Distributional impacts of CO$_2$ pricing — focus on the buildings sector

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Abstract

The building sector is responsible for 16 % of GHG emissions in Germany and its contribution to meeting Germany's climate targets is correspondingly high. Effective climate protection in the building sector can only be achieved with a broad mix of instruments. One important instrument in this mix is CO$_2$ pricing of fossil fuels. In Germany, a CO$_2$ price for the building and transport sector was introduced at the beginning of 2021. This paper analyzes the social impacts of CO$_2$ pricing in Germany and looks into alternative models for revenue recycling. We focus in particular on redistributing revenues by reducing the renewable energy surcharge and thus household electricity prices. Additionally, we consider how the impacts change when efficiency investments are taken in response to the pricing scheme.

Our analysis shows that CO$_2$ pricing in Germany in combination with revenue use for reducing electricity costs has clear positive distributional effects at the level of households. Limiting the pass-through of CO$_2$ cost from landlords to tenants both reduces the burden on tenants and increases incentives for landlords to invest in energy-efficient refurbishments. For households in the first three income deciles, reductions in electricity cost outweigh the CO$_2$ costs incurred. Although high-income households also benefit from an abolition of the renewable electricity surcharge, the costs incurred from CO$_2$ pricing cannot be completely offset. We find, however, adjustment ac-

tions such as investing in more efficient, zero-carbon energy solutions results in net reductions also for these households.

Besides limiting cost pass-through to tenants, we conclude that a carefully chosen approach for revenue recycling is important to protect vulnerable households. Taking into account the practical implementation as well as transaction costs, this results in a favourable assessment for electricity price reduction as a redistribution mechanism compared to a lump-sum rebate of the same revenue amount. These findings can inform the ongoing discussions of introducing an EU-wide carbon pricing mechanism for buildings and transport as proposed by the European Commission.

Introduction

The building sector is responsible for 16 % of total German GHG emissions. Its contribution to meeting the legally binding greenhouse gas reduction targets enshrined in the Federal Climate Change Act is therefore high. According to national climate targets, the building sector must reduce greenhouse gas emissions by about 44 % of 2020 emissions by 2030. Decarbonization of the building sector can be achieved both by replacing fossil heating systems and by increasing energy efficiency through building insulation. However, the specific characteristics of the building sector, such as long investment cycles, low price elasticities and split incentives between landlords and tenants, mean that effective climate protection in the building sector can only be achieved with a broad mix of instruments.

One important instrument in this mix is CO$_2$ pricing of fossil fuels. In Germany, a CO$_2$ price for the building and trans-

port sector was introduced at the beginning of 2021. The price will gradually be increased from €25/t to €55/t by 2025 and will be determined on the market from 2027 onwards. The national CO_2 pricing scheme in Germany started before the EU Commission proposed the introduction of an EU-wide emission trading scheme for buildings and road transport, set to start in 2025. The scope of the current EU proposal is slightly different from the German scheme as it does not cover other means of transportation than road transport and does not cover small industries. Related to buildings though, the scope is similar.

CO_2 pricing aims at creating incentives for climate-friendly investments and / or climate-friendly consumption. As a market instrument, it is – at least in theory - economically efficient. According to their individual decision-making, actors can decide to pay the CO_2 price or to save CO_2 emissions by changing consumption patterns, investing in climate-friendly technologies or other measures and thus avoid the CO_2-related costs.

However, costs imposed by the carbon price and adjustment options differ between actors. Vulnerable consumers, who already spend a significantly higher share of their income on everyday goods such as energy, face a higher burden through additional CO_2 costs or by spending on climate-friendly technologies than consumers with higher incomes (Berry 2019). In addition, tenants in particular are dependent on their landlords' decisions to invest in climate-friendly technologies (Braungardt et al. 2021).

In order to make carbon pricing socially balanced, it is therefore important to use revenues in a just way for compensation or investment support (Antosiewicz et al. 2020; Bach et al. 2019). In this report, we look into different ways of using revenues which are currently employed and further discussed within the German CO_2 pricing scheme for buildings and transport. In particular, we explore the option of revenues being used to reduce the renewable energy surcharge which is a component within the electricity price. Lower electricity prices provide relief particularly for low-income households which spend a substantially larger share of their income on electricity than high-income households.

Various CO_2 pricing and redistribution variants have already been described in the literature[1]. In many cases, redistribution via a per capita climate premium is chosen as it is done within the Swiss national CO_2 pricing scheme. However, in Germany this variant is confronted with considerable challenges in implementation - there is no concrete proposal yet on how such a per capita premium could be technically realised as, in contrast to Switzerland, no national health insurance registry system exists which can be used to transfer money to all citizens.

On the other hand, a reduction in electricity costs through the abolition of the renewable surcharge and reduction of the electricity tax can be easily implemented and also creates incentives for transformation through electrification in other sectors because of lower electricity prices.

The EU proposal for an emissions trading scheme for road transport and buildings puts special emphasis on vulnerable consumers by proposing to set up a Social Climate Fund with

about 25 % of the revenues from the trading scheme which is distributed to member states according to a solidary allocation key. The amounts for Member States are to be topped up by national contributions of about the same amount. A just transition and fair distribution that provides incentives for energy efficiency investment is foreseen for both funding through the Social Climate Fund and through the remaining revenues. Temporary direct income support for vulnerable consumers is possible through the Social Climate Fund.

In this paper, we focus on the German national CO_2 pricing scheme which is already in place and started before the EU proposal for a new emission trading scheme for building and road transport was published. In the following, the distributional effects of the German approach with redistribution via the electricity cost reduction are examined in more detail at the level of private households. First, a comparison is made across different income classes. In a next step, the costs and savings for typical households are illustrated without and with adjustment reactions (purchase of battery-electric cars, installation of heat pumps). The selected sample households represent a broad spectrum of the population living in Germany.

The focus of the analysis is on the year 2025. In the further course of time, with higher CO_2 prices, revenues are expected to rise even with declining emissions (Matthes et al. 2021; Öko-Institut et al. 2021), creating scope for a socially balanced design of additional redistribution measures beyond electricity cost reductions. Even though the carbon price applies to buildings and transport, the focus of the paper is on buildings.

Methodology and data

MICROSIMULATION MODEL SEEK

To estimate the distributional effects, the microsimulation model *SEEK* (Social Effects Energy and Climate Policy) is used. *SEEK* is based on the household survey data of the Income and Consumption Survey (EVS). The EVS is an administrative data source and contains detailed information on household income and consumption patterns, as well as information on other household characteristics such as social status, household type, age, housing situation, etc. The survey is the largest of its kind in Germany and covers about 60,000 households. Participating households document their individual income and expenditure at the personal and household level for one quarter. The EVS is statistically representative for the whole of Germany and is therefore suitable for calculating the expected distribution effects of energy and climate policy instruments. The survey is conducted every five years.

For the statistical analyses, the current wave of the EVS from 2018 was used and processed and evaluated with the help of the microsimulation model *SEEK*. Within the framework of the microsimulation model, the expenditure on housing and transport reported by the households is converted into consumption under the assumption of prices in order to simulate the effect of different CO_2 prices on the households. For the analysis of the effects in 2025, consumption is extrapolated on the basis of Prognos; Öko-Institut; Wuppertal-Institut (2020).

In order to assess the distributional impact of CO_2 pricing and redistribution, the burden on households is compared by income decile. The division into deciles is based on the net

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1. See for example MCC; PIK (2019a; 2019b), IMK (2019), DIW (2019), Agora EW/ Agora VW (2019) as well as RWIC (2019).

Table 1. Household heating and fuel prices (incl. VAT), 2025.

	Natural gas	Heating oil	Petrol	Diesel
	ct / kWh (real 2019)	ct / kWh (real 2019)	ct / kWh (real 2019)	ct / kWh (real 2019)
Projected Price without CO_2 price	6.87	5.78	14.42	11.50
Increase because of CO_2 price of 80 EUR/t CO2 (nominal)	1.70	2.26	2.23	2.26

Source: Öko-Institut calculations based on the price trends used or determined by Prognos; Öko-Institut; Wuppertal-Institut (2020).

Table 2. Household electricity prices (incl. VAT), 2025.

	Electricity price (appliances, e-mobility)	Electricity price (heat pump)
	ct / kWh (real 2019)	ct / kWh (real 2019)
Projected Price incl. renewable surcharge	30.92	23.90
Price after abolition of the renewable surcharge	24.36	17.34

Source: Öko-Institut calculations based on the price trends used or determined by Prognos; Öko-Institut; Wuppertal-Institut (2020).

equivalent income[2] of each household, such that 10 per cent of the Germany population is grouped into each decile based on their income. The first decile comprises the 10 per cent lowest incomes and the tenth decile the 10 per cent highest incomes.

The distributional effects also depend on whether the costs of CO_2 pricing are passed on to tenants or whether there is a limit on this pass-though, such that part of the costs remain with the landlords. Currently, in Germany CO_2 costs are fully passed on to tenants who do not have any influence on the heating system or building insulation of the building they live in. The new government in place since late 2021 is planning a new regulation for 2022 which would limit the pass through of CO_2 costs. The idea is to make pass through dependent on the energy efficiency of the building. The lower the energy efficiency of the building, the higher will be the share of CO_2 costs that landlords have to cover themselves. This will increase the incentives for landlords to invest in energy efficiency refurbishments. As the new regulation is still to be developed and challenges will occur to identify the energy efficiency of all rented buildings in Germany, the fallback option is to split CO_2 costs 50/50 between landlords and tenants. In the following analysis, we analyse this fallback option.

For the distributional analysis, it must be taken into account that some households are landlords themselves and consequently bear the costs of CO_2 pricing for their tenants. The mi-

crosimulation takes into account that 58 % of rented housing in Germany belongs to private individuals (StÄBL 2019). This information is used to distribute the CO_2 costs for heat accordingly. In the following analysis, the CO_2 costs for heat borne by private landlords are included according to the share of private landlords in the respective income deciles. The share of private landlords amongst all households in the income decile is equal to 1 % in the fist decile, rising to 36 % in the tenth decile.

CO_2 AND ENERGY PRICES

For the analysis, we assume a nominal CO_2 price of 80 Euros per ton of CO_2 in 2025.[3] The price is slightly higher than the currently planned fixed-price scheme in the national CO_2-pricing system in order to stimulate emissions reductions and achieve sectoral emissions reductions targets as set out in Germany's Climate Plan. Resulting changes in final energy prices (in real prices of 2019 and including VAT) for 2025 are shown in Table 1: the price of natural gas increases by 25 %, the price of heating oil by almost 40 %, the price of petrol by 15 % and the price of diesel by 20 %.

We estimate a CO_2 price of 80 Euros per ton of CO_2 in 2025 to raise revenues of about 20 billion Euros. In this study, in 2025 the entire revenue is used to refinance the renewable energy surcharge. This implies that electricity prices for households (in real 2019 prices and including VAT) are reduced by 6.5 ct/kWh (real 2019), as shown in Table 2. This translates into a reduction of 21 % for electricity used for appliances and for electric vehicles and by 27 % for electricity used in heat pumps which has a lower price in Germany.

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2. To determine the net equivalent income according to the new OECD scale, the composition of the household is taken into account in addition to the net household income. This considers possible scale or savings effects, such as the shared use of electrical appliances, and thus enables an improved comparison of the standard of living or financial well-being of different households. According to this approach, a single household with a net income of 2 000 Euros has a comparable financial prosperity as, for example, a household with two adults and a net income of 3 000 Euros.

3. EUR80/t CO_2 (nominal) corresponds to EUR71/t CO_2 (real 2019).

ASSUMPTIONS ON INVESTMENT COSTS

The direct distributional effects of the CO_2 price and redistribution are examined in the income deciles framework. In the framework of example households, it is investigated how investment stimulated by the pricing scheme (e.g. investment in installation of heat pump, purchase of battery-electric cars) would affect expenditures and savings. For energy efficiency investments (e.g. installation of heat pumps), households can also benefit from subsidy programmes financed by the Energy and Climate Fund (EKF), e.g. within the framework of the federal funding programme for efficient buildings (BEG). The investment costs applied in this analysis are thus costs that occur after funding.

We consider additional investment costs for the installation of a heat pump in comparison to the purchase of a gas boiler. Additional annualized costs are shown in Table 3 for a partially renovated single-family house with a living space of 110 sqm. Additional annualized costs are equal to 426 Euros per year. For a larger size 150 sqm single-family house with the same efficien-

cy standard, 581 euros per year are applied. The annual performance factor is assumed to be equal to 3.3 (Öko-Institut 2021).

No additional costs are applied for the purchase of a battery-electric car, as the case is considered here in which a household decides in favour of a battery-electric car *instead of* a fossil-fuelled engine and it can be assumed that the purchase costs in the year 2025 will be in the same range, due to complementary policies such as a bonus-malus system in the motor vehicle tax (SKN 2021) or also other policy measures with the same effect (also for used cars).

ENERGY CONSUMPTION AND EXPENDITURE IN 2018

In order to better understand the impacts of CO_2 pricing and redistribution of revenues, we take a look at energy consumption and expenditure across households before the start of carbon pricing. In general, heat consumption increases with household income (Figure 1), which is due in particular to larger living space in upper income deciles. The share of district

Table 3. Investment costs of air heat pump at the time of replacement, partially renovated detached house, 110 m².

EUR real (2019)	Investment costs air HP	Less costs of the gas boiler	After promotion 35%	incl. VAT
Investment costs	15 000	9 000	5 850	6 962
Annuity (Euro/year)				426

Assumptions: Lifespan 20 years, interest rate 2%, Öko-Institut (2021).
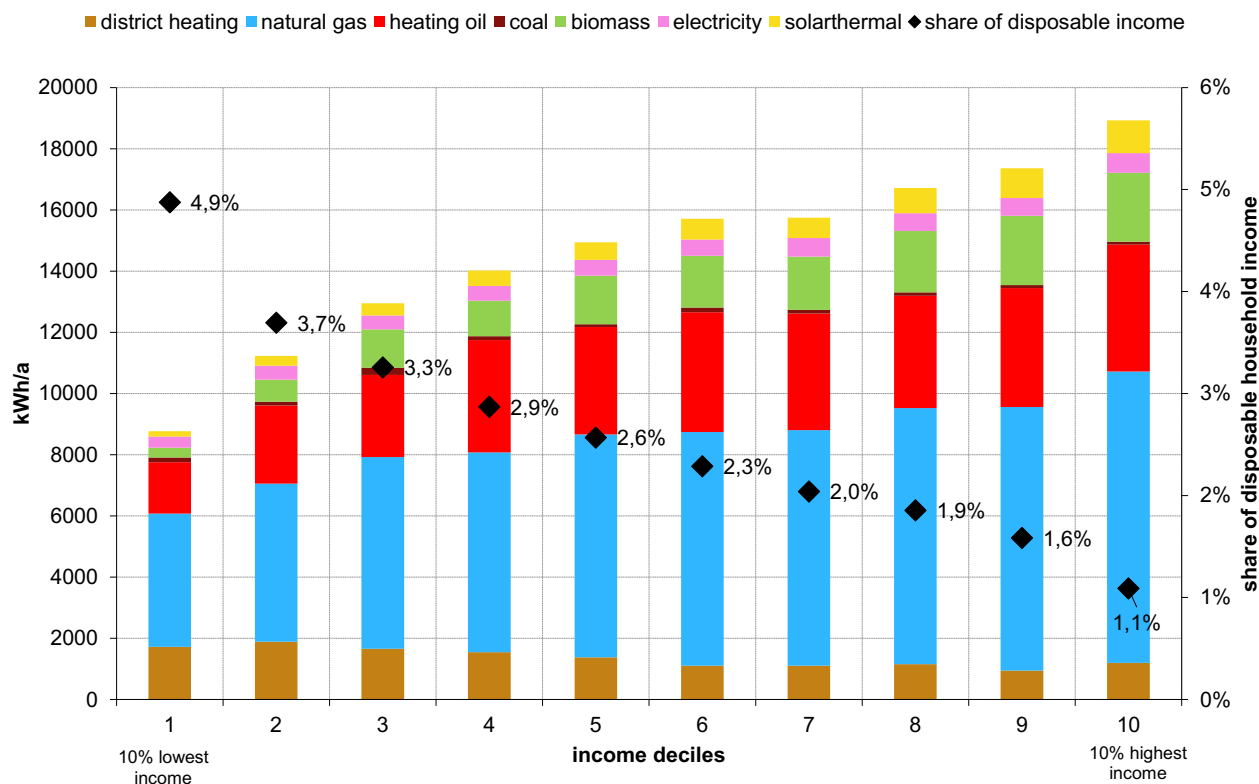

Figure 1. Heat energy consumption by income deciles and share of heating expenditure in income, 2018.
Source: Öko-Institut calculations based on FDZ of the Statistical Offices of the Federation and the Länder, Income and Consumption Survey 2018.

heating as a heat energy source is higher in the lower deciles than in the upper deciles, while the share of heating supplied by oil increases with the deciles. The share of gas as a heat energy source fluctuates around 50 %.

The distribution of petrol and diesel consumption across the ten income classes (Figure 2) depends in particular on whether and how many cars the average household in the respective decile owns, as well as on the miles travelled. Ownership increases strongly with income, such that fuel consumption in the 10th decile is almost six times higher than in the 1st decile. The share of disposable income used for petrol and diesel initially rises up to the 3rd decile with increasing car ownership, but then falls steadily up to the 10th decile, as rising incomes mean that a smaller share of income has to be spent on fuel. These are average values for all households in the respective deciles. Individual consumption and expenditure vary greatly within the deciles. This is taken into account further below when looking at specific example households.

Electricity consumption for household appliances also increases with income (Figure 3) and is 1.5 times higher in the 10th decile than in the 1st decile. However, electricity consumption per person is only slightly higher in higher incomes deciles, as households with higher incomes have more household members (in the 1st decile there are on average 1.5 persons per household, in the upper income deciles 2.2 persons per household). On average, households in Germany spend 2 % of their disposable income on electricity. In the 1st decile, however, this share is five times higher at 5 % than in the 10th decile at 1 %.

Distribution effects

DISTRIBUTIONAL EFFECTS ACROSS INCOME DECILES

In this analysis on the basis of income deciles, we take into account impacts on tenants and owner-occupiers and also include the costs incurred by private landlords due to the 50/50 pass-through rule. The expected distributional effects are shown in Figure 7 for ten income groups. The figure shows CO_2 costs for heat and fuel compared to the savings in electricity costs and also shows the net effect (black diamond). Households with the lowest incomes (1st income decile) save on average 44 Euros per person per year, while households in the tenth decile have additional expenses of 102 Euros per person per year. For the 30 % of the households in the first three income deciles, CO_2 pricing plus electricity price reduction brings about a relief; from the 4th decile onwards, there is a net burden. On average, across all households, there would be a slightly higher additional burden of 26 Euros per person per year.

The additional CO_2 costs for mobility increase with income, as households with higher incomes consume more fuel (cf. Figure 2). In the heating sector, CO_2 costs arise for owner-occupiers who heat with gas, oil or coal, for landlords whose rented flats are heated with gas, oil or coal and who pay 50 % of the CO_2 induced costs, as well as for tenants which cover another 50 % of the CO_2 costs that are passed through to them.

The heat-related CO_2 costs increase with income, as both the proportion of owner-occupiers and the proportion of households who rent out property increase with income. In addition,
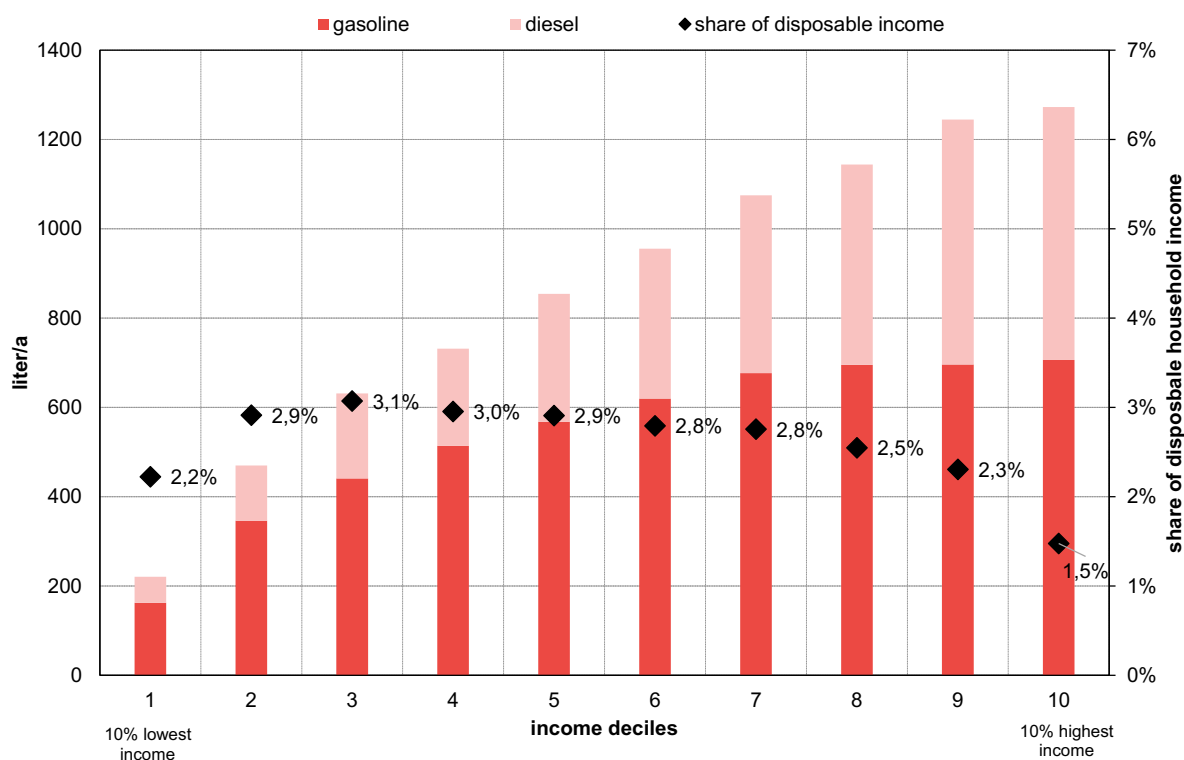

Figure 2. Transport fuel consumption by income deciles and fuel expenditure as a share of income, 2018.
Source: Öko-Institut calculations based on FDZ of the Statistical Offices of the Federation and the Länder, Income and Consumption Survey 2018.
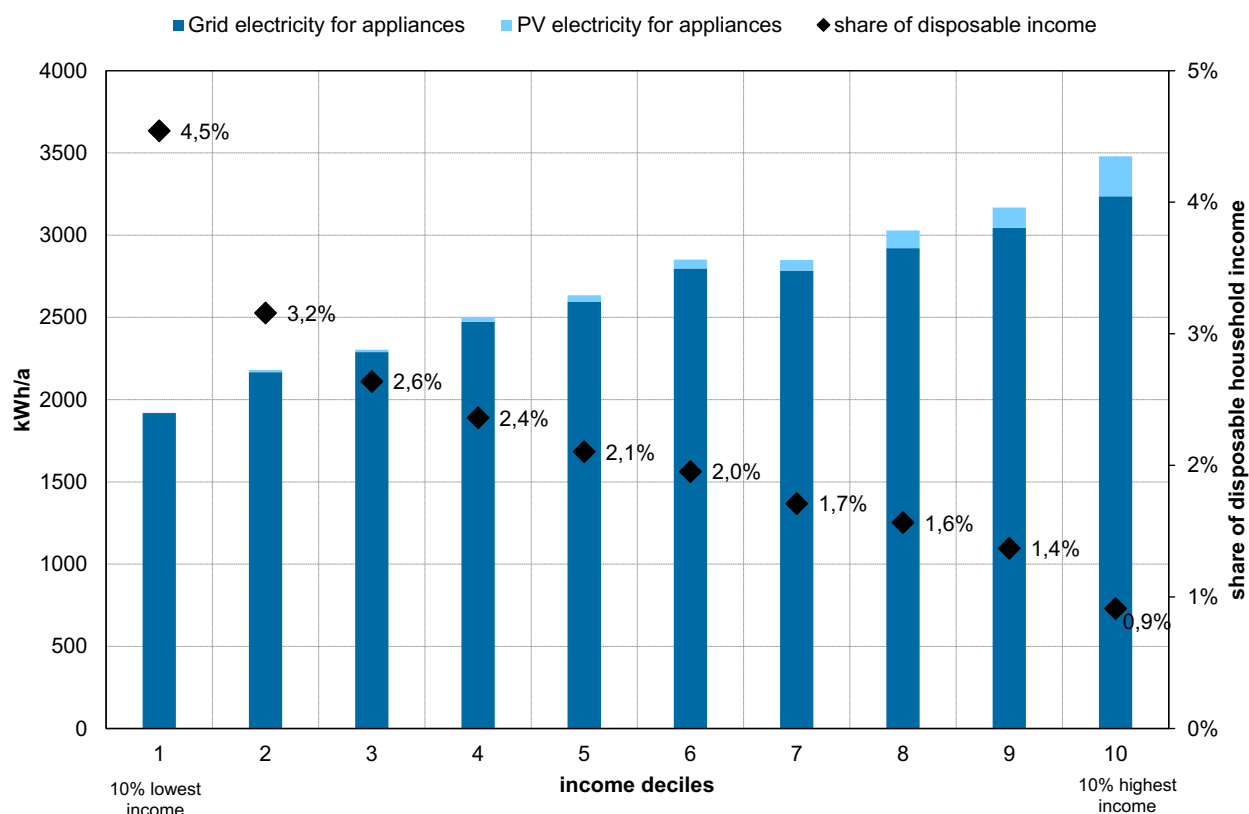
Figure 3. Electricity consumption for appliances by income decile and share of electricity expenditure in income, 2018. Source: Öko-Institut calculations based on FDZ of the Statistical Offices of the Federation and the Länder, Income and Consumption Survey 2018.
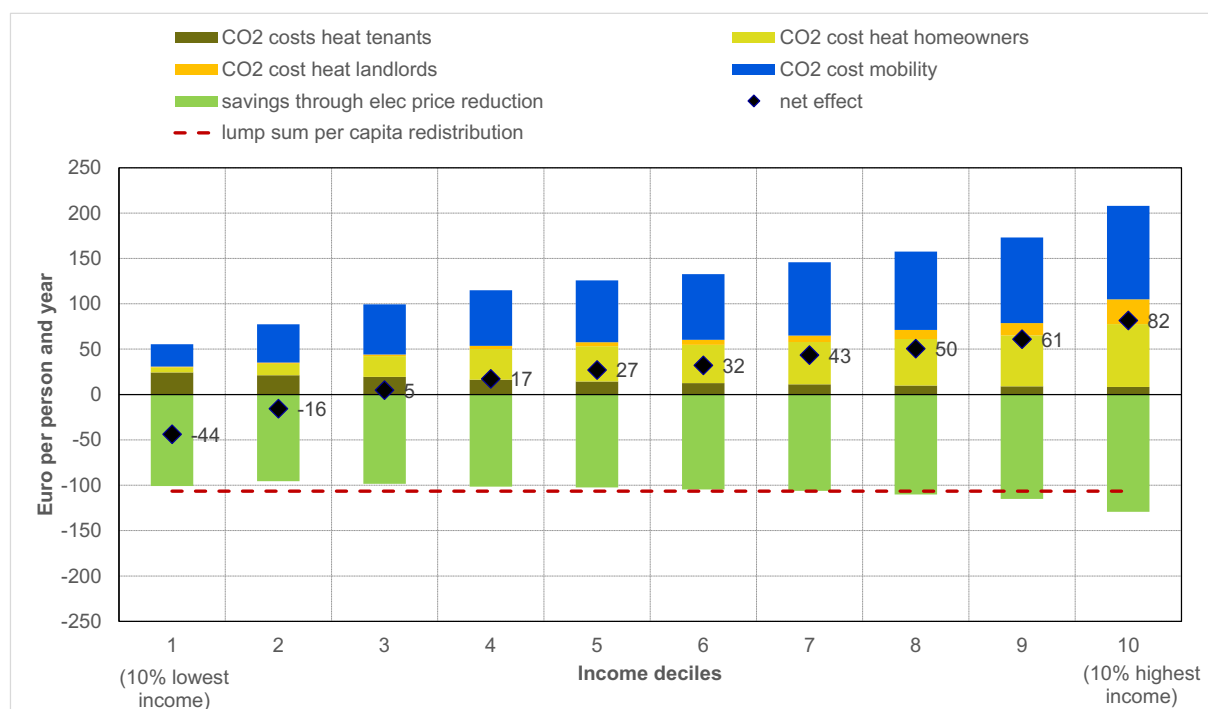

Figure 4. Distributional effects of the reform in 2025, 50/50 regulation of the CO_2 cost allocation for tenants. Source: Öko-Institut calculations based on FDZ of the statistical offices of the Federation and the Länder, income and consumption sample 2018 and own assumptions.

Table 4. Overview: Characteristics of example households.

	Example tenant households				Example households owning their homes		
	Family with medium / low income	Pensioner with medium / low income	Single parents with medium / low income	Single with high income	Family with medium / low income	Family with medium / low income	Couple without children with high income
Income (Euro/year)	60 000 / 35 000	20 000 / 10 000	30 000 / 15 000	80 000	60 000 / 35 000	60 000 / 35 000	110 000
Living space (sqm)	110	55	75	90	110	110	150
Heating energy source	Gas	Gas	Gas	Gas	Gas	Heating oil	Gas
Consumption (kWh/year)	15 400	7 700	10 500	12 600	15 400	15 400	21 000
Car	Petrol		Petrol	Petrol	Petrol	Petrol / Diesel	Petrol / Diesel
Mileage (km)	15 000	-	10 000	15 000	15 000	15 000 / 15 000	15 000 / 25 000
Consumption (l/year)	1 170	-	780	1 170	1 170	1 170 / 1 050	1 170 / 1 750
Electricity consumption (kWh/year)	4 100	1 800	2 700	2 400	4 100	3 800	3 900

Öko-Institut calculations based on FDZ of the statistical offices of the Federation and the Länder, sample survey of income and consumption 2018 and own assumptions.

households with higher incomes have larger living spaces and consume more heating energy (cf. Figure 1).

The relief brought about by the redistribution mechanism through the reduction in the electricity price is distributed fairly constant across the income deciles and is equal to around 100 Euros per person per year. In the upper deciles it is a little higher due to higher electricity consumption (Figure 3) and rises to 129 Euros per person and year in the 10th decile. For comparison, Figure 4 also shows the relief that would result from a per capita redistribution of the same redistribution amount (resulting in 102 Euros per capita per year). Both redistribution variants thus produce similar effects.

This analysis indicates that for the average household in each decile the effects of revenue recycling through the abolition of the renewable surcharge has a distributional effect that does not aggravate inequity and produces net benefits for those who most need relief from the burden of rising energy costs. These analytic findings do not take into account the price effects of the policy, specifically the adjustments that households would make to the composition of their energy consumption when facing these modified energy costs. We explore this adjustment effects in the next section.

EFFECTS BASED ON EXAMPLE HOUSEHOLDS
While the previous section looked at the average effects across income deciles, this section illustrates the effects for concrete example households. The basic characteristics of the example households are summarised in Table 4. The selected sample households represent a broad spectrum of the German population. They include families, pensioners, single parents, singles and couples without children. Both rental households and

those that own and live in their homes are considered. Costs due to the CO_2 pricing differ for both groups, on the one hand due to the limitation of the cost pass-through to tenants, and on the other hand with regard to the decision rationale when installing a heat pump. For the latter, tenants are dependent on investment decisions by their landlords.

In the distributional analysis, we first consider the case in which the households remain with their previous heating energy source and - if available - previous car. In a next step, the impact of climate-friendly investments, such as a change of heating system or the purchase of a battery-electric car, is examined (the "adjustment effect").

Table 5 shows the effects for example households living for rent. The distinction between households that rent and households that are owner-occupiers is necessary because the limitation of the CO_2 costs pass through to tenants results in different effects. In the analysis, it is assumed that 50 % of the CO_2 costs can be passed through. In this analysis of example households, we focus on tenants and owner-occupiers, as the analysis of the detailed impacts of investment decisions on private landlords is beyond the scope of this analysis. [4]

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4. Note that from a landlord's point of view, besides the pass-through rate of the CO_2 price to tenants, other parameters play a role in the cost/benefit consideration, which cannot be examined here. This applies, in particular, to the relationship between possible rent increases to recover renovation costs as well as individual expectations on the rate of return.

Example tenant households

For all example households, the net effect of the CO_2 pricing scheme with revenue used to reduce electricity costs results in (small) additional costs if no reaction to the CO_2 price is considered and thus no investment or adjustment takes place. On average, the sample households are burdened with 0.2 % to 0.5 % of their net household income (marked in yellow in Table 5). One exception is the pensioner, for whom the reduction in electricity costs more than compensates for the additional heating costs.

In a next step, it is assumed that the households shown here (with the exception of the pensioner who lives without her own car) replace their petrol-driven car with a battery-electric car. Since it is assumed that this happens in the context of a planned new or used car purchase and that a fully electric car in 2025 is no more expensive than a car with a conventional engine, no additional investment costs arise. Furthermore, since the electricity costs for operating the battery electric car are less than half the fuel costs of the petrol car, the example households save costs through this adjustment reaction. For low-income house-

holds, these savings can amount to 2.9 % (family) or up to 4.5 % (single parent) of disposable income. Despite the higher mileage, the single household with high income only saves 1.2 % of disposable income, as the comparative income is significantly higher than for the other households.

To sum up, adjustment induced by CO_2 pricing leads to net savings. The avoided CO_2 costs, the reduced fuel costs and the revenue used for electricity cost reduction compensate for the additional costs for heating energy and lead to a significant relief for all sample households.

Example households living in their own apartment or house

Compared to households living in rented accommodation, the effects for homeowners (living in their own property) are somewhat more differentiated (Table 6). Without an adjustment reaction, the selected example households have additional expenses due to CO_2 pricing, since the CO_2 costs for fossil fuel-based heating and the conventionally fuelled car exceed the reduction of electricity costs. The larger the floor area (with the same efficiency) and the higher the mileage, the higher

Table 5. Impact of the reform in 2025 on sample households living for rent. 50/50 rule of CO_2 cost allocation for end-of-renters.

	Family with medium / low income		Pensioner with medium/low income	Single parents with medium / low income		Single with high income	
Living space	110 m²		55 m²	75 m²		75 m²	
Heating energy source	Natural gas		Natural gas	Natural gas		Natural gas	
Type of car	Petrol	E-car		Petrol	E-car	Petrol	E-car
Expenditure / savings due CO_2 pricing and electricity price reduction							
CO_2 costs (EUR)	364	131	65	245	89	340	107
Reduction in electricity costs (EUR)	-269	-269	-118	-177	-177	-157	-157
Adjustment effect							
Fossil fuel savings (without CO_2 price, EUR)	-1 509			-1 006		-1 509	
Additional electricity costs after adjustment (EUR)	621			414		621	
Net effect of CO_2 pricing and electricity cost reduction							
	before adjustment	after adjustment	no adjustment	before adjustment	after adjustment	before adjustment	after adjustment
Delta expenditure (EUR)	95	-1.026	-53	68	-680	183	-938
Medium net income (EUR)	60 000		20 000	30 000		80 000	
In % net income	0.2%	-1.7%	-0.3%	0.2%	-2.3%	0.2%	-1.2%
Low net income (EUR)	35.000		10.000	15.000			
In % net income	0.3%	-2.9%	-0.5%	0.5%	-4.5%		

Source: Öko-Institut calculations based on FDZ of the statistical offices of the Federation and the Länder, sample survey of income and consumption 2018 and own assumptions; figures are in EUR (real 2019).

the CO_2 costs. For middle- and high-income households, the additional costs in our example represent less than 1 % of net disposable income. For a low-income family with oil heating and two cars, on the other hand, the burden is equal to 1.6 % of disposable income.

Similar to tenant, owner-occupiers generally benefit from adjustments by installing a heat pump and switching to a battery-electric car. The purchase of a battery electric car instead of a fossil-fuel car results in additional savings. The low-income example family that installs a heat pump in their house and replaces one combustion-engine car with a battery-electric one saves 2.8 % of its net disposable income.

Looking at the example family with oil heating, it becomes clear how the adjustment reactions interact. By installing a heat pump alone, the additional expenditure decreases very slightly from 568 Euros per year to 566 Euros per year (cf. line "delta expenditure" in Table 6). This means that although the installation of the heat pump does not cause any additional expenditure, in 2025 it is not yet sufficient to offset the CO_2 induced costs (even when including the reduction of electricity costs). This only happens through the purchase of a battery-electric

car (instead of a conventionally powered car). This also applies to the other two example households, for which the effect of installing a heat pump is not shown separately.

This finding is due to the fact that the example calculation only shows the effect in one year. In the following years, the heat pump would increasingly save expenditure on fossil fuels, as the price for gas and heating oil (even independent of CO_2 pricing) continue to rise. This results in significant savings over the lifetime of the heat pump (cf. Öko-Institut 2021).

Overall, it should be noted that there may be constellations in which targeted investment support for investments in climate friendly technology (especially switching to heat pumps) is necessary to avoid high relative burdens.

Conclusions and recommendations

Our analysis shows that CO_2 pricing in Germany in combination with revenue use for reducing electricity costs has a clearly positive distributional effects at the level of households. Households with lower incomes benefit from the abolition of the renewable surcharge, even if the costs incurred from CO_2 pricing

Table 6. Impact of the reform on sample households living in property, 2025.

	Family with medium / low income		Family with medium / low income			Couple without children with high income	
Living space	110 sqm		110 sqm			150 sqm	
Heating energy source	Gas	Heat pump	Heating oil	Heat pump	Heat pump	Gas	
Type of car	Petrol	E-car	Petrol / Diesel	Petrol / Diesel	Petrol / E-car	Petrol / Diesel	Petrol / E-car
Expenditure / savings due to the reform							
CO_2 costs	495		817	470	233	984	233
Relief from electricity costs	-269	-269	-249	-249	-249	-256	-256
Adjustment effect							
Annuity investment heat pump	426		426		426	581	
Fossil fuel savings (without CO_2 price, EUR)	-2 568		-890		-2 094	-3 451	
Additional electricity costs after adjustment	1 430		809		1 430	2 139	
Net effect of CO_2 pricing and electricity cost reduction							
	before adjustment	after adjustment	before adjustment	after adjustment	after adjustment	before adjustment	after adjustment
Delta expenditure	226	-981	568	566	-254	728	-755
Medium net income	60.000		60.000			110.000	
In % Net income	0.4%	-1.6%	0.9%	0.9%	-0.4%	0.7%	-0.7%
Low net income	35.000		35.000				
In % Net income	0.6%	-2.8%	1.6%	1.6%	-0.7%		

Source: Öko-Institut calculations based on FDZ of the statistical offices of the Federation and the Länder, sample survey of income and consumption 2018 and own assumptions; figures are in EUR (real 2019).

are taken into account. Although high-income households also benefit from an abolition of the renewable electricity surcharge, the costs incurred from CO_2 pricing cannot be completely offset by savings due to the reduced electricity price. However, these incremental costs under the CO_2 pricing scheme would be completely offset if those households took adjustment measures to install upgrades to more efficient, zero-carbon energy solutions for heating and mobility.

In the context of this investigation of economic impact, one third of all households would benefit significantly from the CO_2 pricing and revenue allocation scheme as analyzed. In 2025, households in the first income decile would save an average of 44 Euros per person per year, while households in the second income decile would save 16 Euros per person per year. A comparison of the variants for redistribution via, on the one hand, a reduction in electricity costs and, on the other hand, via direct per capita repayments of the corresponding revenue volume yields very similar effects, such that both variants are to be regarded as equally progressive. Taking into account the practical implementation as well as the transaction costs, this results in a favourable assessment for the electricity price reduction as a redistribution mechanism, which can be implemented momentarily. Limiting the pass-through of CO_2 cost from landlords to tenants both reduces the burden on tenants and increases incentives for landlords to invest in energy-efficient refurbishments. Complementary measures, such as the federal subsidy for efficient buildings, offer corresponding investment incentives.

Looking at concrete example households gives an impression of the spectrum of possible effects. Households that live in rented accommodation can benefit significantly from CO_2 pricing and revenue redistribution. The exact effect depends on the number of household members and the respective mileage of an existing fossil car, as well as on whether adaptation measures are implemented, e.g. a fully electric car is purchased. For example, a single-parent household with a low income living in rented accommodation can save 4.5 % of its net income by purchasing an all-electric car as a response to CO_2 pricing. Even without adjustment measures, the pensioner without a vehicle already experiences a positive net effect from CO_2 pricing with revenue redistribution.

For owner-occupiers with fossil-fuel heating systems who drive one or more petrol or diesel cars, adjustment measures are important to reduce expenditure. An investment in a heat pump and in an all-electric vehicle leads to a significant relief for all example households considered (middle- and low-income family, couple without children). Support programmes are of great importance for overcoming the barriers related to initial investments (e.g. for heat pumps). For low-income households, they should be supplemented by hardship schemes if necessary.

The focus of the distribution analysis is on the year 2025. Along with CO_2 prices, revenues are expected to continue to rise after 2025 even with declining CO_2 emissions (see Matthes et al. 2021), such that additional redistribution measures can be implemented for a socially balanced design. The economic efficiency of abatement measures also improves significantly with rising CO_2 prices. The efficiency of investments in heat pumps, for example, increases for two reasons: First, due to the abolition of the renewable surcharge electricity prices and operating costs for the heat pump decrease. Second, costs for fossil fuels increase due to CO_2 pricing.

A clear roadmap for CO_2 pricing and the corresponding redistribution strategy is of great importance for a socially balanced design of the overall scheme. Only if households receive timely and reliable signals for cost developments can investment decisions in adjustment measures be made at the right time, subsidies be claimed and thus positive effects for households be achieved not only in 2025 but especially in subsequent years. Ambitious CO_2 pricing in combination with a redistribution of revenues via the reduction of electricity costs gives clear signals that are indispensable for ambitious climate goals in the German and European context.

It is now to be seen how the EU proposal for an emission trading scheme for building and road transport will play out and whether the German scheme will merge into the EU scheme or coexist. Based on the EU proposal, revenues could potentially still be used to reduce the renewable energy surcharge in Germany. Funding received through the Social Climate Fund would be complementary, focus on vulnerable households and energy efficiency measures in their homes. This will be important to protect vulnerable consumers from additional burden and energy poverty. Lessons learned on distributional impacts and adjustment actions from our study of the German can inform the ongoing discussions at EU-level.

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