WP/21/241

IMF Working Paper

Scaling up Climate Mitigation Policy in Germany

by Simon Black, Ruo Chen, Aiko Mineshima,
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INTERNATIONAL MONETARY FUND

 WP/21/241

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European Department

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Authorized for distribution by Shekhar Aiyar

September 2021

Abstract

Germany has set national greenhouse emissions targets of a 65 percent reduction below 1990 levels by 2030 and net zero emissions by 2045, along with various sectoral emissions goals. To achieve these targets, the government has introduced multi-pronged policy measures, including a national emissions trading system (ETS), which complements the ETS at the EU level. This paper shows the substantial variation in the price responsiveness of emissions across sectors and thus prices implied by sectoral targets. It proposes the following measures to help Germany meet emissions targets with greater certainty and cost effectiveness: (i) further strengthening carbon pricing, for example through automatically rising price floors for the national ETS after 2026; (ii) harmonizing carbon pricing to reduce cross-sector differences in marginal abatement costs; and (iii) introducing feebates (revenue neutral tax-subsidy schemes) to reinforce incentives at the sectoral level. The paper also studies the distributional impact of higher carbon pricing and suggests that reducing social security contributions can mitigate the regressive direct impact of higher carbon pricing on lower-income households. Concerns with carbon leakages and firms' competitiveness are best addressed through agreeing on an international carbon price floor.

JEL Classification Numbers: Q48, Q54, Q58, H23

Keywords: Climate mitigation, emissions trading system, emissions surcharge, price floor, feebate, renewables, electric vehicles, forest carbon storage.

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I. INTRODUCTION[1]

Despite a substantial reduction in greenhouse gas (GHG) emissions, Germany remains a large global emitter. To adhere to the 2015 Paris Agreement, Germany adopted the Climate Change Act (CCA) in 2019, setting the emissions targets of a 55 percent reduction from the 1990 level by 2030 and attaining net zero emissions by 2050. The CCA also sets specified, legally-binding, and progressively tightening aggregated and sectoral emissions targets for energy, industry, transport, buildings, agriculture, and other emissions (e.g., waste). Following the constitutional court ruling in May 2021[2], the CCA was amended in late June 2021, further tightening emissions targets to a 65 percent reduction in GHG emissions below the 1990 level by 2030 and net zero emissions by 2045. The revised CCA also sets an annual path of aggregate emissions through 2040 and revised annual sectoral targets through 2030.[3]

The German government has adopted the Climate Action Program (CAP) 2030, which lays out multi-pronged measures to achieve the emissions targets. The measures (see Box 1) comprise four key components: (i) introduction of a national Emission Trading System (ETS), which covers transportation and building emissions; (ii) additional measures to encourage GHG reductions in buildings, transportation, energy, agriculture, and industry; (iii) compensation for households and firms for the expected price increases; (iv) and introduction of a monitoring and correction mechanism.

Box 1. The Climate Action Program (CAP) 2030

The CAP 2030 contains multi-pronged policy measures to achieve economywide and sectoral emissions targets. The program includes four major components.

- **Introduction of a national ETS**. On January 1, 2021, a national ETS covering CO_2 emissions from transportation and heating fuels became operational, with a price of €25/tonne of CO_2. Carbon pricing is scheduled to increase to €55 by 2025 in a step-wise manner. From 2026 onwards, an emissions cap will be set, which will decline over time in line with 2030 emissions targets, but with an initial price range of €55 to €65 per tonne. The path of carbon prices can be amended once the parliament has approved the revised CCA. The national ETS supplements the EU ETS, which covers energy (i.e., power generation/district heating, industry, and domestic aviation). Allowances in the national ETS will be auctioned with revenues re-invested in climate measures or returned to taxpayers.
- **Measures to encourage GHG reductions in buildings, transportation, energy, agriculture, and industry**. Policies include tax incentives for energy-efficient modernization of buildings, increasing the number of electric vehicles (EVs) and public charging points, expanding renewable energy generation and

[1] The authors would like to thank the German authorities for helpful suggestions and comments. All remaining errors are ours.

[2] The constitutional court ruled that the Climate Change Act 2019 violates the constitutional right of freedoms, especially of the youth, as it offloads major emission reduction burdens onto periods after 2030.

[3] The draft bill indicates that the government, by 2032 at the latest, has to present a legislative proposal to set the annual reduction targets for the years 2041 to 2045.

increasing its use in industry, phasing out coal, encouraging climate-friendly agriculture, and exploring options for carbon storage.

- **Compensation for households and firms for the expected price increase**. The renewable energy surcharge, which is part of electricity bills, has been reduced, while tax relief for long-distance commuters and higher housing allowances have also been provided.
- **Monitoring and correction mechanism**. Each year, the government will assess progress towards the 2030 climate targets in individual sectors. If a particular sector is not complying with its statutory targets, the ministry with lead responsibility will present the climate cabinet with a remedial action plan.[1/]

[1/] As part of the CAP2030, the government set up a "climate cabinet" in April 2019, tasked with reviewing annually the effectiveness, efficiency, and targeting of climate measures.

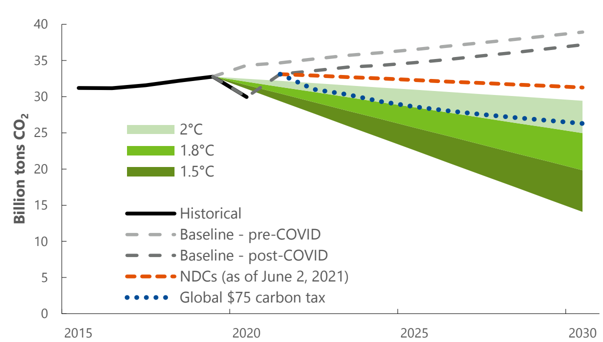
This paper aims to address three key questions. First, are there policy measures that can enhance the effectiveness, cost-effectiveness, and acceptability of Germany's mitigation strategy? Second, what is the distributional impact of higher carbon pricing? Third, how best to address concerns about emissions leakage and losses in competitiveness through increases in cost of domestic relative to foreign products?

The rest of the paper is organized as follows. Section II provides background on emissions trends at the global and national level. Section III describes Germany's emissions targets and mitigation policies at the EU and national level. Section IV discusses options for enhancing the mitigation policies both at the cross-sectional and sectoral level. Section V analyzes the distributional impact of higher carbon prices on households and discusses the issues of potential carbon leakages and the impact of higher carbon prices on firms' competitiveness. Section VI concludes.

II. Global and National Emissions Trends

The window of opportunity for containing global climate change to manageable levels is closing rapidly. To contain projected warming to 1.5º–2ºC above pre-industrial levels, global carbon dioxide (CO_2) and other GHG emissions must be cut 25–50 percent below 2019 levels by 2030 followed by a rapid move towards net zero emissions (see Figure 1 and IPCC 2018). Due to the COVID-19 crisis, global emissions declined by around 6 percent in 2020 from 2019. However, without strong mitigation policies, emissions are likely to start

Figure 1. Global CO2 Projections and Pathways for Warming Targets Trends



Source: IMF staff estimates using UN Environment Programme (2020) and International Energy Agency (2020).
Note: Carbon tax starts at $15 per ton, rising steadily thereafter from 2022 to 2030. Warming pathways assume CO_2 emissions are reduced in proportion to total greenhouse gas emissions. COVD = coronavirus disease; NDCs = nationally determined contributions.

rising again in 2021 as economies recover. With governments bringing forward recovery programs, it is important that fiscal policy reorients private investment towards the development and diffusion of low-carbon technologies. This requires the right price signal on carbon emissions.

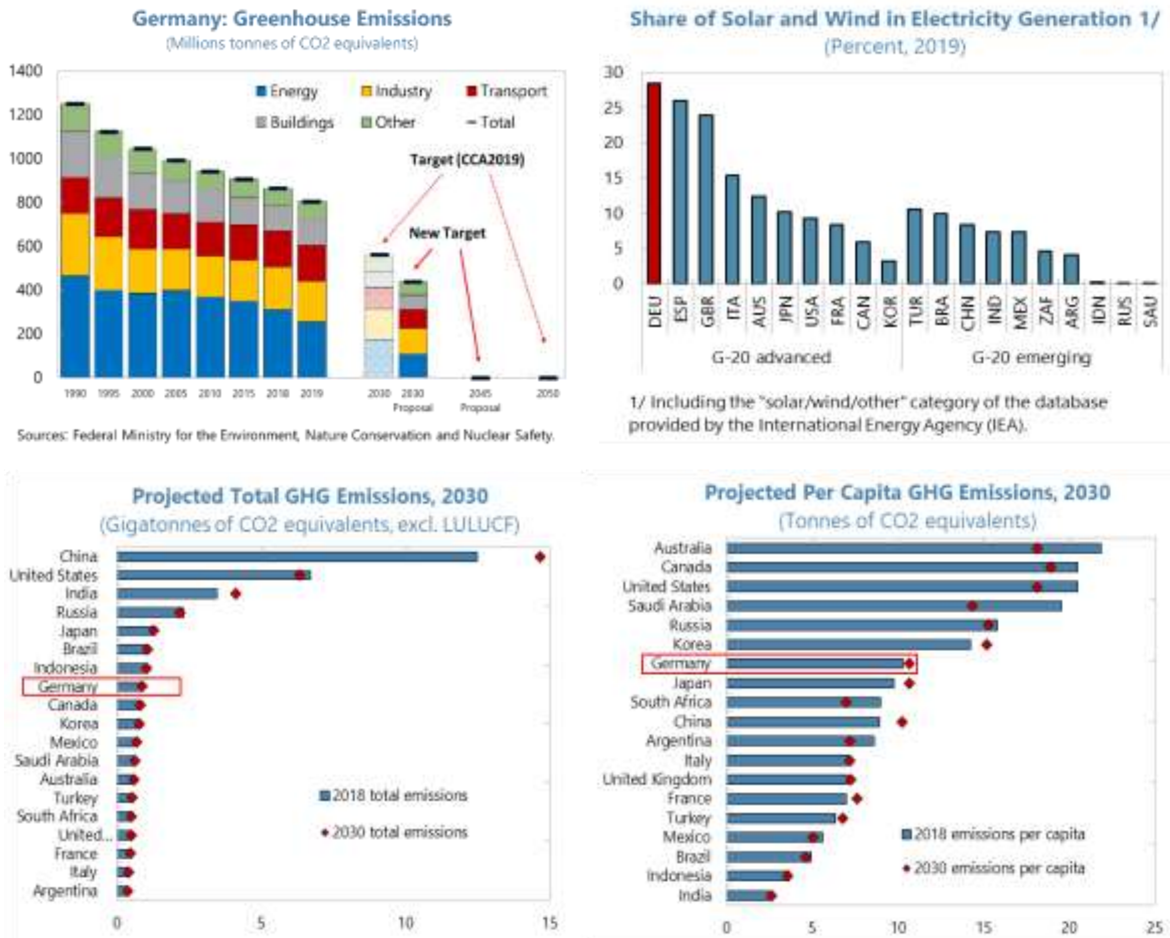
Climate change poses highly uncertain macroeconomic risks at the global and national level. Studies suggest that by 2100 warming could permanently lower the level of global GDP by anywhere between 5 and 25 percent relative to a path with no climate change, due, for example, to rising sea levels, reduced crop yields, more frequent and extreme weather events, and non-market impacts.[4] The overriding concerns however are tail risks (e.g., runaway warming from the release of underground methane, collapsing ice sheets) that are difficult to incorporate in these estimates (Lenton and others 2019, Weitzman 2011). The World Economic Forum (2019) ranks climate change as the greatest threat to the planet. In Germany, 2018 was the hottest year on record—temperatures were 1.5°C higher than pre-industrial levels—and for the first time Germany was one of the three countries most affected by extreme weather conditions worldwide (BMU 2020).

Germany has made substantial progress in reducing GHG emissions. GHGs in 2019 were 36 percent below 1990 levels and 6 percent below 2018 levels. In between 1990 and 2019, GHG emissions from energy fell by 45 percent, industry by 34 percent, buildings by 42 percent, agriculture by 11 percent, and waste management by 76 percent, although transportation emissions remained about unchanged (Figure 2, top left panel). Germany's share of electricity generation from solar and wind systems was among the highest in G20 countries in 2019 (Figure 2, top right panel). Despite this progress, in a business-as-usual (BAU) scenario (i.e., with no new, or tightening of existing, mitigation policies) IMF staff project Germany will remain among the top ten global emitters in 2030, both in terms of absolute and per capita CO_2 emissions (Figure 2, bottom panels).[5]

[4] See Nordhaus (2017) and Burke and others (2015). Non-market impacts include, for example, loss of life, conflicts and violence, biodiversity, and ecosystem damages (Kalkuhl and Wenz 2020). Impact assessments remain highly contentious, for example, impacts on the natural world, mass migration, international conflict and economic growth are all very difficult to quantify.

[5] Using a spreadsheet tool parameterized to individual countries. This tool projects fuel use and emissions by major energy-using sector and estimates the impact of carbon pricing and other mitigation policies based on the proportionate change in energy prices in different sectors and assumptions about the price responsiveness of fuel use by sector. See IMF (2019b) Appendix 3 and Parry and others (2020) for a description of the model and its parameterization.

Figure 2. Trends in Historical Emissions, Projected BAU Emissions, and Renewables



Soure: IMF staff calculations.

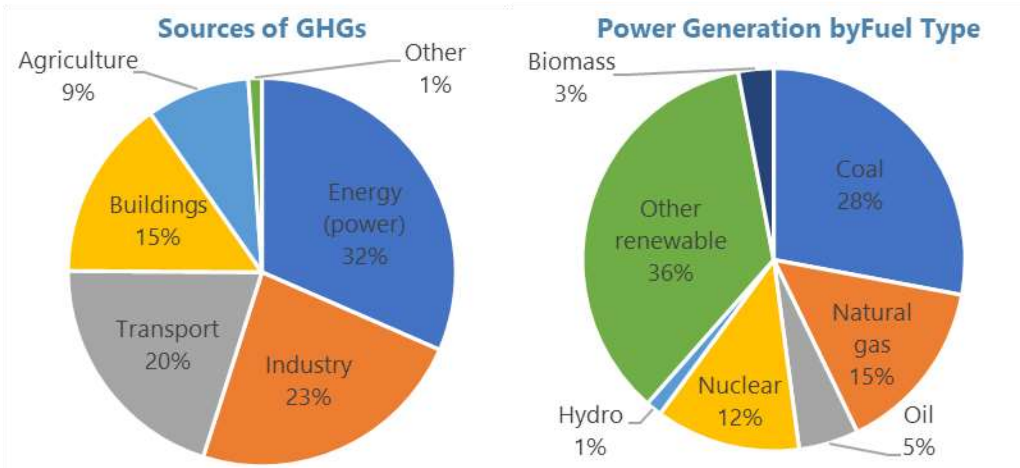
Regarding the sectoral composition of GHG emissions, out of the total 805 million tonnes of CO_2 equivalent[6] in 2019, energy—principally power generation and district heating[7]—accounted for 32 percent, industry 23 percent, transport 20 percent, buildings 15 percent, and agriculture 9 percent (Figure 3, left panel). With respect to the sources of electricity generation, 28 percent was from coal, 15 percent from natural gas, 12 percent from nuclear, and 40 percent from renewables (including hydro, biomass, and other renewables) (Figure 3, right panel). Nearly half of electricity generation from renewables was (mostly onshore)

[6] A "CO_2 equivalent" is a unit of measurement that standardizes the warming potential of different GHGs over a long horizon.

[7] District heating is underground infrastructure through which thermal energy is provided to multiple buildings from central energy plants. Fugitive emissions (e.g., from refineries, distribution of fossil fuels, decommissioned mines) are also included in energy emissions.

wind. The land use, land use change, and forestry (LULUCF) sector absorbed 27 million tonnes of CO_2 in 2018.[8]

Figure 3. Breakdown of GHG Emissions, 2019



Source: BMU (2020) and IMF staff calculations.

III. Policy Background at the EU and National Level

The 2015 Paris Agreement seeks to contain global warming to well below 2°C compared to pre-industrial levels. The Agreement was signed by 195 countries and the EU and was ratified by 189 parties. Parties have submitted Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC) with commitments for reducing GHGs and are currently submitting revised NDCs ahead of COP26 in November 2021. A number of parties, including the EU, have recently pledged emissions neutrality by 2050.[9] At a global level, current commitments for 2030 remain insufficient to meet the Paris target: even if 2030 commitments were fully achieved, the emisisons reductions would ahive only two-thirds of the emisisons reductions needed even for a 2°C target (Figure 1). Getting on track with temperature stabilization goals will require phasing in measures equivalent to a global carbon price of around $75 per tonne by 2030 (Figure 1), whereas the current global average price is only $3 per ton.[10] An additional international mechanism to complement the Paris process is likely needed to overcome free rider and competitiveness obstacles that hamper unilateral actions.

[8] BMU (2020), Section 3.

[9] A registry of NDCs is available at https://www4.unfccc.int/sites/NDCStaging/Pages/Home.aspx. Canada, Japan, Korea, UK, and US have pledged emissions neutrality by 2050 and China by 2060—see www.iea.org/reports/world-energy-outlook-2020/achieving-net-zero-emissions-by-2050.

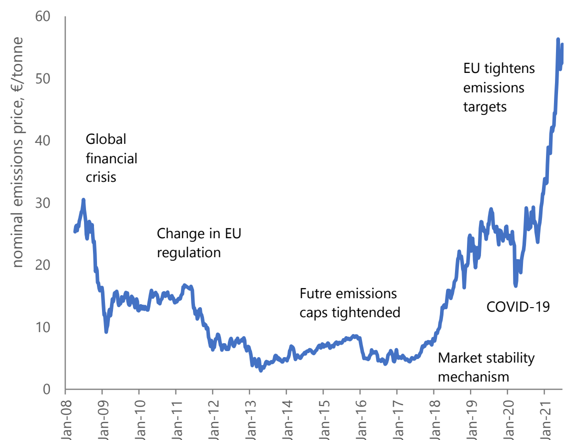
[10] Computed from World Bank Group (2021).

A. EU-Level Policies

The EU submits a single NDC on behalf of its member states, and its revised submission includes a goal of cutting GHGs 55 percent below 1990 levels by 2030[11]—up from the previous commitment of 40 percent below 1990—and to become carbon neutral by 2050. The EU Green Deal, announced on December 11, 2019 (EC 2020) is an action plan for progressing on these goals while supporting EU industry to become green leaders and ensuring a just transition. The deal seeks to mobilize €1 trillion, which will be funded by the EU Budget, the InvestEU Fund, the European Investment Bank, national co-financing structural funds, and private investment. Measures include decarbonizing the energy sector, renovating buildings to improve energy efficiency, promoting clean transportation, preserving biodiversity, improving food sustainability, and eliminating pollution.

The centerpiece of EU policy actions is the ETS, which covers large emissions sources from energy, industry, and within-EU aviation. The ETS works on the "cap and trade" principle, where a cap is set on the total amount of GHGs that can be emitted at the EU level while companies buy or sell allowances, which establishes the emissions price. The EU scheme currently covers about 45 percent of total EU GHGs (WBG 2020). Presently the cap declines by 2.2 percent a year, but this will be tightened given the EU's revised emissions pledge. EU allowance prices had risen to around €50 per tonne by June 2021 (Figure 4).[12] With a fixed cap on emissions at the EU level, emissions reductions from overlapping policies in Germany would be offset tonne-for-tonne by extra emissions in other EU countries (via a decline in the ETS allowance price). This problem is, to some degree, mitigated by the Market Stability Reserve (MSR), which withdraws emissions allowances from the system (sometimes permanently) when the amount of banked allowances (i.e., that firms have purchased but not yet used) exceeds a threshold level. Energy intensive, trade exposed (EITE) industries (e.g., metals, chemicals) are granted free allowance allocations to address competitiveness and leakage concerns, though the European Commission intends to replace this mechanism with a border carbon adjustment (BCA) mechanism slated for introduction in 2023.

Figure 4. Daily EU ETS Price



Source: Carbon Price Viewer- Ember (ember-climate.ord).

[11] Reuter, December 17, 2020.

[12] See EBMER for daily carbon prices. All prices below are expressed in year 2020 € or thereabouts.

For the non-ETS sector—i.e., transport, buildings, agriculture, agriculture—member states are allocated annual emissions targets out to 2030 under the Effort Sharing Regulation. These targets are set more stringent for countries with higher GDP per capita. Germany's target was to cut emissions 38 percent below 2005 levels by 2030, though this target will be tightened following the EU's enhanced commitments. Member states that miss their target in a particular year can use credits from previous years where they exceeded the target or purchase credits from other member states that have over-complied.

B. National Policies

At the national level, Germany's 2019 CCA lays out legally binding annual emissions targets at the economywide and sectoral level.[13] The original CCA stipulates the nationwide targets that are in line with the targets adopted at the EU level, namely at least a 55 percent reduction in GHGs below 1990 levels by 2030 and net zero GHG emissions by 2050.[14] Following the constitutional court ruling in May 2021, Germany further tightened emissions targets in late June 2021: a 65 percent reduction in GHGs below the 1990 level by 2030, an 88 percent reduction by 2040, and net zero emissions by 2045. The CCA also sets emissions targets for six sectors that must be met each year and that decline linearly to 2030, which have also been revised along with the amendment to the CCA in June 2021 (Table 1). For the LULUCF sector, the revised CCA stipulates a net carbon sink of at least 25 million tonnes by 2030, 30 million tonnes by 2040, and 40 million tonnes by 2045.

Table 1. Germany's Emissions and Technology Targets

Sectoral emissions targets	1990 emissions, mn tonnes CO_2 equivalent	Percent change in emissions relative to 1990: 2019 emissions outcome	Percent change in emissions relative to 1990: 2030 emissions target[1/]
Energy (power)	466	-45.4	-77
Industry	284	-33.9	-58
Transport	163	-0.3	-48
Buildings	210	-42.0	-68
Agriculture	90	-24.2	-37
Other (e.g., landfill)	38	-75.6	-89
Total	1,251	-35.7	At least -65
Renewable energy targets[2/]		**Renewable energy shares, percent: 2018 outcome**	**2030 target**
Share of gross electricity generation		42.1	65
Share of gross final energy consumption		17.1	30
EV targets[2/]			**2030 target**
Number of registered electric passenger vehicles			7-10 million

Source: BMU (2020) and Climate Change Act.
[1/] Reflecting the revisions approved by the Bundestag in June 2021.
[2/] Based on the Climate Action Programme 2030, which is expected to be updated to be fully aligned to the revised emissions targets.

[13] BMU (2019).

[14] Gross emissions can be positive, if they are offset by negative emissions (e.g., from carbon capture in the land use sector or direct removal of CO_2 from the atmosphere).

The CAP 2030 sets out multi-pronged policy measures to achieve the emissions targets, with the centerpiece being a national ETS, which was launched on January 1, 2021. Key features of the national ETS are as follows:

- *Coverage*: Suppliers of domestically produced and imported fuels (heating oil, LPG, natural gas, coal, gasoline, and diesel) for the transport and building sectors.

- *Prices*: From 2021-2025 fuel suppliers must purchase allowances from the government at a fixed price rising from €25 to €55 per tonne of CO_2 (there is no cap on the amount of allowable emissions); in 2026 auctions will be introduced alongside a price collar of €55-65 per tonne CO_2 (Figure 5). Fom 2027 onwards, whether a price collar is retained is to be determined. These envisioned prices are, for the most part, on the high side compared with current prices in other carbon tax and ETS schemes (Table 2).

- *Caps*: From 2026 onwards, caps on allowable emissions will be introduced and will decline in line with Germany's emissions targets.

- *Revenue use*: Revenues from allowance sales are earmarked for climate measures (e.g., incentivizing low-carbon transport, energy-efficient buildings, reduced renewable energy surcharge, higher communer allowance for long-distance commeters).

CAP 2030 also includes a variery of other regulatory, pricing, and funding support including:

- *Additional private sector incentives*: These include subsidies for wind and solar generation, for switching from coal to gas, and for retiring coal plants; enhanced incentives for electric vehicles (EVs) and relating annual circulation

Figure 5. Germany: Planned Carbon Pricing
(Euro per tonne of CO_2)

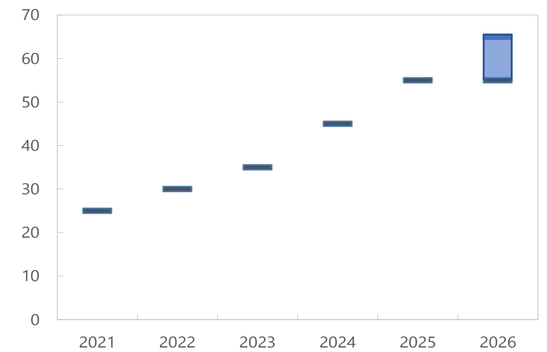


Table 2. Selected Carbon Pricing Schemes, 2020

Country/ Region	Year Introduced	Price 2020, \$/Ton CO_2	Coverage of GHGs: Million Tons	Coverage of GHGs: Percent
Carbon taxes				
Chile	2017	5	58	39
Colombia	2017	4	46	24
Denmark	1992	26	25	40
Finland	1990	68	41	36
France	2014	49	172	35
Ireland	2010	28	32	49
Japan	2012	3	909	68
Mexico	2014	<1-2	381	47
Norway	1991	3-53	47	62
Portugal	2015	26	16	29
S. Africa	2019	7	512	80
Sweden	1991	119	44	40
Switzerland	2008	99	6	33
Emissions Trading Systems				
California	2012	15.3	375	85
EU	2005	35	2,249	45
Germany 1/	2021	29	238	31
Korea	2015	33	489	70
New Zealand	2008	14	45	51
Regional US	2009	5	108	18
Carbon price floors				
Canada	2019	22	71	9
UK	2013	22	136	23

Source. WBG (2020) and staff calculations.

1/ Germany's scheme covers emissions outside of the EU trading system and was launched in 2021.

taxes to vehicle emission rates; incentives for energy-efficient refurbishment of buildings and phasing out of oil-based heating from 2026; and measures to encourage climate-friendly agriculture.

- *Public investment*: EV charging stations will be increased to one million by 2030 while public transportation will be promoted through lowering the VAT rate on train tickets (from 19 to 7 percent) and extra funding (around €1-2 billion per year) for transit infrastructure projects. The power grid network will be expanded in line with the expansion of renewable energy.

- *Research and development (R&D)*: Efforts include advancing carbon-saving technologies for industry (e.g., carbon capture and storage for cement production, use of electric rather than coal heating in steel production); battery cells for EVs; and laboratories for sector coupling (e.g., the Tesla Gigafactory).[15]

- *Just transition assistance*: Household and firm compensation for higher energy and consumer prices and €40 billion for developing new economic structures in the coal regions in North Rhine-Westphalia and central Germany through 2038.

IV. Policy Options for Enhancing Mitigation

A. Cross-Sector Carbon Pricing

Carbon pricing has several environmental, fiscal, economic, and administrative advantages over other mitigation instruments.[16] Carbon pricing provides across-the-board incentives for firms and households to reduce energy consumption and shift to cleaner fuels without favoring any specific energy matrix, other than discriminating by its carbon content (by reflecting the cost of carbon emissions in the prices of fuels, electricity, and other intermediate and final goods). It also automatically minimizes mitigation costs by equalizing the cost of the last ton reduced across fuels and sectors (“marginal abatement cost”), mobilizes valuable revenues, and generates domestic environmental benefits (e.g., reductions in local air pollution mortality). Furthermore, carbon pricing is administratively straightforward, at least for countries with mature institutional capacity.

Good carbon pricing strategy comprehensively covers emissions, establishes predictable prices, aligns stringency with mitigation goals, and exploits fiscal opportunities. The national ETS, combined with the EU ETS, implies fossil fuel emissions in Germany are

[15] Sector coupling involves the increased integration of energy end-use and supply sectors; electrifying energy demand while reinforcing the interaction between electricity supply and end-use. This can improve the efficiency and flexibility of the energy system, as well as its reliability and adequacy. In addition, sector coupling can reduce the costs of decarbonization (Van Nuffel and others 2018).

[16] See, for example, Chen and others (2020), IMF (2019 a and b), Pigato and others (2019), PMR (2017), Stiglitz and others (2017).

comprehensively covered by pricing schemes. However, under the current framework, emissions allowances cannot be traded between the national ETS and EU ETS, preventing the equalization of the marginal abatement cost across all the sectors.

While important steps have been taken, there remains significant uncertainty over carbon prices. For power and industrial sector emissions, covered by the EU ETS, allowance prices have a history of volatility (Figure 4). Although carbon pricing has been rising since 2018, reflecting the introduction of the MSR and recently enhanced EU emissions targets, future prices remain uncertain. In addition, in Germany's national ETS, prices from 2027 onwards are uncertain. Price uncertainty may be a deterrent to low-emission investments with high upfront costs and long-range emissions reductions. To mitigate such concern, the national ETS could incorporate an automatically escalating price floor after the expiration of the price collar in 2026. Several other EU countries have implemented robust pricing for the sectors under the EU Effort Sharing Regulation—for example, carbon taxes are currently equivalent to about €60 and €100 per tonne in Finland and Sweden, and Ireland has annonced an increase in its carbon tax to over €100 per tonne by 2030.

The responsiveness of emissions to carbon prices differs greatly across sectors (Table 3). The impact of carbon pricing on sectoral emissions depends on how carbon pricing affects future energy prices and assumptions about the price responsiveness of the use of fuel and electricity in each sector.[17] We find that the national emissions targets for the power sector, which is covered by the EU ETS, could be met under a price of €100 per tonne in 2030. However, even a price of €150 per tonne appears to be inadequate to meet the targets for the transport and building sectors and is only just sufficient to achieve the target in industry. Prices consistent with emissions targets are much higher in the domestic than the EU ETS sector because emissions respond less to prices in the building and transportation sectors. This primarily reflects the lower carbon-intensity and therefore more moderate price increase from carbon pricing on fuels consumed by these sectors (mostly liquid fuels and gas) compared with the power sector (and to some extent the industrial sector), where there is significant use of coal.

Table 3. Sectoral Emissions Outcomes, 2030

Sector	Percent emissions reductions below BAU						
	Target	Carbon price, €/tonne					
		25	50	75	100	125	150
Power (electricity)	47	23	31	44	**49**	**54**	**57**
Industry	36	12	18	23	27	30	**38**
Power + industry	42	22	31	36	40	**43**	**51**
Transport	42	4	7	10	13	15	21
Buildings	24	3	6	10	13	16	19
Transport + buildings	35	3	7	10	13	15	21
Whole sector	44	16	23	28	33	36	42

Source. IMF staff.
Note. Bold cell entry indicates a price meeting an emissions target.

[17] In IMF staff modelling, these assumptions are based on results from the modelling literature and econometric studies of fuel price elasticities.

The great variation in the elasticity of emissions to carbon pricing across sectors suggests that reducing gaps in the marginal abatement cost across sectors could help cut aggregate emissions in an economically efficient way. More concretely, higher carbon prices should be applied to sectors with a relatively low abatement cost, such as power and industry.

- At the EU level, extending the EU ETS so that aggregate emissions from power, industry, transport, and buildings are subject to one aggregate cap with a common emissions price across all sectors, would lead to a more cost-effective balance of emissions reductions across sectors. This would, however, require compensation for member states with relatively less stringent targets under the current effort-sharing mechanism.

- An alternative reform would be to allow member states to re-allocate emissions reductions from the transport/buildings sectors to the power/industry sectors. This would lower mitigation costs at the national level, given the much higher cost of incremental abatement in the former sectors implied by the emissions targets. Such a re-allocation is currently precluded by EU burden sharing rules.

- Another EU level reform would be to establish an exogenous and escalating price floor for the EU ETS.[18] Besides providing a critical signal for ensuring that new investment is efficiently allocated to clean technologies, this reform would also allow overlapping measures at the member state level to lower emissions at the EU level (under a pure EU cap these measures only lower allowance prices without affecting EU emissions). Germany could push for a robust price floor under the EU ETS through reform of the Market Stability Reserve.

- In the absence of broader EU reforms, imposing a domestic surcharge on emissions covered by the EU ETS could ensure robust carbon pricing in Germany. The surcharge could be set such that the combined price on power/industrial emissions equals a price target that ramps up predictably over time, ideally in line with prices in the national ETS. The surcharge would resemble the U.K. Carbon Price Floor, which imposes a national level variable tax, set for three years in advance, on power sector emissions, equal to the difference between an exogenous target price and the projected EU ETS price (Hirst 2018). The Netherlands is also implementing a similar scheme for emisisons from the power (and waste) sectors where the planned target price will rise from €30 per tonne of CO_2 in 2021 (which is non-binding at present) to €125 per tonne in 2030.[19]

[18] There is some uncertainty over the legality of an EU level price floor if it is viewed as a fiscal (general revenue-raising) instrument rather than an instrument to support an environmental regulation. Use of allowance auction revenue to support the low carbon transition may help to address this issue (e.g., Fischer and others 2019).

[19] Government of the Netherlands (2019).

B. Fiscal Instruments at the Sectoral Level

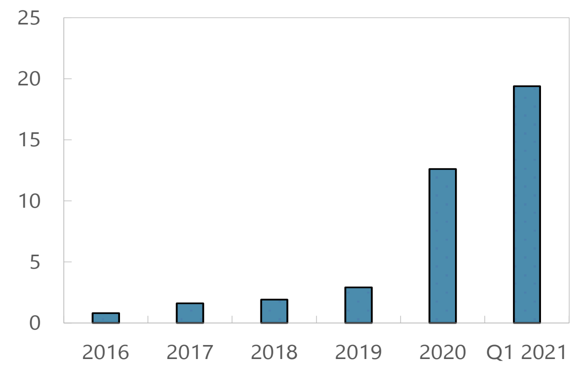
Meeting sectoral emissions targets solely with carbon pricing would require very high carbon prices in some cases, which can trigger public resistance. For example, France's planned increase in its carbon tax was suspended in 2018 at €45 due to public protests. In addition, even if carbon pricing by itself were to meet nationwide emissions goals, it may be insufficient to achieve sectoral targets (e.g., for EVs). There is therefore a balance to be struck between economy-wide pricing measures and reinforcing instruments at the sectoral level, which are not as efficient but can have a key role in avoiding a significant increase in energy prices. Sectoral instruments should be designed flexibly, allowing firms and households to choose responses that minimize costs for a given emissions reduction. Reinforcing instruments can imply differing implicit carbon prices across sectors but can be appropriate as countries move to decarbonize sectors (like transport) that are less responsive to carbon pricing.

Feebates—revenue neutral tax-subsidy schemes—are the fiscal analogue of more traditional regulations. Feebates are a novel instrument as they would be applied by finance ministries; reinforcing instruments have largely taken the form of regulations to date, which are the more natural instrument when climate policy is under the purview of environmental ministries. Feebates are potentially more flexible and cost effective than regulations given that the latter are only fully cost-effective with extensive credit trading provisions across firms and time. At the same time, feebates can naturally complement and reinforce (rather than substitute for) existing regulations (e.g., by rewarding firms for going beyond standards). The discussion below illustrates the use of feebates for transportation, power, buildings, forestry, and agricultural sectors.

Transportation

Road vehicles account for almost 95 percent of transportation emissions in Germany, with nearly two-thirds of these emissions from passenger vehicles and the remainder from trucks and buses.[20] As of 2020, two-thirds of the 48 million passenger vehicles (stock) were powered by gasoline and one-third by diesel. However, a temporary VAT cut and increased incentives for alternative fuel vehicles led to a surge in EV sales in

Figure 7. Share of EV Sales
(Percent to total sales)



Source: S&P Global Ratings, ACEA

[20] BMU (2020), Fig. 25. The other 5 percent of transportation emissions are from domestic aviation, inland and coastal shipping, and rail.

2020.[21] And this trend was uninterrupted in Q1 2021 despite the expiration of the VAT cut (Figure 7).

Decarbonizing road transportation through carbon pricing (or higher road fuel taxes) alone is difficult due to the relatively modest impact it has on retail fuel prices and political resistance to higher road fuel prices.[22] Therefore, clean vehicles are also promoted through regulations. For example, EU standards for the fleetwide average emission rates of new passenger vehicles are 95 grams (g) CO_2/km in 2021 and emission rates will be reduced by 37.5 percent by 2030. At the national level in Germany, light commercial vehicles were subject to a limit of 147 g CO_2/km in 2020 and this emission rate will be reduced by 31 percent by 2030. From 2025, manufacturers of heavy goods vehicles must cut average emission rates by 15 percent by 2025 and 30 percent by 2030 relative to 2020 levels.[23] By themselves these standards would achieve roughly half of Germany's target emissions reductions for transportation in 2030.[24]

Annual circulation taxes for passenger vehicles in Germany are also related to CO_2 emission rates. As announced in September 2020, from 2021 onwards vehicles with emission rates below 100 g CO_2/km will receive an annual subsidy of €30 while vehicles with emission rates above 100 g CO_2/km will be subject to taxes that rise linearly up to €670 for a vehicle with emission rate of 300 g CO_2/km. In addtion, EV buyers receive a subsidy of up to €9,000, and hybrids €5,625. Unlike in most other European countries, internal combustion engine (ICE) vehicles are not subject to registration fees.[25]

[21] The government provides the following purchase incentives ("innovation bonus") for new and used battery electric vehicles (BEVs), fuel-cell electric vehicles (FCEVs), and plug-in hybrid electric vehicles (PHEVs) through end-December 2021: for eligible cars with net list price of equal or less than €40,000, €9,000 for BEVs and FCEVs and €6,750 for PHEVs; for cars with net list price exceeding €40,000, €7,500 for BEVs and FCEVs and €5,625 for PHEVs.

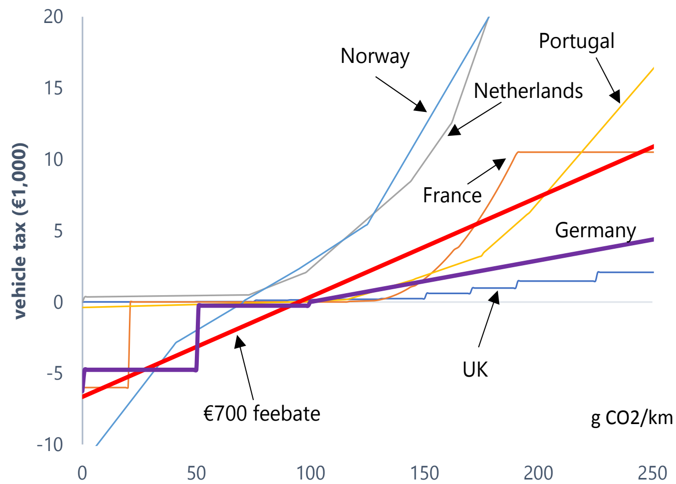
[22] IEA (2019), pp. 125-126.

[23] Vehicle emission rates are measured using the United Nations "Worldwide Harmonized Light Vehicles Test Procedure."

[24] This calculation assumes: current on-road emission rates are 20 percent above the current new vehicle standard; the average new vehicle purchased over the period has emission rate of 17.5 percent lower than the 2020 standard; 7.5 percent of the stock is replaced each year; and no change in vehicle km travelled.

[25] There is a one-time fee on initial vehicle registration, but this is only about €26. Vehicles are also subject to annual fees rising from €0 to €50 (gasoline vehicles) or €250 (diesel vehicles) for engine capacities of between 0 and 2,500 cubic cm. See ICC (2018), pp. 11-12.

Figure 8. CO_2-Based Components of Vehicle Taxes



Source: ACEA (2018) and IMF staff calculations.
Note. Feebates assume on road fleet average emission rate of 115 g CO_2/km. Circulation taxes for Germany are expressed on a lifetime basis assuming a 13 year life and 7 percent discount rate.

The existing tax system has limited effectiveness for two reasons. First, expressing the circulation tax on a lifetime basis, Germany applies lower taxes for high emission vehicles than most other countries (Figure 8)—that is, it does less to drive a wedge between the price of high- and low-emission vehicles. Second, as the EU emission rate standards are applied to the fleetwide average emissions, any shift in demand to low-emission vehicles created by the tax system might be offset by less efforts in reducing emission rates of other vehicles in the fleet.

A feebate applied to vehicles, which are paid by consumers, would address both problems. A feebate provides a sliding scale of fees on vehicles with above average emission rates and a sliding scale of rebates for vehicles with below average emission rates. Specifically, vehicle sales would be subject to an annual fee given by:

$$\{CO_2 \text{ price}\} \times \{\text{the vehicle's } CO_2\text{/km} - \text{the industry average } CO_2\text{/km}\}$$
$$\times \{\text{the average lifetime km driven per vehicle}\}$$

For illustration, a feebate with price of €700 per tonne of CO_2 would provide the same EV subsidy as at present, but apply a tax of €7,400 to a vehicle with 200 g CO_2/km (an increase of around €4,500). Subsidies for EVs would decline over time as the average fleet emission rate declines, which is appropriate as the cost differential between clean vehicles and their gasoline/diesel counterparts narrows over time (e.g., with improvements in EV battery technology). And manufactureres would be penalized for any increase in emissions for the rest of their fleet in response to higher sales shares for EVs. Other attractions of feebates include as follows:

- Feebates automatically maintain revenue neutrality despite the progressive decarbonization of the vehicle fleet because the average fleet emission rate in the feebate formula updates;

- Feebates do not require new data or administrative capacity relative to the existing emission rate program; and

- The CO_2 price in feebates can be adjusted if targets for EV penetration are not being met.

A feebate with a rising price that is sufficient to progressively shift the share of EVs in new vehicle sales to 100 percent by 2030 would reduce road fuel emissions 30 percent below otherwise projected levels for 2030.[26] Deeper reductions would continue after 2030 as the fleet continued to turn over.[27]

Broader reforms using other fiscal instruments could address other transportation externalities. These reforms include (i) introducing charges on all passenger vehicle use related to km driven that vary with the prevailing degree of road congestion (i.e., charges per km would be higher for driving in congested conditions than non-congested conditions); and (ii) promoting a market-driven transition to pay-as-you-drive auto insurance (Box 2).

Box 2. Broader Reforms to the Pricing of Road Transport

Congestion can be efficiently managed (for given road capacity) through km-based taxes varying by location and time of day. Per km tolls on busy roads that progressively rise and fall over the rush hour exploit behavioral responses for reducing congestion (e.g., setting off before or after the peak of the rush hour; shifting to off-peak travel, less congested roads, or public transport; carpooling; reducing trip frequency). Developments in metering technologies such as global positioning systems imply that people's driving could be tracked and billed accordingly.[1] Km-based charging might be promoted through subsidizing/taxing vehicles with/without monitoring capacity during a transition period with monitoring capacity eventually becoming mandatory. Unlike fuel taxes, km-based taxes provide a robust general revenue base, which would be unaffected by decarbonization of transportation.

Transitioning from lump-sum to pay-as-you-drive (PAYD) automobile insurance, under which premiums vary in proportion to the policyholder's annual km, would further reduce driving and help to internalize traffic accident externalities. Motorists do not account for various accident risks to others posed by their own driving (e.g., injury risks to pedestrians and to other vehicle occupants in multi-vehicle collisions, third-party property and medical costs) (Parry 2004). Existing rating factors, as determined by insurance companies, could be used to set per km charges for different drivers as an (albeit imperfect) proxy for external accident risk: drivers with prior crash records, for example, would pay higher variable charges and would have the greatest incentives to drive less. The transition to PAYD could occur on a voluntary basis, with the government kickstarting the process using tax incentives.[2] Drivers with below-average annual km would have the strongest incentives to take up PAYD and as they switched, premiums would rise for the remaining pool of drivers with lump-sum insurance, encouraging further shifting to PAYD. On average, PAYD would raise the marginal cost of driving by around 4 cents per km (while reducing the average accident risk for all drivers).[3]

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[26] This calculation assumes 8 percent of the fleet is replaced each year (i.e., vehicle lifespans are 12 years) and initially 2 percent of new vehicle sales are EVs, rising linearly (due to the feebate) to 100 percent by 2035.

[27] There is a key role for other complementary policies, for example, provision of EV charging infrastructure, procurement for EVs in public vehicle fleets.

[1] The administrative costs would however be higher than for collecting fuel taxes, due to the need to charge individuals rather than fuel distributors. An alternative, bottom-up approach would be to progressively expand congestion-charging zones (e.g., in London), though this would be far less comprehensive than a nationwide charging system.

[2] Government incentives may be needed to overcome obstacles to the private development of PAYD. When an insurer charges by the km, its costs are reduced to the extent that its own customers reduce their accident risk by driving less. However, the costs to other insurance companies also are lowered because the risk of multi-car accidents for their own customers is lower, but savings cannot be captured by the company offering the km-based insurance.

[3] Assuming an annual insurance payment of €500 and 11,450 km driven per year.

Energy

Germany plans to phase out coal and nuclear generation and replace them with renewables. Coal is to be phased out by 2038 at the latest[28] while the seven remaining nuclear power plants will be de-commissioned by 2022. Natural gas is being used as a bridge fuel during the transition to greater renewable generation as it produces 45 percent less CO_2 emissions per unit of energy than coal, has minimal local air pollution costs[29], and is more easily ramped up and down to offset the intermittency of renewable generation.

A feebate could reinforce incentives for shifting to a cleaner power generation mix. Under this scheme generators could be subject to a fee given by:

$$\{CO_2 \text{ price}\} \times \{CO_2/\text{kWh} - \text{industry-wide average } CO_2/\text{kWh}\} \times \{\text{electricity generation}\}$$

The feebate can reinforce incentives for switching to clean fuels without a first-order tax burden—that is, a tax on remaining emissions—on electricity producers and consumers. The scheme could build off existing procedures for monitoring power company emissions under the EU ETS.[30]

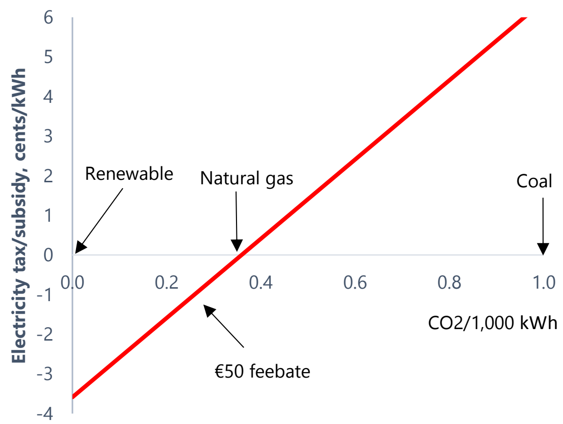
[28] Intermediate targets include reducing installed coal generation capacity from 42 gigawatts (GW) in 2019 to 30 GW in 2022 and 17 GW in 2030.

[29] Coady and others (2018), Figure 1.

[30] Nuclear is carbon free but could be exempted from the subsidy portion of the feebate given the plan to phase it out.

For illustration, assuming the average retail price of 30 cents/kWh, a feebate with price €100 per tonne would apply a fee equivalent to 6 cents/kWh for coal and a subsidy of 4 cents/kWh for renewables (Figure 9). No fee would be applied to natural gas as its emission rate is around the average across all generation fuels. Fees on fossil fuel generation would rise over time, and become positive for natural gas, and rebates for clean fuel generation decline, with progressive reductions in the industry-wide emission rate.

Figure 9. Illustrative Feebate for Power Sector



Source. IMF staff.

Industry

Energy-intensive sectors such as steel, chemicals, metals, cement, lime, glass, and paper generate most of industrial GHGs. About two-thirds of the emissions are from fuel combustion in furnaces while one-third are process emissions.[31]

Feebates could reinforce incentives for cleaner production processes in carbon-intensive industries. In this case, firms within an industry would be subject to a fee given by:

$$\{CO_2 \text{ price}\} \times \{CO_2/\text{output} - \text{industry-wide average } CO_2/\text{output}\} \times \{\text{firm output}\}$$

The feebate, which would be applied to emissions from fuel combustion and direct and process emissions, avoids a first-order burden on the average producer as they pay no charge on their remaining emissions. This helps to alleviate concerns about competitiveness and leakage impacts compared with a pricing scheme that charges for remaining emissions. Again, the scheme could build off existing procedures for monitoring firms’ direct emissions under the EU ETS. Annex 1 provides illustrative comparisons of the impacts of carbon pricing and feebates on production costs in the steel and cement industries.

Buildings

There are about 22 million buildings in Germany, of which about 90 percent are private residences. Of the latter, 8 percent are new buildings, 4 percent are fully refurbished, 52 percent are partially refurbished, and 36 percent are non-refurbished—on average these

[31] About one-third of process emissions are from metal manufacturing (e.g., CO_2 released during the production of pig iron used in steel manufacturing) and another third from mineral production (e.g., CO_2 released during the burning of clinker to produce cement). See BMU (2020), Figure 2.

building types consume 103, 132, 163, and 170 kWh annually per square meter, respectively.[32] CO_2 emissions from buildings—e.g., private homes, commerce, trade and services—are caused mainly by burning fossil fuels to produce space heating and hot water.

The current refurbishment rate is 1 percent a year, while raising this to 1.5 percent is needed to meet emissions targets for the sector. Refurbishment measures include (i) insulation work on roofs, walls, and windows and (ii) switching from oil and gas heating to electric pumps and renewable heating (e.g., solar, geothermal), and the government provides tax incentives for energy efficient retrofits.[33] Actions through both new and existing buildings are needed given the very gradual turnover of the building stock. However, building refurbishment may be held back by liquidity constraints, cost-benefit mismatches between owners and renters, and unawareness or uncertainty of potential energy savings from upgrades.[34]

Feebates could be used to encourage the phase out of fossil fuel-based space heating and more energy-efficient appliances. Revenues from an interim tax on gas and oil heating technologies could fund subsidies for electric or other clean fuel heating systems. And sales of appliances, such as refrigerators, air conditioners, washing machines, could incur a fee equal to:

$$\{CO_2 \text{ price}\} \times \{CO_2 \text{ per unit of energy}\} \\ \times \{\text{energy consumption per unit} - \text{industry-wide energy consumption per unit}\} \\ \times \{\text{number of units}\}$$

For refrigerators, for example, the energy consumption per unit would be kWh/cubic foot cooled (and the number of units would be cubic feet). Refurbishments might also be encouraged by linking property taxes to a building's energy performance classification.

Agriculture

Agricultural GHGs can be reduced through several channels. Reducing livestock herds, particularly beef and dairy cattle, curtail methane releases from enteric fermentation (40 percent of German agricultural GHGs) and nitrous oxide emissions from manure (15 percent). Meanwhile, reducing crops for human and animal consumption (40 percent of German agricultural GHGs) reduces nitrous oxide emissions from soils, especially where there is intensive chemical fertilizer use.[35] At the consumer level, shifting from meat and dairy products to plant-based and poultry diets would reinforce mitigation incentives.

[32] BMU (2020), Fig. 34.

[33] New oil-based heating systems will be banned from 2026 onwards

[34] See for example Arregui and others (2020) and Burke and others (2019).

[35] From https://di.unfccc.int/detailed_data_by_party.

Currently, agricultural programs in Germany support low-nitrogen fertilizers, organic farming, and carbon sequestration.

Direct monitoring of farm level emissions is currently not practical, but emissions can be estimated indirectly using farm-level data (on livestock herds, feed, crop production, fertilizer use, and acreage) and default emissions factors (IPCC 2019). Emissions taxes can be levied based on the proxy emissions. However, such taxes would likely face strong political opposition and could cause significant carbon leakage as the tax burden can reduce the international competitiveness of German farmers. A feebate approach is worth studying, based for example on GHG equivalent emission rates per hectare or nutritional value.[36] Another approach would be to combine an emissions fee with the revenues recycled to the agricultural sector in the form of a rebate proportional to the value of farm output. This scheme would cost-effectively promote all behavioral responses for reducing the emissions intensity of farming and, from an administrative perspective, the fees and rebates could be integrated into collection procedures for business tax regimes for farmers. For illustration, under this scheme with an emissions price of €50 per tonne CO_2 equivalent would on net tax cattle farms at 11 percent of value output and subsidize plant-based agriculture at 3 percent (Table 4). Demand responses at the household level might be promoted through taxes on meat and dairy products (from both domestic and overseas suppliers).[37]

Table 4. Impact of Agricutural Emissions Fee with Value-Based Rebate, 2018

Farm type	GHGs, million tons CO2 equivalent	Emissions share	Value of output €billion	Value output share	Effect of €50 per ton emissions fee: Fees (€billion)	Subsidies (€billion)	Net payments (€billion)	Net payments % value output
Plant-based	11	0.20	17.5	0.42	0.47	0.98	-0.52	-2.9
Dairy	17	0.30	11.3	0.27	0.70	0.63	0.07	0.6
Cattle	15	0.27	3.7	0.09	0.62	0.21	0.41	11.1
Pig	8	0.15	7.4	0.18	0.34	0.42	-0.07	-1.0
Poultry	5	0.08	1.4	0.03	0.19	0.08	0.11	8.2
Total	56	1.00	41.3	1.00	2.31	2.31	0.00	0.0

Sources: FAOSTAT and IMF staff calculations

Note: Payments are calculated prior to behavioural responses.

[36] Basing the feebate on emission rates per hectare could be problematic because livestock is land intensive but the emissions per hectare could be smaller than for crops. The feebate could be disaggregated with higher pivot points for beef producers and lower pivot points for crop producers—this might enhance acceptability (by lowering fees for the former) though it would lower incentives to switch from livestock to crop operations.

[37] See Batini and Fontana (2021).

Forestry and land use

Forestry is currently absorbing, on net, 70 million tonnes of CO_2 a year, but broader land use conversions (beyond the forestry sector) are releasing 43 million tonnes.[38] Forestry and land use policies should promote, nationwide, the main channels for increasing carbon storage. These include afforestation, limiting deforestation, reducing other emissions-releasing land conversions (e.g., converting grassland to farmland or settlements), and enhancing forest management (e.g., planting larger trees, fertilizing, tree thinning, increasing rotation lengths).

A national feebate program could cost-effectively promote all responses for increasing carbon storage without a fiscal cost to the government. The policy would apply, to forestry and agricultural landowners, a fee given by:

$$\{CO_2 \text{ rental price}\}$$
$$\times \{\text{carbon storage on their land in a baseline period} - \text{stored carbon in the current period}\}$$

This scheme would reward all channels for enhancing carbon storage, either through landowners paying lower fees or receiving larger subsidies (unlike an afforestation subsidy, which just rewards one channel). Periods here could be defined as averages over multiple years given that carbon storage might be lumpy during years when harvesting occurs. Feebates can be designed—through appropriate scaling of the baseline over time—to be revenue neutral in expected terms (again, unlike an afforestation subsidy). And a feebate could be administered based on the registry of landowners used for business tax collection. Feebates have not previously been used in the forestry sector anywhere in the world, but they bear a partial resemblance to environmental services payments programs that were first introduced in Costa Rica.[39] Annex II explains the CO_2 rental price and further design/monitoring issues. For illustration, fully stocking a treeless hectare with new trees, under a €50 feebate, results in a flow of payments that, in discounted terms, would increase the value of the hectare by about €2,000 (this is about 10 percent of average agricultural land value in Germany).[40]

C. Other Supporting Policies

There are a variety of market failures at different stages of the process of developing and deploying new emissions-saving technologies that warant public investment and technology

[38] BMU (2020), Figure 41. Expanding forest coverage can generate other environmental co-benefits beyond carbon storage, such as reduced risks of water loss, floods, soil erosion, and river siltation. However, if increased storage comes at the expense of longer rotations and reduced timber supply for construction materials, this could have the perverse effect of increasing CO_2 emissions through additional use of steel and cement.

[39] See, for example, www.fonafifo.go.cr/en. Costa Rica's scheme involves payments to develop and maintain forests (but does not apply fees for reductions in forest coverage).

[40] Calculation assumes the planting sequesters an additional 3 tonnes of CO_2 each year over a 20-year growth cycle with payments discounted at 5 percent. Agricultural land values were equivalent to €22,500 per hectare in 2016 (Silvis and Voskuilen 2016, Figure 1).

policies.[41] Examples of such failures are those associated with knowledge spillovers in shifting to new technologies, warranting additional policies targeted to specific technologies. Public investment can also address network externalities associated with clean technology infrastructure (e.g., the reluctance of one electricity producer to extend the power grid if other producers can also benefit from it).

Green technologies

Increasing public support for R&D on green technologies and the deployment of new technologies would help address market failures and generate positive spillovers. The government should provide direct support for R&D on technologies that are not yet commercially viable but have considerable social benefits. For example, carbon capture and storage, smart grids, and batteries to store intermittent renewable power may be socially desirable but not financially attractive to private investors. Still, they can help reduce carbon emissions, improve the current power system's flexibility, and reduce the pressure on the existing grid system. Government support may also be needed when deploying new technology to promote learning by doing at one firm that can benefit other firms adopting the technology late, as the production cost can be high at the early deployment stage of new technology and will fall as output increases. Government support should then be gradually phased out as technologies are widely adopted.

Infrastructure

An upgraded infrastructure is needed to support the expansion of green energy supply and promote its usage. The largest share of renewable energy is from wind, generated mostly in Germany's north and north-east parts. To fully utilize this renewable power, the electricity grid needs to transport it to where it is currently needed, as well as where it would be needed in the future. Large metropolitan and industrial centers are primarily located in the south and west parts of the country, and north-south transmission lines are currently facing bottlenecks and rising costs when transporting and stabilizing the power generated from volatile renewables even at current capacity.[42] Grid expansion should therefore be prioritized. The Network Development Plan 2019-2030 assesses where extra-high-voltage grids need to be expanded or upgraded over the next 10 to 15 years and defines appropriate expansion projects.

In the transportation sector, sufficient rapid charging stations are necessary to encourage and enable the uptake of electric vehicles. The government plans to increase public charging stations from the current 35 thousand (including less than 3 thousand fast charging units) to 1

[41] See for example Arregui and others (2020).

[42] Grid stabilization means balancing the production and consumption of energy.

million by 2035. Frontloading such investment could encourage speedier adoption of electric cars and crowd in private investment to further expand the charging infrastructure.

D. Mitigating the Impact of Carbon Pricing on Households and Firms

Households

A uniform carbon price of US $50 per tonne in 2030 would increase coal prices in Germany 91 percent above BAU levels in 2030, gas prices 23 percent, retail electricity prices 9 percent, and retail gasoline prices 8 percent (Table 5). BAU prices for coal, gas, and electricity in Germany in 2030 (prior to further increases in carbon pricing) are higher than in most other G20 countries, so the percent increases tend to be lower in Germany.

Table 5. Energy Price Impacts of $50 per tonne CO2 Price

Country	Coal		Natural gas		Electricity		Gasoline	
	Baseline Price, $/GJ	Price Increase	Baseline Price, $/GJ	Price Increase	Baseline Price, $/kWh	Price Increase	Baseline Price, $/liter	Price Increase
Argentina	2.9	172%	3.7	86%	0.08	18%	1.14	13%
Australia	3.4	154%	7.9	37%	0.12	25%	1.13	12%
Brazil	4.4	122%	9.2	34%	0.07	7%	1.23	8%
Canada	2.6	209%	4.2	69%	0.08	10%	1.14	11%
China	4.4	114%	10.5	25%	0.05	46%	1.13	12%
France	6.2	94%	15.8	18%	0.13	2%	1.77	9%
Germany	5.8	91%	12.4	23%	0.17	9%	1.74	8%
India	5.0	99%	3.5	98%	0.06	47%	1.12	12%
Indonesia	2.7	187%	5.7	44%	0.08	57%	0.45	31%
Italy	4.6	116%	15.4	24%	0.12	11%	1.90	8%
Japan	3.7	132%	11.1	24%	0.12	24%	1.37	10%
Mexico	1.8	284%	3.0	91%	0.09	26%	0.97	14%
Russia	2.2	209%	2.7	95%	0.08	36%	0.73	18%
Saudi Arabia			3.9	69%	0.10	33%	0.27	45%
South Africa	1.6	285%	3.7	62%	0.05	66%	1.16	10%
Korea	4.7	103%	11.4	25%	0.08	37%	1.46	8%
Turkey	1.4	421%	7.6	41%	0.06	59%	1.40	10%
United Kingdom	6.9	74%	11.5	27%	0.12	9%	1.72	8%
United States	2.4	220%	4.4	69%	0.07	23%	0.83	16%
Simple Average	3.7	171%	7.8	51%	0.11	39%	1.19	14%

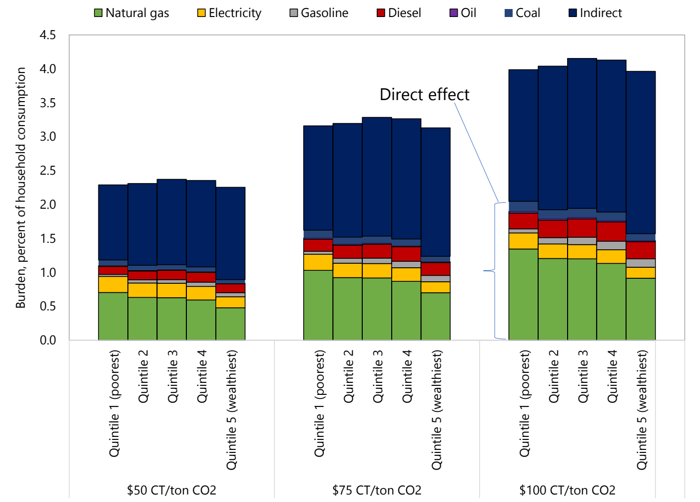
Source: IMF staff calculations.
Note: Baseline prices are retail prices estimated in Coady and others (2019) and include preexisting energy taxes. Baseline prices for coal and natural gas are based on regional reference prices. Baseline prices for electricity and gasoline are from cross-country databases. Impacts of carbon taxes on electricity prices depend on the emissions intensity of power generation. Carbon tax prices are per ton. GJ = gigajoule; kWh = kilowatt-hour

Higher carbon prices affect households directly by raising the price of energy and indirectly through driving up costs and prices for consumption goods in general. For the direct impact, we calculate additional household expenditure under higher carbon pricing by accounting for the impacts of carbon pricing on fuel and electricity prices and reductions in household demand for energy products. For the indirect impact, we calculate indirect price increases for other consumer goods by assuming full pass-through of the burden from producers to consumers using the World Input-Output tables (demand responses for these products are ignored but are likely of minor significance for overall incidence impacts). The composition of the consumption basket—including the share allocated for fuels and utility bills—differs greatly across income groups, leading to the different impact of higher carbon pricing. We, therefore, calculate the composition of private consumption by income quintile using the Household Budget Survey by Eurostat, supplemented with the CPI weights.

An analysis of the incidence of raising the carbon price by $50, 75, and 100 per tonne of CO_2 from existing prices by 2030 is conducted using consumption survey data by income quintile.[43] The burden calculation does not take into account the use of carbon price revenue, which could correct for any regressive impact. The results suggest that the direct impact (i.e., the sum of impact from higher pricing of natural gas, electricity, gasoline, diesel, and oil) is moderately regressive, with an impact of 2 percent of consumption for the lowest income group compared to 1.6 percent of consumption for the highest income group under a carbon price of $100 (Figure 9). However, the regressive impact—driven largely by spending on recreation and tourism, transportation equipment, and transportation services—largely offset the progressive indirect impact, making the overall impact broadly neutral.

Figure 9. Germany: Carbon Price Burden on Households

(Percent of total consumption, by household income quintile)



Sources: Eurostat LIS database, Haver Analytics, and IMF staff calculations.

Compensating the lowest quintile fully for the effect of raising carbon price by a $100 per ton would require revenues of 0.1 percent of GDP, which is substantially smaller than the estimated carbon revenue of 0.75 percent of GDP. The government has made it clear that all additional revenue from carbon pricing will be re-invested in climate action measures or returned to taxpayers, and the CAP 2030 already contains several measures to mitigate the adverse impact on households. For example, the renewable energy surcharge is reduced, subsidies for long-distance commuters are increased[44], and housing benefits are raised. Furthermore, there is additional budget support for refurbishing buildings to increase energy efficiency and making public transportation cheaper. A broader compensation mechanism

[43] We are here assuming full pass-through of carbon pricing into consumer prices, adjusting for declines in energy consumption based on estimated elasticity and assumed changes in energy efficiency.

[44] 35 cents per km for distances of 21 km or more.

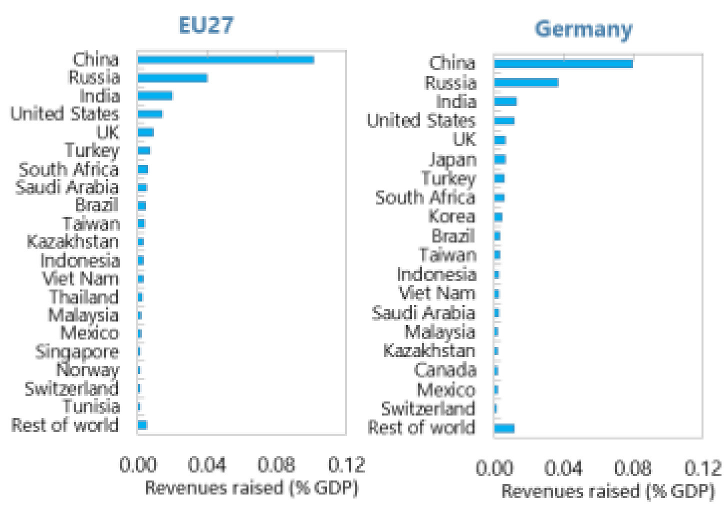
could seek to reduce labor tax burden on lower-income households, which could also entail a positive effect on labor supply.

Firms

Some countries may be concerned that increasing the stringency of their carbon pricing regimes could result in an increase in carbon-intensive production overseas leading to carbon leakage. A recent study provides some evidence that an increase in energy prices could decrease carbon in exports, though not in imports (Misch and Wingender 2021).[45] However, most econometric studies have found that existing carbon pricing policies, notably the EU's ETS, have not resulted in carbon leakage. Nonetheless countries concerned about such effects are increasingly considering border carbon adjustments (BCAs).

The EU plans to address the impact of higher energy prices on vulnerable firms through a BCA slated for introduction in 2023. A BCA is a measure applied to traded products that seeks to make their prices in destination markets consistent with the costs they would have incurred had they been regulated under the destination market's greenhouse gas emission regime (Cosbey et al. 2012). Under this scheme, importers pay an import tax or purchase emissions allowances, while exports might receive rebates for impact of carbon pricing on their fuel and electricity inputs. A $120 per tonne BCA applied to EITE industries at the EU level would have raised revenues of about 0.2 percent of GDP at the EU and German level in 2015 (Figure 10).

Figure 10. Revenues from $120 BCA, 2015



Source: OECD (2021).

The BCA would replace the current free allowance allocations for EITE industries; free allowances become less effective at preserving firms' international competitiveness with deeper decarbonization. Concerns about BCAs on administrative complexities and legal risks

[45] According to Misch and Wingender (2021), Germany's leakage rate—the amount of increase in carbon emissions abroad when Germany reduces carbon emissions domestically—is estimated to be around 0.22. This implies that a reduction of 100 tonnes of carbon emissions domestically would be accompanied by an increase of 25 tonnes abroad. Germany's leakage rate is estimated to be relatively small compared to many other EU countries, but larger than other key non-EU economies (e.g., the U.S., Japan, India, China).

could be lessened by limiting the BCA to EITE industries.[46] However, there is also a concern about the possibility of legal challenges at the World Trade Organization (WTO), or retaliation by trading partners.[47]

A coordinated approach under an International Carbon Pricing Floor (ICPF), with countries agreeing on ambition and acting simultaneously on the needed policies, would help to address concerns that deter stronger unilateral ambition and policy actions (Parry and others 2021). A "minilateral" approach, where a small group of countries agree on the global goal and act simultaneously on the pricing to achieve it, facilitates negotiation and even if a country does not see it as being in its own unilateral interest to adopt a carbon price, it can still be far better off due to the collective benefits if all relevant countries adopt the same price. In fact, country participants may support robust floor prices as this leads to bigger emissions reductions for all participants and bigger benefits for all—this is the key incentive to join the agreement. The arrangement can be designed pragmatically with differentiated price floors and transparent transfer mechanisms to address the differentiated responsibilities of developing countries. And countries where carbon pricing is politically difficult might be accommodated so long as they achieve equivalent emissions reductions through other mitigation measures.

V. Conclusion

Using multiple, complementary mitigation instruments to reduce Germany GHGs is appropriate given uncertainty about the effects and feasibility of individual instruments. Together with the EU and national ETSs, fiscal instruments can help Germany meet its ambitious emissions targets with greater certainty and cost effectiveness. The acceptability of fiscal instruments can be increased by keeping them revenue neutral (in the case of feebates) or by using revenues (in the case of carbon pricing) to fund the green transition or to more broadly reduce taxes on labor.

A number of additional measures could enhance the cost-effectiveness and acceptability of the mitigation strategy

- *Further strengthen carbon pricing.* A more well-specified schedule of carbon prices over a longer time horizon would provide a critical signal for ensuring that new investment is efficiently allocated to clean technologies. In particular, the domestic ETS could incorporate an automatically escalating price floor after the expiration of the price collar.

- *Reduce gaps in the marginal abatement cost across sectors.* Higher carbon pricing in sectors with a relatively low abatement cost, such as power and industry, could help reduce nationwide emissions in an economically efficient way. In this context, at the EU

[46] EITE industries account for about 85 percent of the emissions from manufacturing in the EU-27 (OECD 2021).

[47] See Flannery and others (2020).

level, Germany should push for a robust price floor under the EU ETS through reform of the Market Stability Reserve and extension of the ETS to transportation and buildings. Alternatively, Germany can apply a domestic carbon surcharge to emissions covered by the EU ETS.

- *Introduce feebates.* Feebates apply a revenue-neutral, sliding scale of fees on products or activities with above average emission rates and a sliding scale of rebates on products or activities with below average emission rates. These could complement existing sectoral policies.

- *Look for ways to frontload public investment in green infrastructure and further support green technologies.* While the bulk of green investment will come from the private sector, the public sector has a catalytic role through infrastructure investment, co-funding for projects with large upfront investment costs, and risk sharing.

Fiscal policy can protect the most vulnerable households and firms from the effects of higher carbon pricing. Higher carbon prices affect households directly by raising the price of energy and indirectly through driving up costs and prices for consumption goods in general. The overall impact of carbon price increases is estimated to be broadly neutral in Germany; while the direct effect is regressive, the progressive indirect effect is expected to mitigate the distributional impact. The government intends to re-invest additional revenue from carbon pricing in climate action measures or return it to taxpayers, and the CAP 2030 already contains several measures to mitigate the adverse impact on households. However, the government can consider using the revenue from carbon pricing to reduce labor tax for lower-income earners.

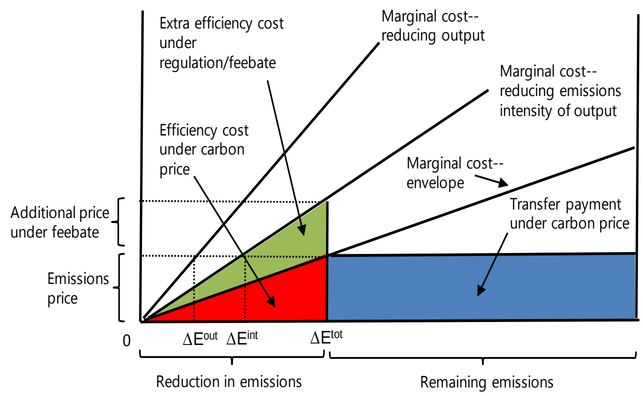
The introduction of a BCA at the EU level in 2023 could alleviate the concerns with carbon leakages and the impact of high energy prices on vulnerable firms. However, there is a risk of legal challenges at the WTO, or retaliation by trading partners. A coordinated approach under an ICPF, with countries agreeing on ambition and acting simultaneously on the needed policies including floor carbon prices, comprises an alternative way to address carbon leakages and competitiveness issues.

Annex 1. Burden of Carbon Mitigation Policies on Industries

Conceptual Analysis

The burden—or increase in private production costs—for industries from carbon mitigation policies is depicted graphically in Figure A1. The upper, middle, and lower curves are the marginal cost of reducing emissions through reducing domestic industry output, reducing the emissions intensity of output, and the envelope of these two curves, respectively. A carbon pricing policy reduces emissions by ΔE^{tot}, with ΔE^{int} and ΔE^{out} coming from reduced emissions intensity and reduced output respectively.

Figure A1. Burden of Carbon Mitigation Policies in Industry



The burden of carbon pricing on industries (prior to compensation schemes) has two components. One is the economic efficiency cost of the behavioral responses (the red triangle in Figure A1), reflecting the resource cost of adopting cleaner (but costlier) production methods. The other is the transfer payment, for example, payments to the government for emission allowances to cover remaining emissions (the blue rectangle).

Alternative mitigation instruments to carbon pricing are less efficient but may impose a much smaller burden on industries. A feebate applied to an industry reduces emissions intensity but (to an approximation) has no impact on output as, unlike a carbon price, it does not charge for remaining emissions. A higher price on emissions is therefore needed to achieve equivalent emissions reductions as under pure carbon pricing, and this implies a higher efficiency cost (the extra green triangle in Figure A1). Under the feebate however there is no transfer payment—the overall burden is therefore generally lower under the feebate. The EU ETS does provide energy-intensive trade exposed firms with free allowance allocations, which compensates them for the transfer payment). This compensation however is lump-sum, rather than per unit of output, so it does not prevent a large increase in unit production costs and it diverts revenue from the government budget.

Illustrative Impacts of Carbon Pricing and Feebates on Production Costs for Steel and Cement

Steel. Traditionally steel is produced using an integrated process involving heating coal to form coke, feeding coke and iron ore into a blast furnace, and using an oxygen furnace to purify the molten metal—the process produces about two tons of CO_2 per ton of steel.[48] Alternatives include an electrified process using scrap metal, and emerging technologies—for example, applying CCUS, or feeding an electric furnace with iron made by direct reduction (e.g., using natural gas). These alternatives produce CO_2 emissions of about 0.3–0.4 tons per ton of steel.

A carbon price of $50/ton of CO_2 would increase the cost of integrated production by about $100/ton of steel through the first-order transfer payment, about one sixth of recent steel prices.[49] And it would increase the cost under alternative technologies by about $20/ton of steel.[50] In contrast, under a feebate the cost for integrated production (given an assumed industry average emission rate of 1 ton of CO_2 per ton of steel) would increase $50 per ton of output, while alternative technologies would receive a subsidy of about $30 per ton of output. A higher

Cement. About 90 percent of cement is produced using traditional kilns to decompose calcium carbonate into clinker and CO_2 and then using mills to mix clinker with other minerals like limestone and grinding it—the process produces about 1 ton of CO_2 per one ton of cement, with process emissions contributing about 70 percent of these emissions. Alternatives include state-of-the-art plants in terms of energy efficiency, currently about 10 percent of production, and CCUS—either post-combustion (where CO_2 is extracted from exhaust gases) or oxy-combustion (where fuel is burned with a mixture of pure oxygen and exhaust gases). State-of-the-art plants largely eliminate non-process emissions. Post- and oxy-combustion reduce emissions about 55 and 85 percent respectively, while increasing capital costs by about 25 and 100 percent respectively.

A carbon price of $50/ton of CO_2 would increase the cost of traditional production about $50 per ton of cement, or about 40 percent,[51] while increasing the price of more efficient and CCUS-fitted plants by $30, and $8–25 per ton of output respectively through the first-order transfer payment. In contrast, a feebate with price $50/ton of CO_2 would only increase the cost of traditional production by $5 per ton of cement, while providing a subsidy to more efficient and CCUS-fitted plants of $10 and $18–35 per ton of output.

[48] Unless otherwise noted, all data in this Annex is taken from van Reijven and others (2016).

[49] See www.focus-economics.com/commodities/base-metals/steel-usa.

[50] Technology switching is more likely to take the reform of retrofitting existing plants, rather than scrapping plants and building new ones, given that existing steel factories can potentially produce for several decades. Incentives will vary across plants, for example with local fuel and electricity prices.

[51] Cement prices are currently around $125 per ton (www.ibisworld.com/us/bed/price-of-cement/190).

Annex 2. Further Design Details for Feebates Applied to Forestry

Feebates for the forest sector should involve rental payments, rather than large upfront payments for tree planting, given that changes in carbon storage may not be permanent. The problem with one-off, upfront payments is that afforestation may be reversed—for example, a new tree farm receiving an upfront rebate may be subsequently harvested or destroyed (by fires, pests, windstorms), requiring complex, ex-post re-payment procedures to provide adequate incentives for maintaining the land-use change. Rental payments should equal the product of the carbon price times, the interest rate, and the number of years in a period.[52] The carbon price would need to rise over time to provide ongoing (rather than one off) increases in carbon storage. Partial exemptions from fees may be warranted for timber harvested for wood products (e.g., furniture, houses) because the carbon emissions (released at the end of the product life) will be delayed, perhaps by several decades or more.

Feebates have become more practical with advances in monitoring technologies. Forest carbon inventories are estimated through a combination of satellite monitoring, aerial photography, and on-the-ground tree sampling. Satellite pictures can be used to measure forest coverage and over time reveal visible land use changes like clear-cutting of intact forest. Carbon storage per hectare of forested land is more difficult to verify however, as it varies with land productivity, tree species, and forest management practices (e.g., selective harvesting can reduce stored carbon without visible clear cuts). Low-level aerial photography along forest boundaries, using technologies like Light Detection and Ranging (LIDAR), can estimate wood volume (therefore implicitly account for selective harvesting and changes in forest management) much more cheaply than on the ground sampling. However, on-the-ground sampling (the most expensive technology) is still needed for densities below a certain threshold—administrative costs might be kept down by, for example, limiting sampling to once every several years.[53]

[52] Sedjo and Marland (2003).

[53] Measuring above ground carbon only (usually about three quarters of the total) could also keep costs down.

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