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Article

Facilitating the transport and heating transition: Strengthen carbon pricing, introduce a climate dividend, and reduce adaptation costs

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AT A GLANCE

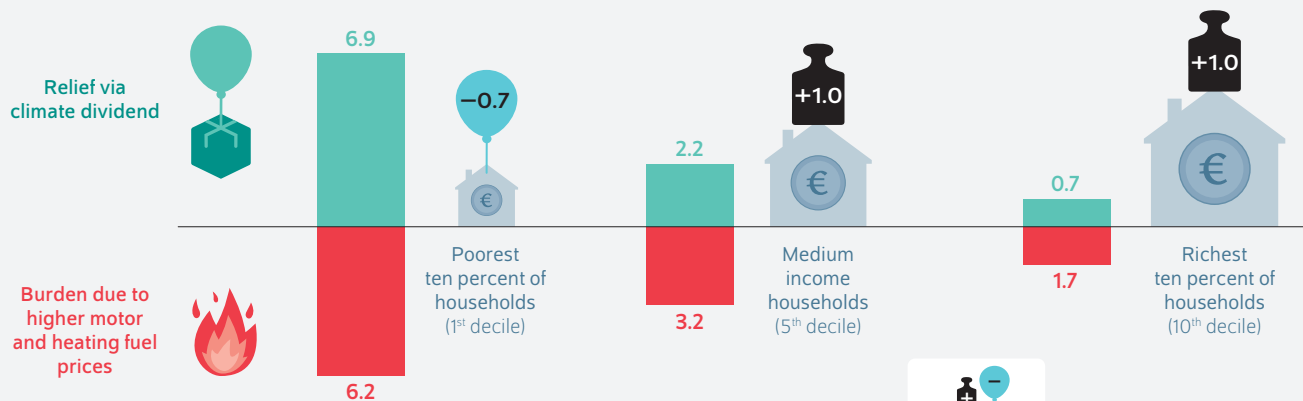
Facilitating the transport and heating transition: strengthen carbon pricing, introduce a climate dividend, and reduce adaptation costs

By Stefan Bach, Hermann Buslei, Lars Felder, and Peter Haan

- Distributive effects of long-run, high fossil fuel prices are investigated, including carbon pricing, on private households
- Higher energy prices affect poorer households more, but a flat-rate climate dividend can counteract this
- For hardship cases with high energy consumption, additional aid is necessary
- Increasing the carbon price to 150 euros per ton in the long term could reduce the carbon emissions of private households by up to 33 percent
- Reducing adaptation costs reduces the burden on households and increases emission savings

Long-run higher fossil fuel prices and a climate dividend: burdens on and relief of households

In percent of net household income



Source: Microsimulation analyses using data from the Socio-Economic Panel (SOEP), v37.

1 Average values; some households may have substantially larger or smaller net effects.

Burdens and relief¹

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FROM THE AUTHORS

“Carbon pricing is an effective instrument to support the heating and transport transition. High burdens on low-income households can be compensated with a climate dividend.”

— Stefan Bach —

MEDIA



Audio Interview with Stefan Bach (in German)
www.diw.de/mediathek

Facilitating the transport and heating transition: strengthen carbon pricing, introduce a climate dividend, and reduce adaptation costs

By Stefan Bach, Hermann Buslei, Lars Felder, and Peter Haan

ABSTRACT

Despite the easing of prices on the energy markets, private households continue to be burdened by elevated prices. The planned increase in the carbon price for transport and heating will raise the burden on private households even further. These additional costs are unequally distributed and have a regressive effect, as poor households must spend much more relative to their net income than rich households. Using the tax revenue from carbon pricing to fund a flat-rate climate dividend per person reduces this regressive effect substantially. However, low-income households with a high level of energy consumption, which are impacted in particular, need additional relief or more support in conserving energy. Adaptation responses to the higher prices are uncertain, but could result in emissions savings of up to 30 percent.

The energy price crisis appears to be easing. In the long term, predictable price developments for fossil fuels are important in order to provide consumers with certainty in switching to climate-friendly technologies. To achieve this, carbon pricing via the European and national Emissions Trading Systems (EU ETS and nEHS) is used: When the permitted emission amounts are successively reduced, the carbon price, and thus also fossil fuel prices, increase. This sets broad economic incentives to switch to climate-friendly alternatives.

Higher energy prices mean consumers are paying more. The lower income groups are affected by these higher costs relatively more, as their energy costs make up a significantly larger share of their income. Unlike the energy crisis of 2022, which was triggered by higher import prices, carbon pricing creates additional government revenue. This revenue can then be used for relief on taxes and duties, higher social transfers—including, for example, a flat-rate climate dividend for all private persons—or adaptation aid for conserving energy.

In this study, the long-term effects of rising motor and heating fuel prices on private households as well as the relief impact of a climate dividend are investigated.¹ In doing so, the potential effects on carbon emissions are also taken into account by making assumptions on the long-term adaptation to higher energy prices.

Carbon pricing will make fossil fuels more expensive in the long run

As of mid-May 2023, the final consumer prices for motor and heating fuels are lower than at the peak of the energy price crisis in 2022, but are still significantly higher than in previous years (Table 1). Compared to the average prices for 2019, which were roughly the same as the average level from the years before up to 2021, motor fuels currently cost a good 20 percent more. Heating oil is 35 percent more expensive and natural gas is 46 percent more expensive (here, the current contracts for new customers are used). The nEHS for

¹ This study was supported by the Interdisciplinary Social Research Funding Network (Fördernetzwerk Interdisziplinäre Sozialforschung).

motor and heating fuels, which was introduced in 2021 and in 2023 will be levied with a fixed price of 30 euros per ton of CO₂ and passed on to customers, accounts for only a minor share of these price increases (Table 2). Electricity prices, which will not be investigated here further, have also decreased significantly, benefiting from the lower gas prices and end of the EEG surcharge. This should decrease the significance of the electricity and gas price brakes currently in place.

It is assumed here that without future increases in the carbon price, fuels and heating oil will become cheaper again because the shortages on the international markets will ease.² Natural gas, however, is likely to remain significantly more expensive compared to pre-2021 levels at ten cents per kilowatt-hour due to the change in the supply situation.

From 2026, the trading phase of the nEHS will begin with a set price range of 55 to 65 euros per ton of CO₂. If a carbon price of 60 euros per ton is applied, the end consumer price for fuels and heating oil will remain below the current level despite the associated price increase due to the assumed decline in international energy prices. The prices for natural gas will increase (Table 1 and Table 2).

From a macroeconomic perspective, there is a strong case for stronger price incentives in climate action, especially in the transport and heating transition.³ In this way, broad incentives for conserving and replacing fossil fuels are set and emissions are reduced. To this end, the carbon price of the current nEHS should continue to rise in these sectors after 2026 and be coordinated with the future European Emissions Trading System.⁴

In this study, it is assumed that the carbon price for motor and heating fuels will increase to 150 euros per ton in the long run—by 2035 at the latest, for example—as a result of a further tightening of emission rights. The related price effects would be noticeable (Table 1 and Table 2). Although they would still be below the peaks reached in 2022 during the energy crisis, these prices would apply permanently. This is likely to significantly increase the incentives for decarbonization in motor and heating fuels.

² It is also assumed that the increase in the prices of fuel and heating oil since 2019 will decrease by half. Cf. Energiewirtschaftliches Institut an der Universität zu Köln (ewi), *Szenarien für die Preisentwicklung von Energieträgern* (2022) (in German; available online; accessed on May 16, 2023. This applies to all other online sources in this report unless stated otherwise).

³ Cf. Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung, *Aufbruch zu einer neuen Klimapolitik. Sondergutachten* (2019) (in German; available online); Andreas Burger et al., "CO₂-Bepreisung im Verkehrs- und Gebäudebereich sozialverträglich gestalten. Herausforderungen, Strategien, Instrumente," *Climate Change* 47 (2022) (in German; available online).

⁴ The National Emissions Trading System (nEHS) for heat and transport is not yet linked to the European Emissions Trading System (EU ETS) for power plants and industry, where emissions certificates are currently traded at a carbon price of around 90 euros per ton. Currently, the EU is planning a second European Emissions Trading System for heating and transport (ETS2) from 2027, see Bundesministerium für Wirtschaft und Klimaschutz, "Europäisches Parlament bestätigt Einigung zur Reform des EU-Emissionshandels," press release, April 18, 2023 (in German; available online).

Table 1

End consumer prices for motor and heating fuels including VAT

Fuel type	Unit	Average 2015–2021	2019	Mid-May 2023	Assumption for 2026	Long-run assumption
End consumer prices						
Super E10	Euro/liter	1.41	1.44	1.77	1.69	1.94
Diesel	Euro/liter	1.23	1.29	1.57	1.53	1.81
Light heating oil	Euro/liter	0.61	0.68	0.91	0.89	1.17
Natural gas (new customers)	Euro/kWh	0.068	0.068	0.099	0.106	0.126
Change in end consumer price compared to 2019 in percent						
Super E10	Percent	-2.2	0.0	23.1	17.4	35.1
Diesel	Percent	-4.8	0.0	21.4	18.0	40.0
Light heating oil	Percent	-10.5	0.0	34.6	31.2	73.1
Natural gas (new customers)	Percent	0.6	0.0	45.7	56.8	85.4

Sources: Federal Statistical Office; Federal Ministry for Economic Affairs and Climate Action, consumer portals online.

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Table 2

Carbon pricing in the heating and transport sectors

Fuel type	Unit	2023	Assumption for 2026	Long-run assumption
Carbon price	Euro/t CO ₂	30	60	150
Impact on the end consumer price including VAT				
Super E10	Euro/liter	0.085	0.169	0.423
Diesel	Euro/liter	0.095	0.190	0.474
Light heating oil	Euro/liter	0.094	0.189	0.472
Natural gas (new customers)	Euro/kWh	0.006	0.013	0.032
Impact on the end consumer price in percent of 2019 prices				
Super E10	Percent	5.9	11.8	29.4
Diesel	Percent	7.3	14.7	36.6
Light heating oil	Percent	14.0	27.9	69.8
Natural gas (new customers)	Percent	9.5	19.1	47.7

Source: Authors' own calculations.

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Climate dividend and other aid could reduce real income losses of low and medium income earners

The distributional effects of the higher energy prices and the relief via the climate dividend are simulated using household data from the Socio-Economic Panel (SOEP) (Box 1). First, the effects of higher energy prices in 2026 with a carbon price of 60 euros compared to the 2019 price level are presented (Figure 1). The effects of the financial burden and of the relief are based on 2023 income levels, assuming that the higher energy prices are already having an effect.⁵ Changes in consumption are not considered; energy consumption is based on 2019 data.

Averaged across all households with gas and oil heating, the 2026 energy prices assumed here represent real income losses of 1.5 percent of net income compared to 2019. Of this 1.5 percent loss, 0.85 percentage points are accounted for

⁵ As private households' real income in the next years is likely to increase, the actual burden will be somewhat smaller. This could be offset by a corresponding increase in the carbon price.

Box 1

Simulations of the distributional effects of higher energy prices and a climate dividend

In this study, the distributional effects of higher energy prices and of relief via a flat-rate, per capita climate dividend are simulated using 2020 household data from the Socio-Economic Panel (SOEP).¹ The effects of the energy price increase since 2019 are considered—i.e., the price level before the crises. Incomes are extrapolated to 2023. The burden and relief effects are expressed as a percentage of 2023 household net income, broken down by deciles of equivalence-weighted household net income.² Thus, these are the relative income effects in terms of disposable income following deduction of income tax and social contributions. Only households with gas or oil heating are observed, which make up around 75 percent of private households. These households are the ones primarily affected by the higher energy prices and carbon pricing in the transport and heating sectors. Households with district heating and electric heating are not included here; they are only directly affected by national emissions trading in the case of motor fuels.

1 Detailed information on energy consumption was surveyed in the 2020 SOEP wave. Cf. for more on the methods, Stefan Bach and Jakob Knautz, "Hohe Energiepreise: Ärmere Haushalte werden trotz Entlastungspaketen stärker belastet als reichere Haushalte," DIW Wochenbericht, no. 17 (2022) (in German; available online); Isabel Schrems et al., "Wirkung des nationalen Brennstoffemissionshandels – Auswertungen und Analysen. Grundlagen für den ersten Erfahrungsbericht der Bundesregierung gemäß § 23 BEHG im Jahr 2022," *Climate Change* 45 (2022) (in German; available online).

2 To make the income situations of households of different sizes and with different compositions comparable, a needs-adjusted per capita net income (equivalized income) according to the new OECD scale is determined for each household member. Then the population is divided into ten groups of equal sized based on their income (deciles).

by the carbon price, while the remaining 0.65 percentage points result from the exogenous price increase on the energy markets.⁶ The financial burden on households is unevenly distributed and has a regressive effect: Poorer households pay much more relative to their income than rich households. Households in the bottom decile—the poorest ten percent of the income distribution—spend 3.5 percent of their net income covering higher energy prices, while the richest ten percent—the top decile—spend just under one percent of their net income. The regressive effect is particularly pronounced for heating fuels. The amount spent on motor fuels, in contrast, is nearly proportional for low and medium incomes and only becomes noticeably regressive in the top two deciles. At the same time, the simulation takes into account that the higher heating costs of basic welfare households are covered by the government.

A climate dividend, which is planned as a long-term compensation instrument for private households, is considered here as a relief model. The revenue from carbon pricing, including value-added tax, insofar as it is attributable to private

6 In the event of stronger or weaker price trends on the international energy markets, this burden would increase or decrease accordingly.

households, would be paid out per capita as a flat-rate sum known as the climate dividend.⁷ At a carbon price of 60 euros per ton, this results in a dividend of 170 euros per year per person, nearly 14 billion euros in total. As the climate dividend would be paid independently of energy consumption, the saving incentives due to higher fossil fuel prices remain.

The climate dividend would be relief in the amount of 0.7 percent of households' net income on average. For the middle and lower income deciles, the relief relative to net income is substantially larger, so that the climate dividend combats the regressive burden of higher energy prices. Furthermore, it is assumed here that households on basic welfare receive the climate dividend in full.⁸

When combining the financial burden and the relief, households with gas or oil heating systems are burdened in the amount of 0.8 percent of their net income overall. This net burden—despite relief in the form of the climate dividend—is due to the price increase on the energy markets, which develops independently of the carbon price. By income deciles, the net burden is largely proportional: It is somewhat higher in the middle deciles, while lower in the bottom and top deciles.

The net burden on the households varies, however. For individual cases, it depends on the level of energy consumption. Larger households and families with children benefit from the climate dividend, as they receive relief for each household member. Some households are burdened less than average and some are even relieved in total. At the same time, there are many households that are burdened substantially above the average. This is a sociopolitical problem, especially for low-income households. For these hardship cases, further targeted aid in addition to the climate dividend could be necessary.

Higher burden and more relief in the long run due to higher carbon pricing and climate dividend

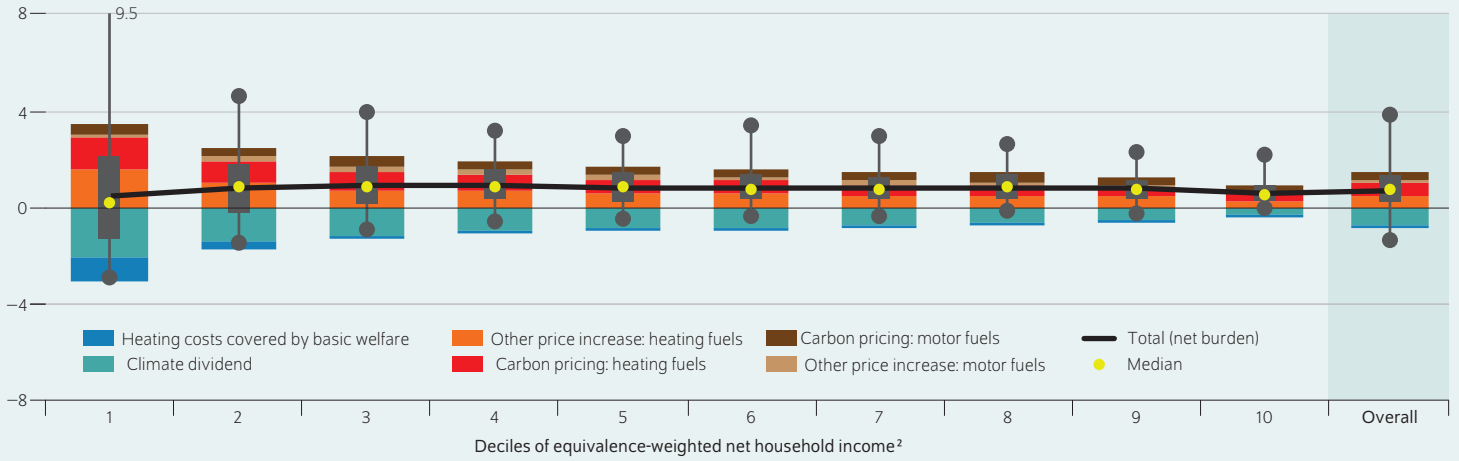
With long-term energy prices and a carbon price of 150 euros per ton, the burden on households increases significantly (Figure 2) when no consumption adjustments are taken into account. Compared to 2019, households with gas or oil heating are burdened in the amount of 2.8 percent of their income on average. Of this burden, carbon pricing accounts for an average of 2.1 percentage points, or 75 percent. The burden on the lower income groups is higher than the burden on the upper income groups. At the same time, revenue from carbon pricing increases, making significantly more

7 However, it is still unclear how the climate dividend can be implemented technologically and if the carbon pricing revenue can be used to fund it. In fact, the revenue has so far flowed into the *Klima- and Transformationfonds* (KTF) and has been used for the end of the EEG surcharge as well as subsidy programs. The nEHS is to be replaced by a second European emissions trading system in 2027. It is still unclear whether the entire revenue can be paid out as direct income transfers in the process. General Secretariat of the Council of the European Union, *Interinstitutional Files: 2021/0206(COD)* (2023) (available online).

8 With regard to the carbon pricing, basic welfare households will then be "doubly" relieved, as their higher energy costs are covered by the government and they will also receive the full climate dividend. In this respect, the climate dividend could be reduced, for example by the average carbon pricing burden on basic welfare households.

Figure 1

Burden on private households due to higher energy prices¹ in 2026 compared to 2019 as well as relief via a climate dividend
In percent of net household income



1 Including VAT. 2019 consumption levels. Income extrapolated to 2023.

2 Equivalence-weighted with the new OECD scale. Refers to the population in private households with oil or gas heating.

Note: The dark gray boxes in the columns are box plots: They mark the 25th percentile at the bottom and the 75th percentile at the top. Thus, they include exactly half of the households. In other words: For half of the households, the burden due to rising energy prices (accounting for relief) lies in this range. The thin vertical lines on the columns demarcate the 2.5th percentile at the bottom and the 97.5th percentile at the top. This means 95 percent of all households in a decile are in this range.

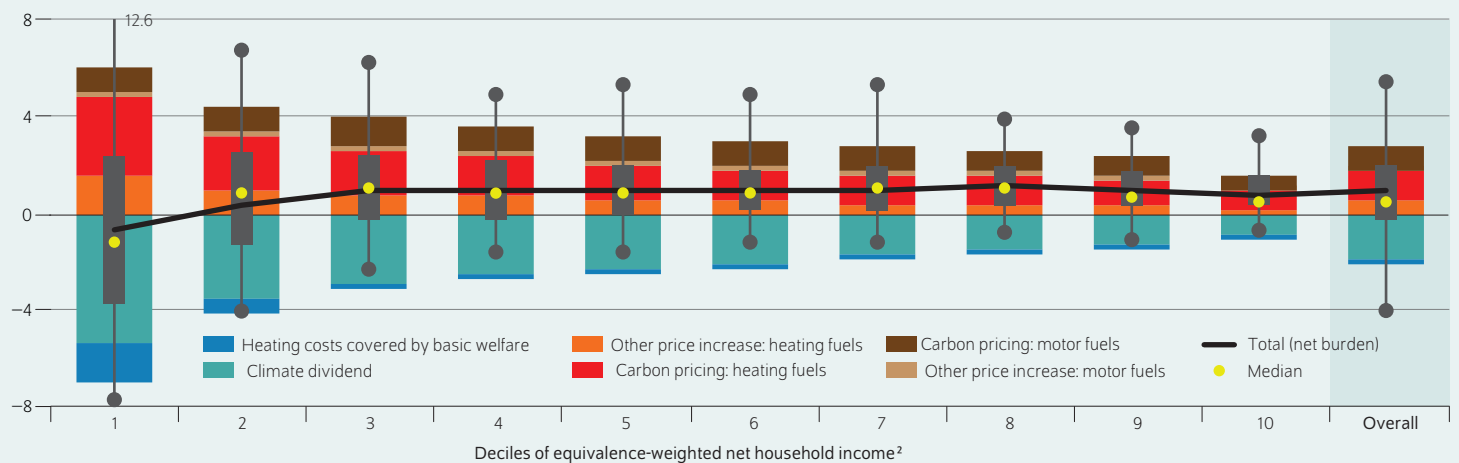
Source: Microsimulation analyses with the Socio-Economic Panel (SOEP), v37.

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High energy prices burden poorer households more. A flat-rate climate dividend can mitigate this, but hardship cases remain.

Figure 2

Burden on private households due to long-run higher energy prices¹ compared to 2019 as well as relief via a climate dividend
In percent of net household income



1 Including VAT. 2019 consumption levels. Income extrapolated to 2023.

2 Equivalence-weighted with the new OECD scale. Refers to the population in private households with oil or gas heating.

Note: The dark gray boxes in the columns are box plots: They mark the 25th percentile at the bottom and the 75th percentile at the top. Thus, they include exactly half of the households. In other words: For half of the households, the burden due to rising energy prices (accounting for relief) lies in this range. The thin vertical lines on the columns demarcate the 2.5th percentile at the bottom and the 97.5th percentile at the top. In other words, 95 percent of all households in a decile are in this range.

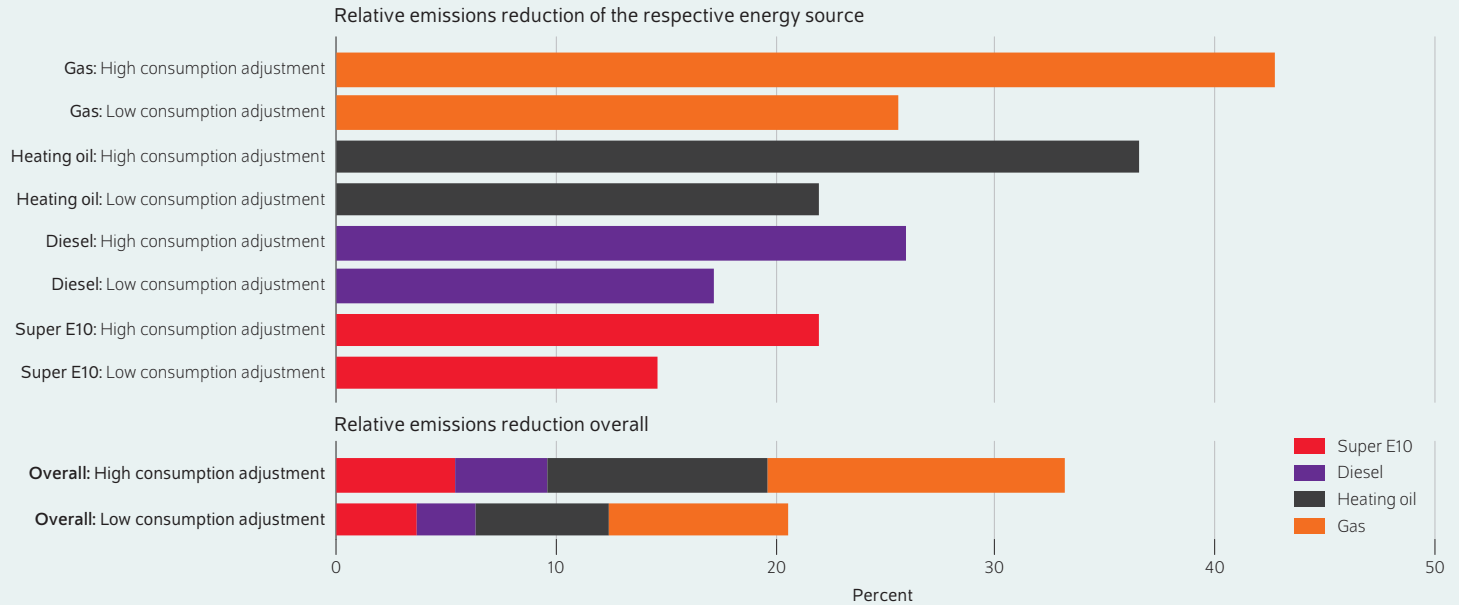
Source: Microsimulation analyses with the Socio-Economic Panel (SOEP), v37.

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Raising the carbon price to 150 euros per ton will lead to a high burden, but will enable greater relief through the climate dividend. Poorer households benefit from this.

Figure 3

Long-term decline of private households' carbon emissions¹
In percent



¹ Private households with oil or gas heating. Relative to 2019 emissions.

Source: Microsimulation analyses with the Socio-Economic Panel (SOEP), v37.

A long-run increase in the carbon price to 150 euros per ton could reduce private households' emissions by up to 30 percent.

financing for the climate dividend available. Here, this is considered to be 422 euros per year per person.

Through the climate dividend, the burden on households can be significantly reduced. Overall, there is a net burden of 0.9 percent of net income. Combined with the fact that the government covers heating costs for basic welfare households, households in the bottom decile are even relieved on average, although hardship cases continue to be substantially more affected by the additional financial burden. This result emphasizes the significance of the climate dividend, which can be used to reduce the burden on a broad base of households. The net burden increases to a good one percent of net income up until the third income decile, and then runs widely proportionally over the higher income deciles. Furthermore, the spread of burdens and relief increases. This increases the number of cases with a low net burden or little relief, while at the same time more households have a disproportionately high burden and there are thus more hardship cases.

Adaption responses are high but come with costs over the long run

Higher energy prices incentivize private households to save. From today's perspective, it is difficult to quantify the extent of these savings. Estimates are used to show possible effects (Box 2), but these are based on past data, which cannot be

used to map the effects of more fundamental changes in the technologies used, such as the transition to electric cars or heat pumps and the associated investment and operating costs. Due to this, additional assumptions must be made that are associated with great uncertainty.

To limit this uncertainty, two scenarios are investigated: one with high and one with low adaptation responses. Fuel consumption changes are roughly differentiated by income group by assuming stronger adaptation responses for high-income households than for low-income households.

Under the adaptation responses assumed here, higher energy prices in the long run could noticeably reduce household carbon emissions (Figure 3). Gas and heating oil consumption declines somewhat more strongly than fuel consumption. Overall, the carbon emissions of the private households with gas or oil heating observed here decrease by 21 percent in the scenario with low adaptation responses and by 33 percent in the scenario with high adaptation responses. In this respect, long-term higher energy prices, which are primarily caused by rising carbon prices, can noticeably reduce private households' carbon emissions.⁹

⁹ While electricity consumption will increase in the future due to electric cars and heat pumps, higher emissions from electricity production will have to be offset, insofar as fossil fuels are still used in the process.

Box 2

Long-term price elasticity of private household fuel demand

In this analysis, the simulated price changes for households are combined with price elasticities to estimate the demand effects.¹ The change in demand is calculated using the following equation:

$$dN = \mu \, dP = \frac{\partial N}{\partial P} \frac{P}{N} \, dP$$

N stands for the demand for a particular good, P for the price of this good, and μ for the demand elasticity. dP indicates a certain percentage change in the price, for example by five percent. The percentage change in the demand amount (dN) is then the product of elasticity (for example -0.4) and the specific price change, a decrease in demand of two percent, for example.

Frequently elasticities are differentiated between short-run and long-run elasticities for the temporal distribution of changes to demand. For the more long-run price elasticities of demand for motor and heating fuels that are of interest here, a number of estimates can be found in the literature.² It becomes clear that estimation results differ depending on assumptions and context, and that behavioral effects can only be determined under uncertainty. To account for this uncertainty, different scenarios are depicted in this analysis: One with low adaptation and one with high adaptation. This also takes into account different adaptation possibilities depending on household income. Here, too, there is no uniform trend. For motor fuels, studies overwhelmingly find that

¹ For these calculations, it is assumed that elasticities can reflect changes in demand from small price increases (such as one percent) as well as from significant price increases, as used in the simulations.

² Cf. Stefan Bach et al., "CO₂-Bepreisung im Wärme- und Verkehrssektor: Diskussion von Wirkungen und alternativen Entlastungsoptionen," *DIW Politikberatung Kompakt* 140 (2023) (in German). A compilation of estimation results incorporating new studies was prepared by Hermann Buslei, "Schätzungen der langfristigen Preiselastizitäten der Energienachfrage für Heizung und Verkehr, eine Übersicht mit Schwerpunkt Deutschland," *DIW Politikberatung kompakt* Nr. 194 (available online).

The adaptation responses significantly reduce the effects of higher energy prices in isolation. However, adaptation comes with costs. In particular, new technologies must be used to ensure that space heating and transport are climate neutral. This requires investment costs for energy-efficient refurbishment, new heating systems, or new vehicles as well as their operating costs (electricity or e-fuels).¹⁰ From today's perspective, the adaptation costs are likely to be only somewhat below the energy costs saved on fossil heating and fuels in most cases. The distributional effect of the higher energy prices, including the costs of adaptation responses, would then be close to the results without adaptation responses (Figure 2). However, subsidy programs for investments or future cost decreases for climate-friendly technologies, decrease the

¹⁰ See Matthias Kalkuhl et al., *CO₂-Bepreisung zur Erreichung der Klimaneutralität im Verkehrs- und Gebäudesektor: Investitionsanreize und Verteilungswirkungen* (Mercator Research Institute on Global Commons and Climate Change: 2023) (in German; available online).

Table

Assumptions of long-run price elasticities of demand for motor and heating fuels

		Scenarios			
		Low		High	
Heating	Total	-0.3		-0.5	
Transport	Total	-0.4		-0.6	
	Quarterly	First	Fourth	First	Fourth
		-0.32	-0.48	-0.48	-0.72

Source: Hermann Buslei (2023), *ibid.*

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low-income households are less able to adapt and therefore have lower elasticities. For heating fuels, the differences in the magnitude of elasticities in the lowest and highest income quartiles (with different signs) are mostly small in the available studies, so it is not distinguished between them.

When interpreting elasticities, it must be remembered that the influence of new technologies can not be estimated. The elasticity estimations use a concrete price and past demand variation. The measured reactions were certainly also partially determined by the substitution possibilities. The latter is likely to change significantly in the future due to the (increasing) availability of electric heating and electric vehicles. Therefore, the elasticities might actually be higher than estimated above using the available empirical results.³

³ For a use of price elasticities to estimate the effects of price changes in energy demand in model calculations, cf. Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung, *Aufbruch zu einer neuen Klimapolitik. Sondergutachten*. There, further limitations of this approach are discussed.

adaptation costs and make it possible to reduce carbon emissions to an even greater extent.

Conclusion: Complement carbon pricing with a climate dividend

Higher prices for fossil fuels, especially a steadily rising carbon price, support the transport and heating transition. The associated burden on households, however, is unequally distributed and has a regressive effect, as the poorer households are burdened more relative to their net income than rich households.

This effect could be offset by a flat-rate, per capita climate dividend, which would primarily benefit low and middle income households. Even with high carbon prices, such as the assumed 150 euros per ton here, the net burden could be confined to a moderate level. Therefore, a climate dividend

CARBON PRICING

funded by the revenue from carbon pricing should be introduced soon as a general and wide-reaching relief instrument. Low-income households with high energy consumption, however, need additional relief or more support in conserving energy. In return, the climate dividend could be reduced for those with higher incomes.

Long-run increases in fossil fuel prices, including raising the carbon price up to 150 euros per ton, could significantly reduce carbon emissions. For the adaptation responses assumed here, the carbon emissions of private households decrease by up to 33 percent. This would be an important step in achieving the climate targets. However, this cannot achieve extensive decarbonization in the areas of transport and private household heating.

Adaptation creates new costs for households, primarily investment costs for energy-efficient refurbishment, new

heating systems, or new vehicles and their operating costs for electricity or e-fuels. These additional costs are expected to partially offset savings in existing energy costs, ultimately resulting in distributional effects similar to those of higher energy prices. Subsidy programs can reduce the adaptation costs, but increase public expenditure.

Costs for adapting to climate neutral technologies in heating and transport affect the public's acceptance of the green transition, as current debates on the Buildings Energy Act (*Gebäudeenergiegesetz*) show. A steadily and successively rising carbon price creates signals for long-term investment decisions. At the same time, further instruments such as regulatory requirements and bans or infrastructure adaptation are needed to achieve the climate targets. If climate-friendly technologies become more affordable in the future, adaptation costs decrease and carbon emissions are reduced more quickly.

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