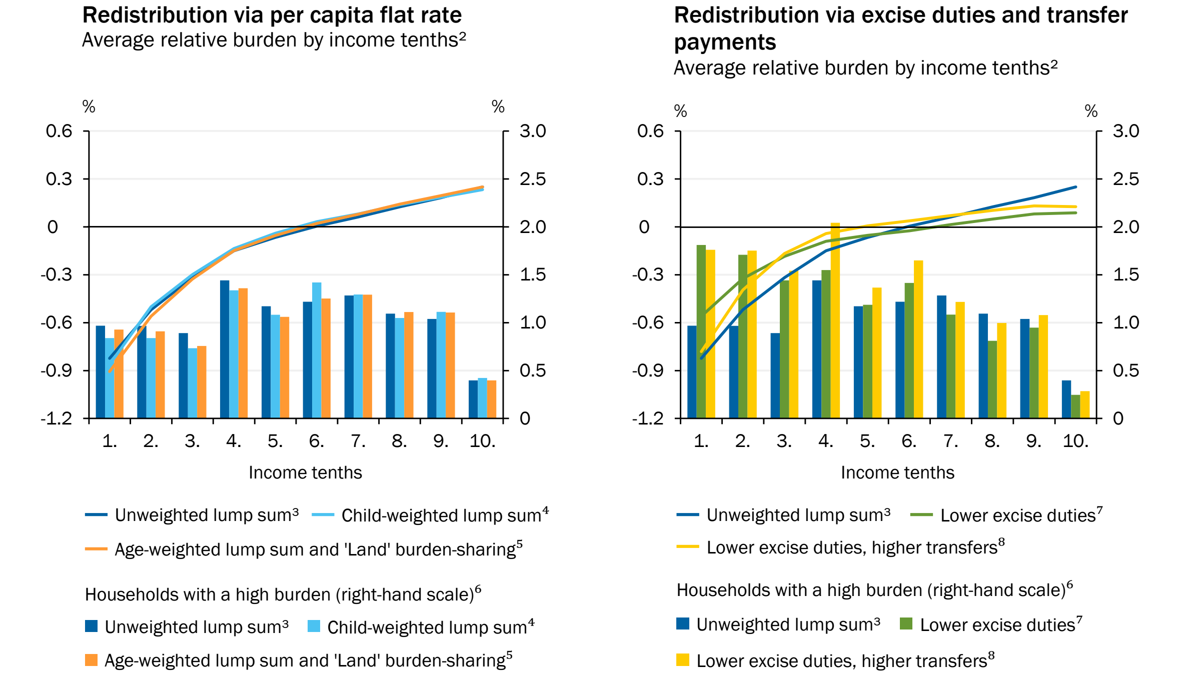
Model calculations in which, on the one hand, the lump sum for children is determined according to age and, on the other, **households** in a small town or **in rural areas** receive a higher amount and are given relief because of their **higher mobility needs**, again indicate that the average distribution effect in the lower income bracket remains almost equivalent. However, the number of cases of hardship would fall. ↘ CHART 28 LEFT

One advantage of lump-sum reimbursement would be its high visibility. Every year, information could be sent to inform everyone about the exact reimbursement and the development of carbon reductions. This easily understandable information – as well as the direct and clearly visible pay-out for each recipient – could help **increase acceptance of carbon pricing** (Edenhofer et al., 2019).

234. However, one **challenge** of a flat-rate reimbursement is its administrative feasibility. In Switzerland, the per-capita lump sum can be paid by the health insurance funds, since they have a **complete population register**. There is no comparable system in Germany. Since, however, there is an insurance obligation in statutory health insurance, a system could be based on this, for example. People not covered by statutory insurance could be included via an opt-in procedure. Gechert et al. (2019) see the Federal Central Tax Office as a suitable institution for paying out the lump sum on the basis of the tax identification numbers available there. However, it remains to be seen to what extent the legally prescribed use of this identification number can be extended without infringing the right to informational self-determination. It should also be noted that the administrative challenges would tend to be greater the more differentiated the reimbursement process is.

↘ CHART 28

Distribution effects of different reimbursement mechanisms[1]



1 – Calculations for 2013. A uniform CO_2 price of 35 euros per tonne CO_2 is estimated. The price in the EU ETS sector is €25 per tonne of CO_2. If a consumer good is included in the EU ETS, only the difference between the uniform CO_2 price and the EU ETS price is used for the budget. All scenarios are revenue-neutral. 2 – Burden in relation to net equivalised income. 3 – Uniform per-capita lump sum for adults and children. 4 – A reduced lump sum for children under the age of 25. The lump sum for children is 54 % of the adult lump sum. This corresponds to the ratio between the subsistence levels for tax purposes of children and adults. Lump sum for adults is 10 % higher compared to the lump sum without child weighting. 5 – The children's age is taken into account in the reimbursement. The lump sum is based on the ratios of the 'standard requirements stages' in accordance with the Standard Requirements Determination Act (Regelbedarfs-Ermittlungsgesetz). Furthermore, an additional need is recognised for single parents. The lump sum for adults is 13 % higher compared to the lump sum without age weighting. Households living in rural areas receive a 10 % higher allowance. 6 – Households with high burdens are defined as those which, after reimbursement, bear a net burden exceeding 1.5 % of their annual net equivalised income. 7 – Electricity tax and EEG surcharge are waived for households, taking the minimum tax into account. The reduced VAT rate is lowered until revenue neutrality is reached. 8 – In addition to the waiver of the electricity tax and the EEG levy, the increase in the SGB II benefit (income support for employable persons) for accommodation and living costs is taken into account. In addition, current housing benefit recipients are fully reimbursed for the additional heating costs. The remaining budget is used to lower the reduced VAT rate.

Sources: Federal Statistical Office, Pothen and Tovar Reaños (2018), RDC of the Federal Statistical Office and Statistical Offices of the Länder, Einkommens- und Verbrauchsstichprobe 2013 Grundfile 5 (HB), own calculations

Lowering excise duties as a practicable solution

235. An alternative to direct reimbursement might be the indirect repayment of the revenue from carbon pricing by **lowering excise duties**. International comparisons show, for example, that taxes on electricity consumption are relatively high in Germany. ↘ITEM 102 Lower income tenths pay more relative to their income ↘ CHART 26 RIGHT In addition, a reduction in electricity costs would strengthen sector coupling, as the substitute for fossil fuels would become cheaper (acatech et al., 2017). For example, it would be possible to reduce electricity tax to the European minimum level (Edenhofer and Schmidt, 2018).

The model calculation simplifies matters by assuming that **electricity tax** is only reduced for households. This concept of partial relief is motivated by the assumption that industry, services and commerce can pass on all the additional costs of carbon pricing to households and are not burdened. Any redistribution between private and commercial actors is thus excluded in the model analysis. At the same time, it would be possible to finance a large proportion of the **EEG surcharge**, which is currently added to the electricity price, from the additional federal revenue. This should be permissible under state-aid law (Büdenbender, 2019). Another possibility would be to lower the reduced VAT rate to the European minimum rate. According to the Income and Consumption Survey (EVS), the revenue from a carbon price of €35 per tonne of CO2 is enough for the complete reduction of electricity tax, the EEG surcharge and for lowering the reduced VAT rate to 6.4 %.

236. Compared to lump-sum reimbursement, the reduction in excise duties involves **less progressive** relief. Households in the lower income groups benefit less, because for them the absolute tax savings are lower than a per-capita lump sum. For households in the higher income tenths, the ratio between the return options is reversed. They are less burdened than in the case of direct reimbursement as their tax savings are higher. ↘ CHART 28 By comparison, there would be a higher percentage of hardship cases according to the model calculations. A direct per-capita lump sum therefore seems better suited for cushioning cases of hardship.

On the other hand, the option of reducing excise duties is likely to be more practicable to implement as it relates to existing taxes. However, a general problem with the reduction of such levies would be that, although the reform could be made revenue-neutral in the short term, a **continuous adjustment of tax rates depending on revenue** from carbon pricing is likely to entail **different levels of administrative effort**, depending on the excise duty considered. The annual adjustment of the EEG surcharge shows that this is possible to a certain extent.

Higher transfers as supplementary measures

237. Mechanisms already exist in the German transfer system that would automatically offset additional burdens caused by carbon pricing. Both SGB II (basic security for employable persons) and SGB XII (income support) pay the actual

home heating expenses, if they are reasonable. A climate dividend could therefore be offset against the transfer payments. If offsetting were waived, the burden due to CO_2 pricing would be reduced in the lower income bracket, which could have negative labour-supply effects. In addition, the basic security (SGB II) level will rise with higher consumer spending. Part of the revenue would therefore be automatically returned to the households. Cases of hardship in the lower income bracket would then be largely excluded by the current welfare state. However, in order to reduce the burden caused by carbon pricing not only in the lowest income bracket, **housing benefits** could **be increased**. At the same time, however, this means that in the targeted income range pricing would have only a reduced steering effect; this would depend on the specific design.

238. In the model calculations for lump-sum reimbursement, automatic mechanisms were initially neglected, since the per-capita flat rate is the more generous regulation for the majority of the recipients of basic security. However, if only taxes are reduced, an **adjustment of income support would be constitutionally required**. The financing requirements and the relief for transfer recipients should therefore be taken into account in the model calculations. In addition, a **reform of housing benefits** is being considered. In the model calculations, it is assumed that the additional heating costs are fully reimbursed to households receiving housing benefits. The financing requirement for the higher transfers is offset by a smaller reduction in value-added tax, so that revenue neutrality is still ensured.

239. Again there is a progressive distribution effect. Compared to the scenario of a simple tax reduction, however, taking basic security into account and extending housing benefits lead to a **higher degree of progression**. ↘ CHART 28 RIGHT As expected, the lower two tenths of income are favoured by the transfers. Relief for households in the higher income tenths would be less effective, as VAT could not be reduced as much. This would increase the number of cases of hardship, especially in the middle income bracket.

240. These calculations do not take into account the fact that **more people would be entitled to benefits** as a result of the extension of basic security and housing benefits. If these people exercise their rights, transfer costs will also be higher.

Easing the burden on the labour factor

241. Further options could help achieve revenue neutrality through other **reductions in direct taxes or social security contributions**. This was already the aim of the Ecological Tax Reform begun in 1999. At that time, pension insurance contributions were lowered. The motivation for this was to achieve a '**double dividend**' (Pearce, 1991; Goulder, 1995; Bovenberg, 1999). The first dividend is derived from the steering function of environmental taxes. Reduced emissions were to generate positive effects by mitigating climate change.

The second dividend comes from **reducing the burden on labour**. The resulting convergence of net wages and gross labour costs can have positive effects on production and employment. Following a similar motivation, the carbon tax introduced in Sweden in 1991 reduced the tax rates on income and capital gains (Ackva and Hoppe, 2018).

242. The impact of such a reform will ultimately depend on its precise design and the resulting reactions of the **labour supply** of households. Static modelling, as applied here, is unable to do this. Therefore, no detailed analysis is carried out of the distributional effect of this reform option.

243. The problem with such a compensation option is that it is more complex to link the amount of relief to the amount of additional revenue. On the one hand, the respective revenue effect would have to be estimated; on the other, regular adjustments would be necessary to the income tax rate or to social security contributions. In addition, visibility is likely to be rather low, as the individual benefits are generated steadily over the year and not paid out directly. However, reimbursement could be made visible more easily than in the case of excise duties, for example in the income tax assessment notice or pay slip. Another aspect is that specific groups are either not subject to income tax or do not pay social security contributions. **Certain population groups** would thus be **excluded** from **reimbursement**, but not from carbon pricing.

244. In addition to the reductions in taxes and levies mentioned above and a lump-sum reimbursement of funds, the tax revenue could be used for **flanking environmental-policy measures** aimed at a stronger reaction to the carbon price, thus supporting its signal effect. The resulting distribution effects depend greatly on the design.

2. Targeted use of accompanying measures

Promoting the purchase of low-emission machinery and equipment

245. The climate-policy instrument that is the focus of discussion here is a price for greenhouse-gas emissions. As the central instrument of climate policy, it is so promising because it provides incentives to drive innovation towards technologies with lower CO2 emissions. Furthermore, it results in companies and households emitting less CO2 by changing their behaviour and investing in machinery and consumer goods respectively. As shown by the effects on a moderate pricing of CO2 emissions estimated on the basis of earlier **reactions to price changes**, the reductions in emissions associated with these incentives are limited. Either very high prices or **stronger reactions to price increases** will probably be necessary to meet emissions-reduction targets under international agreements.

However, there are good reasons to assume that the reaction is likely to be greater than described above. On the one hand, historical reactions have so far been measured over relatively short periods of time and with relatively small price changes. On the other, **new technological possibilities** and substitution opportunities, which only become competitive as a result of higher prices, did not play a role.

246. Accompanying measures should be considered to intensify the adjustments and thus contain the carbon price required to achieve the goals. However, measures should only be considered that can specifically remove obstacles or address externalities as a supplement to the carbon price. Particular attention should be paid to **avoiding deadweight effects**.

247. An important measure will be to **inform** households and businesses about how the carbon price functions and how it is likely to develop, as well as about how this price translates into costs when making purchase and investment decisions. In this context, information might include the aggregated energy costs for 'typical' drivers (when motor vehicles are to be purchased), or the project costs and cost savings for energy-related building renovations (Edenhofer et al., 2019).

Existing instruments such as the energy certificate or advice on energy-saving can be effective, but there is still room for improvement in Germany. **Expanding and improving the instruments**, e.g. by standardising energy advisory services and energy certificates, could support the decisions of both house buyers and sellers (Amecke, 2011; Henger et al., 2017). Other measures are already having an impact. For example, Andor et al. (2017) show that the use of energy labels, i.e. categorising electrical appliances according to their energy efficiency, can have a significant influence on purchasing decisions. Similar instruments known in behavioural economics as 'nudges' can, when properly designed, also reduce individual energy consumption without high costs (Andor and Fels, 2018).

248. In order to enable especially households and companies with limited budgets or liquidity to switch to lower-carbon equipment or machinery, subsidies in the form of **grants or loans** can be important for **purchases**. However, with these instruments in particular it is important to ensure targeted support and avoid deadweight effects.

Electromobility in particular is currently being promoted in the transport sector. Companies are subsidised for purchasing energy-efficient and low-carbon heavy commercial vehicles (BMVI, 2018b). Under Germany's Electromobility Promotion Programme, companies and private individuals receive funding for the purchase of most electric cars and cars with fuel cells (BAFA, 2019). €1.2 billion will be made available for electromobility up to 2020. Half will be paid by the Federal Government, the other half by the automotive manufacturers. Tax incentives currently also exist. For example, battery-powered vehicles are not subject to motor vehicle tax for a period of ten years (BMWi, 2019c). It seems problematic that this (exclusively) promotes a particular technology. Rather, funding should focus on reducing emissions, regardless of technology.

249. In the **buildings sector**, landlords and tenants may not have the same incentives when it comes to a building's energy efficiency. This applies in particular to **existing tenants**, who are limited in the way they can react to an increase in energy costs. Although the landlord bears the costs of renovation and must take action, it is the tenant who benefits from the lower energy costs. The costs of energy-related renovation can **only be partially passed on**. ↘ ITEM 82

The Federal Government is already promoting the voluntary energy-related renovation of buildings with a variety of instruments. Among others, the KfW Group and the Federal Office of Economics and Export Control offer several programmes of subsidies with a strong focus on the heating sector. These are often grants and **loans with repayment subsidies** or a **partial debt relief** for private individuals, companies and municipalities (BMWi, 2019d).

Since last year, low-income households in France have been issued energy cheques as compensation to finance energy costs or renovation measures. This will **promote the switch to lower-emission technologies**, so that the individual tax burden will be lower in future (Boyette, 2018).

The Federal Government's funding measures can also be supplemented with Länder funding. Furthermore, **energy-efficient construction** is supported. In total, the Federal Government is promoting the field of buildings efficiency with more than €17 billion up to 2020. Since 2000, around five million owners have received a subsidy (BMWi, 2018c).

250. The coalition agreement laid down a "right to choose between a subsidy and a reduction in taxable income" (Bundesregierung, 2018). However, so far there have been no tax concessions for refurbishment via improved tax credits. **Targeted premiums**, e.g. for the replacement of heating systems, could, however, be **superior** to **tax depreciation**. On the one hand, they reduce deadweight effects. On the other, people with comparatively low incomes are hardly reached by tax-related measures.

251. Alternatively, the **incentives for refurbishment could begin when the rent is set**. For example, the scope for rent increases could be linked not to a fixed quota via a modernisation levy, but might depend on how much the tenants save in heating costs. This would be comparable to a utilities charge that depends on amounts saved (Klinski, 2010; Kossmann et al., 2016).

252. In some areas, the provision of **infrastructure and the creation of suitable conditions** are necessary in order to create substitution opportunities in the first place. This may include the development of local public transport, long-distance transport, and the cycling and pedestrian infrastructure. Furthermore, it may be necessary to expand the infrastructure for car and intelligent freight transport, for example by extending the network of filling (charging) stations for

other engine types. Furthermore, **the grid and storage infrastructure needs to be expanded**. Here it can be useful if the state sets uniform standards. The expansion of the network could then be organised on a private-sector basis. ↘ ITEM 70

253. In building renovation as in infrastructure expansion, the shortage of skilled workers and **capacity utilisation** are limiting factors. Even owners of buildings who are willing to renovate find it difficult to find sufficient suitable personnel (German Environment Agency and BMU, 2011; Pfnür and Müller, 2013; Kenkmann and Braungardt, 2018). This requires on the one hand productivity improvements and, on the other hand, measures to increase and make better use of the labour potential, for example by increasing the immigration of skilled workers or making working hours more flexible (GCEE Annual Report 2018 item 614).

254. The transformation of an economy towards drastically reduced carbon consumption generates high investment and capital requirements. The financial market plays a decisive role. This is where the funds are mobilized to finance the investment in lower-carbon technologies stimulated by the carbon price. In view of the **large financing requirements** for investments and possible value changes in existing assets due to climate change, the stability of the financial system vis-à-vis climate risks should be particularly closely monitored. ↘ BOX 6

↘ BOX 6

Opportunities and risks of climate change for the financial markets

Risks to the financial sector arise from global warming itself and as a result of tightening (political) regulation aimed at creating a decarbonised economy (ECB, 2019). The literature discusses the **carbon bubble** as a potential risk to financial stability, i.e. the assumed overvaluation of carbon-intensive companies that could result not least from incompatibility with the goals of the Paris Climate Agreement. There could be a fall in the value of assets ('**stranded assets**') if investments that have already been made are no longer profitable due to climate-related changes in market conditions or regulations.

Due to the high debt ratio in carbon-intensive industries, financial institutions may face high losses in this context (ESRB, 2016). For the reasons mentioned, an orderly transition to climate-friendly investment instead of abrupt **disinvestments** from carbon-intensive plants would probably involve fewer risks for the stability of the financial system (ESRB, 2016). In order to be able to comprehensively assess risks from climate change and climate policy for financial stability, it is also necessary to extend existing stress tests to include scenarios that explicitly take risks from climate change into account.

At the same time, the financial sector has an essential role to play in financing global investment requirements in the context of international climate policy and in steering the economy towards sustainable investment. This can generate opportunities to actively meet the resulting challenges with suitable adaptation strategies. **Sustainable investment approaches** limit the investment universe on the basis of ESG (Environmental, Social and Governance) criteria, or address selected sustainability challenges ('impact investment'). Taking ESG criteria into consideration in investments can, under certain circumstances, take on an insurance function against climate risks for investors (Jagannathan et al., 2017; Bannier et al., 2019).

In addition, a number of climate-friendly financial instruments have been developed in recent years, and, of these, green bonds should be mentioned first because of their volume. **Green bonds** are bonds whose proceeds are earmarked for the implementation of environmental and climate-protection projects. Since the first green bond was issued by the European Investment Bank (EIB) in 2007, the instrument has gained significantly in importance (Climate Bonds Initiative, 2018). Green bonds can be issued by states ('sovereign green bonds') or companies. Taking into account the cumulative global emission volume since 2007 and new emissions in 2018, American, Chinese and French issuers are the key players in the green bond market (Climate Bonds Initiative, 2019). In the USA, the market for green bonds is supported by preferential tax treatment. The German market is the world's fourth largest emissions market for green bonds (Climate Bonds Initiative, 2017). The group of investors for government bonds could possibly be expanded when the federal, state and municipality governments would follow the model of neighbouring European countries and issue more green bonds.

Efforts to develop a uniform **EU classification system** as well as **labelling systems** for sustainable financial products within the EU are important steps towards protecting the integrity of the sustainable financial market and towards making it easier for investors to access these products (European Commission, 2018c). It also seems to make sense to develop a uniform **benchmark concept** that helps investors to accurately assess the carbon balance of their investments and to gauge the existing risk from stranded assets. The recent political agreement at EU level on new disclosure requirements for sustainable investment and sustainability risks is to be welcomed in this context (European Commission, 2019 f.).

Giving sustainable investments preferential treatment by reducing **capital requirements** as proposed by the European Commission in its March 2018 Action Plan (European Commission, 2018 d) is not appropriate. Supervisory regulations should not be used to channel capital flows towards green investments without proof that such investments are less risky than others (ECB, 2018). Otherwise, this would pose a risk to financial stability in certain circumstances.

No overburdening with goals of industrial and regional policy

255. Many of the measures implemented to date in German climate and environmental policy have simultaneously pursued **objectives other than the mitigation of climate change**. These include goals of industrial and regional policy, ensuring equal living conditions or reducing pollution in cities. It would, however, be highly advisable to pursue these objectives separately from climate-change mitigation in the course of a change-over in climate policy to pricing CO_2 emissions and, where necessary, using more suitable and targeted instruments.

256. For example, the **externalities** of urban transport, particularly traffic congestion, noise and air pollution, are local problems that can be better limited by pricing those responsible for the externalities locally. A **city toll** based on local pollution levels, the time of day and a vehicle's emissions would make the external costs visible and thus lead to an efficient reduction of externalities (GCEE Annual Report 2018 item 30 ff.). Outside cities, the costs of using the road infrastructure can be priced-in via toll systems. ↘ ITEM 105 Similarly, electricity consumption could be controlled by means of appropriate network charges on the basis of smart-meter applications to prevent local grid bottlenecks or grid collap-

se (Board of Academic Advisors to the Federal Ministry for Economic Affairs and Energy, 2014).

257. A **guiding industrial policy** to promote specific industries or technologies is unlikely to reach its targets. Rather, it makes more sense to pursue a **technology-neutral** innovation policy. A uniform cross-sector carbon price can make a contribution here. In addition, care should be taken to make sure that the accompanying measures, although useful, do not create new distortions.

The reorganisation of the energy supply system leads to a **structural change**. From a socio-political point of view, it may be necessary to **cushion** its consequences with appropriate measures. However, in deciding whether intervention beyond the **existing mechanisms** of the tax and transfer system and regional policy is necessary, it should not be a criterion whether structural change has been triggered by climate change, technological change or globalisation. The argument that structural change in the case of climate change is brought about by discretionary policy decisions and should therefore be dealt with separately is not convincing. After all, similar arguments could be used stating that the structural change triggered by globalisation and technological change is also driven by many discretionary policy interventions, such as the fixing of tariffs and free trade agreements or the regulation and promotion of technological innovation.

VIII. CONCLUSION: ESTABLISHING THE CARBON PRICE AS A CENTRAL INSTRUMENT OF CLIMATE POLICY

258. The Federal Government currently has a great opportunity to leave the climate policy by regulatory law of the past behind. By consistently pricing greenhouse-gas emissions, it can make the urgently needed course correction in German climate policy. This **reorientation of climate policy** should replace the idea of detailed control pursuing small-scale objectives with market-oriented instruments. Only in this way can the agreed climate targets be achieved in an economically efficient manner. In this way, Germany could prove to be an **international role model** in the national implementation of globally agreed climate targets and, at the same time, make a contribution to increasing societal acceptance of climate protection. A reliable and long-term strategy also creates incentives for innovation and investment in climate-friendlier alternatives.

259. The aim of this new departure in climate policy should be to integrate all relevant sectors into a **comprehensive European emissions-trading scheme** for greenhouse gases in the medium term, by 2030 at the latest. This step would supersede separate climate-policy targets in individual sectors, and the price established in integrated emissions trading would be the central instrument of European climate protection. Additional national climate targets should be dropped without replacement.

This integrated emissions trading should in turn be linked to other systems worldwide with the aim of agreeing on **globally uniform pricing** for greenhouse gases. Negotiations to prepare for this extension of the EU ETS and its global interlinkage should start now. Should it not be possible to persuade all member states to extend the EU ETS, there would be the possibility of an **opt-in**, whereby the sectors of several member states not yet covered by the EU ETS could be integrated into the EU ETS ↘ ITEMS 116 FF.

260. Germany should **set an example** by working together with its European partners to achieve the agreed climate-policy goals in an economically efficient manner; this can be achieved with comprehensive emissions trading. On the other hand, it is not a good idea to strive for further national, let alone sectoral targets beyond those agreed at European level. Germany should use its willingness to make even greater climate policy efforts as a **lever in European and global climate-policy negotiations**. Otherwise, the chance of persuading other states to jointly set more ambitious binding goals in line with the principle of reciprocity will be lost.

261. The Federal Government should immediately move towards this integrated pricing of greenhouse gases by setting up a **separate pricing system** as a central climate-policy instrument for the transition in areas not yet covered by the EU

ETS. However, it must remain the medium-term goal to allow this separate system to merge with integrated emissions trading. **Two routes** are available for this transitional solution in the non-EU ETS sector: a separate emissions-trading scheme and a carbon tax.

In both approaches, the political will to credibly establish the carbon price as a central instrument of climate policy is decisive. Separate emissions trading for the non-EU ETS area should be easier to communicate as a climate-policy strategy and easier to transfer to the EU ETS. However, establishing it will take some time. The political challenge in this case is to **credibly** signal that this establishment process is being pursued seriously by making rapid steps towards it, and that the choice of this route is **not a delaying tactic**. In addition, an emissions-trading system will probably only fulfil the hopes placed in it if the market participants accept the binding nature of the quantity restriction.

If a separate emissions-trading system is chosen, the quantity of emission allowances and their path must be determined. It makes sense to enter the market with a relatively high volume of allowances and then to reduce it more and more over time. Furthermore, **administrative preparations** should begin immediately. ↘ ITEM 10 If the political decision is taken to lay down a price corridor, the paths of minimum and maximum prices should be determined ↘. ITEMS 140 FF.

262. A **carbon tax**, on the other hand, could be introduced comparatively quickly in the non-EU ETS sectors by adding it to the existing energy taxation system. However, this route cannot mean declaring a price path prescribed by a carbon tax at the beginning and then implementing it in the coming years. Rather, the avoidance costs in the buildings and transport sectors are unknown, so that the carbon price not only gives a control signal, but also serves as a **method of discovery** for these hitherto unknown costs.

The carbon tax can only be used as an meaningfully instrument of climate policy to achieve integrated emissions trading if policy-makers can maintain their policy of **regularly adjusting** this tax in line with the degree to which climate-policy targets are not met. Moreover, a carbon tax will probably only find broad support among the population if citizens assume that, once introduced, the carbon tax will not be used along the road for political goals other than climate policy. It must therefore be **quickly abolished** once the non-EU ETS sectors have switched to integrated emissions trading. Signalling this in a credible way will be a major challenge for policy-makers, given their past track record on tax policy.

If the decision is made in favour of a carbon tax, the first step is to lay down the tax rate to be levied at the beginning. **Starting at a relatively low level** is recommended. It seems reasonable to use the current prices in the EU ETS as orientation, thus starting at a value between €25 and €50. However, the lower the entry level, the sharper the future tax increases would have to be in order to react to missed targets. ↘ ITEM 133

263. What both routes have in common is that three aspects must be taken into account:

– First, the international **competitiveness** of German companies must be maintained. The EU ETS already provides a proven set of instruments for this purpose, which protects energy-intensive and internationally competitive companies from competitive disadvantages caused by climate policy. Although the impact of climate policy on domestic companies is lower in the non-EU ETS sector, it is advisable to keep pace when recording the effects and adapting the compensatory instruments. However, the **larger** the international **coalition** for carbon pricing, the **smaller** the otherwise threatening **negative repercussions**. On the one hand, comprehensive pricing would not put domestic companies at a competitive disadvantage vis-à-vis their foreign competitors. On the other, the danger that carbon consumption will simply be shifted to other countries is reduced. If that were allowed, national reduction targets would be achieved, but climate change would not be contained.

– Second, targeted **accompanying measures** are needed to strengthen incentives for changes in behaviour and for investing in lower-carbon machines and consumer goods. This includes informing households and companies and investing in the infrastructure. In the same way, the energy taxation system must be completely revised in the longer term and consistently aligned to the implicit carbon content of energy sources. Other fiscal purposes associated with energy taxation, such as financing the road infrastructure, could instead be financed by usage-based charges.

– Third, the **revenue** from carbon pricing, whether from auctioning allowances or from a carbon tax, should be **redistributed**. This could significantly increase public acceptance of the measure. The steering effect of reducing greenhouse-gas emissions should be in the foreground. In addition to designing measures accordingly, it will also be essential for policy-makers to **inform** the public in detail and **explain** the effects and institutional changes. The labelling and visibility of the measures seems indispensable in this context.

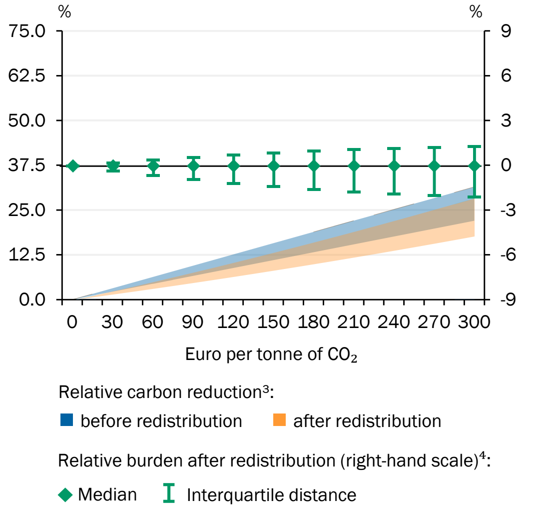
264. Overall, policy-makers thus have a wide range of options at their disposal to put together a **reform package** that makes sense in terms of climate policy due to its consistent orientation towards the idea of pricing greenhouse gases, limits the economic burdens that inevitably arise from the need for transformation, and at the same time shapes them in a socially balanced way. The decisive factor now is the will to consistently pursue this departure towards a new climate policy.

APPENDIX

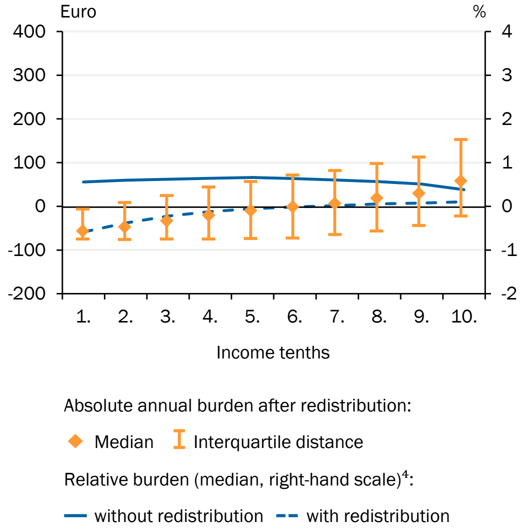
↘ CHART 29

Effects of a carbon price in non-EU ETS sectors on private households' income and carbon consumption[1]

Relative reduction in carbon emissions according to different price and elasticity scenarios and the corresponding relative annual burden after lump-sum return[2]
for different carbon prices in the non-EU ETS sector



Absolute and relative burdens at a uniform carbon price of €35 per tonne of CO_2 in non-EU ETS sectors
by income tenths

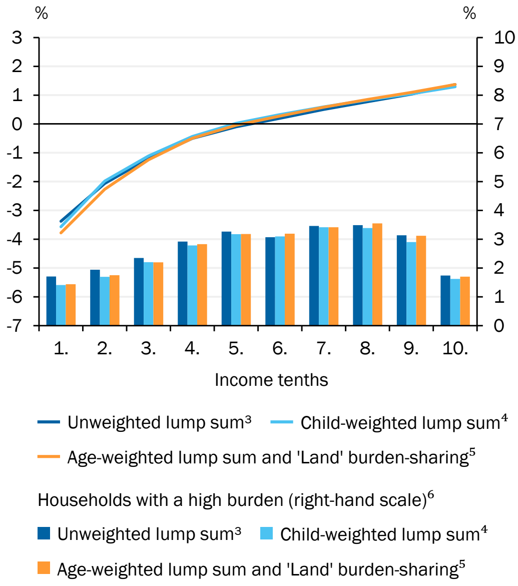


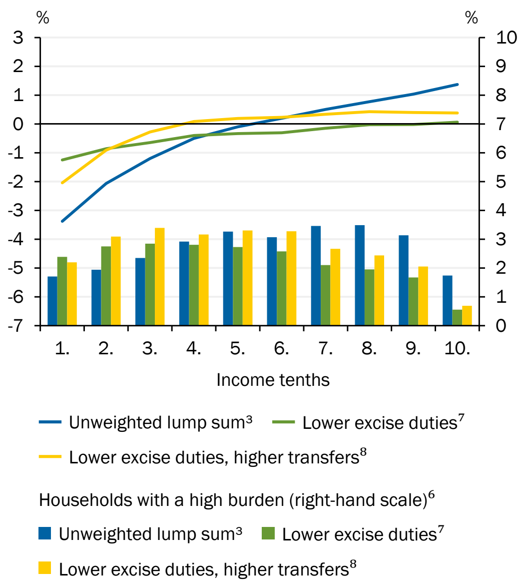
1 – Calculations refer to the base year 2013. As non-EU ETS sectors, only buildings and transport are taken into account. 2 – Revenue-neutral lump-sum return. 3 – Upper interval limit determined by 30 % higher elasticities and 10 % higher carbon content of goods. 4 – Burden relative to equivalence-weighted disposable income.

Sources: Federal Statistical Office, Pothen and Tovar Reaños (2018), RDC of the Federal Statistical Office and Statistical Offices of the Länder, Einkommens- und Verbrauchsstichprobe 2013 Grundfile 5 (HB), own calculations

↘ CHART 30

Distribution effects of different reimbursement mechanisms with a uniform CO_2 price of 130 euros per tonne CO_2[1]





1 – Calculations for 2013. A uniform CO_2 price of 130 euros per tonne CO_2 is estimated. The price in the EU ETS sector is €25 per tonne of CO_2. If a consumer good is included in the EU ETS, only the difference between the uniform CO_2 price and the EU ETS price is used for the budget. All scenarios are revenue-neutral. 2 – Burden in relation to net equivalised income. 3 – Uniform per-capita lump sum for adults and children. 4 – A reduced lump sum for children under the age of 25. The lump sum for children is 54 % of the adult lump sum. This corresponds to the ratio between the subsistence levels for tax purposes of children and adults. Lump sum for adults is 10 % higher compared to the lump sum without child weighting. 5 – The children's age is taken into account in the reimbursement. The lump sum is based on the ratios of the 'standard requirements stages' in accordance with the Standard Requirements Determination Act (Regelbedarfs-Ermittlungsgesetz). Furthermore, an additional need is recognised for single parents. The lump sum for adults is 13 % higher compared to the lump sum without age weighting. Households living in rural areas receive a 10 % higher allowance. 6 – Households with high burdens are defined as those which, after reimbursement, bear a net burden exceeding 5 % of their annual net equivalised income. 7 – Electricity tax and EEG surcharge are waived for households, taking the minimum tax into account. The reduced VAT rate is lowered until revenue neutrality is reached. 8 – In addition to the waiver of the electricity tax and the EEG levy, the increase in the SGB II benefit (income support for employable persons) for accommodation and living costs is taken into account. In addition, current housing benefit recipients are fully reimbursed for the additional heating costs. The remaining budget is used to lower the reduced VAT rate.

Sources: Federal Statistical Office, Pothen and Tovar Reaños (2018), RDC of the Federal Statistical Office and Statistical Offices of the Länder, Einkommens- und Verbrauchsstichprobe 2013 Grundfile 5 (HB), own calculations

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