Heating Up Inequality?

Socio-spatial impacts of ETS2 on European housing and cohesion

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Bertelsmann Stiftung
Carl-Bertelsmann-Straße 256
33111 Gütersloh
Germany

Dr. Thomas Schwab
Senior Expert European Economics
Phone +49 (30) 27 57 88-132
thomas.schwab@bertelsmann-stiftung.de

Sara Hagemann
Project Manager
Phone +49 (5241) 81-81143
sara.hagemann@bertelsmann-stiftung.de

bertelsmann-stiftung.de

Contributions:

- Bertelsmann Stiftung: Sabine Feige, Jeanne Froissart, Sven Hellbusch
- Forschungszentrum Jülich: Tabassum Tazin, Ghazi Allagui

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Thomas Schwab (Bertelsmann Stiftung)
Sara Hagemann (Bertelsmann Stiftung)
Johannes Többen (Forschungszentrum Jülich)
Imke Rhoden (Forschungszentrum Jülich)
Sandra Venghaus (Forschungszentrum Jülich)
Jochen Linßen (Forschungszentrum Jülich)

Abstract

ETS2 will introduce uniform EU-wide carbon pricing for heating, affecting about half of all households across the Union. Using a synthetic EU population of 188 million households, this study shows that most can absorb the additional costs, but a significant minority faces high burdens—especially in Eastern and Southern Europe. ETS2 revenues can cushion these impacts but are insufficient to fund large-scale heating system replacements. Targeted support and complementary investment policies are essential for a fair and effective transition.

JEL-Codes: Q52, Q48, H23, D31, R28

Contents

1 Introduction

Climate change is increasingly visible across Europe and globally. In response, the European Union has committed to achieving climate neutrality by 2050. Meeting this objective requires rapid and far-reaching decarbonisation efforts across all sectors of the economy and daily life. Residential space heating plays a central role in this transformation, as it accounts for roughly half of the EU's final energy consumption (European Environment Agency, 2024) and one-third of energy-related carbon emissions (European Environment Agency, 2025a). Yet despite this significance, emissions from residential buildings have long received less political and analytical attention than other sectors.

Decarbonising the housing sector poses distinct challenges for policymakers and citizens alike. It requires substantial investment in energy-efficient buildings and the replacement of fossil-fuel heating systems. At the same time, building characteristics, climate conditions and income levels vary widely across Europe, resulting in large differences in households' abilities to undertake such investments. Southern European households, for instance, face lower heating needs but often rely heavily on gas, while Scandinavian households experience high heating demand but have already transitioned largely to fossil-free systems. These disparities shape both the distributional consequences of climate policy and its political feasibility.

Against this backdrop, the EU has agreed to extend carbon pricing, its key climate policy instrument, to emissions from buildings and road transport under a new emissions trading system, Emissions Trading System 2 (ETS2). By putting a market-based carbon price on fossil-fuel heating from gas, oil and coal, ETS2 seeks to internalise environmental costs, shift relative prices and accelerate the move towards climate-neutral heating. In nine member states, ETS2 will replace existing national pricing mechanisms for buildings. In the remaining 18, it will introduce carbon pricing for the first time.

The political debate surrounding ETS2 is highly sensitive, especially in the housing sector. Once it takes effect, ETS2 will affect 103 of Europe's 188 million households that rely on fossil fuels for space heating. Concerns about affordability and the potential overburdening of households have already contributed to the European Council and European Parliament postponing the system's initial start date from 2027 to 2028. At the same time, knowledge gaps in politics and population as well as unsubstantiated claims by critics across the EU continue to fuel doubts about the distributive effects and political feasibility of ETS2, particularly regarding the carbon price level that households can bear. Because the ETS2 price will be market-determined, is expected to fluctuate and is intended to rise over time, understanding household-level impacts is essential for an evidence-based debate.

This study provides new and unprecedented evidence on the expected distributional effects of ETS2 in the residential heating sector for two illustrative price levels: 60 EUR/t CO_2, which is likely to approximate the price at ETS2 introduction given current expectations, and 180 EUR/t CO_2, which may represent a long-run price level but is currently unlikely. The exact carbon price remains uncertain because it is determined by supply and demand for emission allowances.

While a uniform EU-wide carbon price offers advantages such as cost efficiency and policy harmonisation, it also has an inherent drawback. It does not account for Europe's diverse spatial, socio-economic and housing realities. Differences in building stock, heating demand, income levels and living costs mean the same price signal translates into very different effective burdens for households across member states. Since past decarbonisation efforts also vary across the EU, ETS2 places relatively greater pressure on households in member states that have made less progress in reducing emissions from residential heating.

To close knowledge gaps on the differences in impacts, we develop a highly granular assessment of household-level impacts of ETS2 across Europe. Using a synthetic population that models all 188 million EU households, we trace how specific household characteristics interact with price increases. The model integrates demographic variables such as age, sex and employment status, building attributes such as floor space, heating type and construction period and economic factors such as disposable income and household-specific price elasticities. By combining high-quality administrative data sources with survey-based microdata to bridge information gaps, we map households' exposure in 1,160 NUTS-3 regions to carbon pricing under ETS2. This level of granularity allows us to identify precisely which households are most affected, where they live and how strongly their financial burden increases, information that is essential for designing equitable redistribution of ETS2 revenues and effective mitigation measures.

Our results show that the vast majority of households can absorb the additional heating costs induced by ETS2, both at a moderate price level of 60 EUR/t CO_2 and a hypothetical long-run price level of 180 EUR/t CO_2. On average, households with fossil-fuel heating systems face annual costs of about 60 EUR per year at an ETS2 price level of 60 EUR/t CO_2 and around 285 EUR at 180 EUR/t CO_2. However, averages mask large disparities. These are already visible at a carbon price of 60 EUR/t CO_2. In Germany and France, where comparable carbon prices already exist, households experience virtually no change. In Sweden and Denmark, where current national carbon prices exceed 60 EUR/t CO_2, ETS2 may even reduce heating costs. In Poland, where no carbon pricing exists, ETS2 increases consumer prices by about 17% for gas, 19% for heating oil and 42% for coal. A typical coal-heated Polish household would face an increase in heating costs of roughly 500 EUR per year. Assessing whether such cost increases are excessive or manageable requires more information such as disposable income, heating expenditures, building characteristics and behavioural responses to rising prices.

Some households face substantially higher costs far above these EU-means. For the 10% most affected households, a group of roughly 10 million households across Europe, average additional heating costs are about three times higher in absolute terms and as a share of income. These households are characterised not only by lower disposable incomes but also by housing and demographic features that constrain their ability to adapt. They are more likely to live in single- or two-family homes, have larger household sizes and include more elderly and female members. They already spend a comparatively high share of their income on heating, meaning even moderate price increases further strain their budgets. Such households are primarily located in eastern member states such as Poland, Hungary or Slovakia, but also in parts of Spain, Italy or Greece.

Designed as the twin policy to ETS2, the Social Climate Fund aims to safeguard social equity while preserving the efficiency of carbon pricing. Its objective is to channel ETS2 revenues, up to 87 billion EUR between 2026 and 2032, to households most affected to support investments in clean technologies and prevent fossil lock-ins. Our analysis shows that at a moderate ETS2 price level of 60 EUR/t CO_2, the pre-allocated ETS2 revenues, including the Social Climate Fund and the national ETS2 revenues accruing to member states, are sufficient to cushion the additional financial burden of ETS2 on heating for the most vulnerable households, despite uncertainty about needed funding in the transport sector, which is beyond the scope of this study. In only a handful of member states, Social Climate Fund resources alone may not be sufficient to compensate the additional burdens from ETS2 on heating and potential transport-sector costs.

The central policy challenge is the design and implementation of targeted support measures. Well-designed policies to avoid unmanageable burdens and to support investment in clean technologies will be crucial. The Social Climate Plans are an essential element of this, especially to ensure that vulnerable households are enabled to exit fossil-fuel heating and that ETS2 ultimately maintains public support and political backing (see also Jüngling et al., 2025). The European Commission should ensure that the Social Climate Fund resources are used as intended to support vulnerable households. In addition, alignment between spendings financed by the Social Climate Fund and national ETS2 revenues is essential to avoid inefficient or contradictory policy mixes. Social Climate Plans also offer an underused opportunity for cross-country learning in policy design, which should be actively promoted.

Our analysis provides detailed evidence on which households in each EU member state require the greatest financial support to cope with rising fossil energy prices. Member states should now establish the necessary institutional infrastructure to identify and reach eligible households. This requires timely investments in data systems, administrative capacity and effective delivery mechanisms.

At the same time, ETS2 revenues alone will not be sufficient to finance the large-scale investments required for climate-neutral heating across the EU. Replacing fossil-fuel heating systems typically requires tens of thousands of euros per household, sums beyond the reach of many households, including but not limited to those most affected by carbon pricing. Rising heating costs can further entrench fossil lock-ins by reducing a household's ability to invest. This underlines the need for additional public funds to accelerate the replacement of heating systems in the residential sector. Member states should therefore complement their revenues from ETS2 with additional funding to provide complementary measures, including grants, concessional loans, and guarantees to unlock investment at scale. Cohesion policy, with housing as a renewed priority, could also provide much-needed funding.

Early investment in replacing fossil heating systems not only protects vulnerable households but also yields systemwide benefits for ETS2 by accelerating the transition. Every household that exits fossil-fuel heating earlier reduces not only long-term exposure to carbon prices but also alleviates upward pressure on ETS2 prices.

By providing new and highly granular evidence on the socio-economic and geographic dimensions of vulnerability to rising energy prices, this study advances the policy debate on ETS2. While previous studies have examined ETS2 impacts, mostly for single EU member states (see Antosiewicz et al., 2025; Noka et al., 2025b; Perdana and Vielle, 2026), our approach offers substantially greater granularity, allowing for the precise identification of most affected households. In doing so, we move beyond aggregate indicators for vulnerability and energy poverty such as the widely used 2M measure or the self-reported inability to keep the home adequately warm (see, for example, Maier and Dreoni, 2024; Noka et al., 2025a; Schumacher et al., 2025). Instead, we identify vulnerability directly at the household level by looking at the actual effects of carbon pricing on heating cost burdens.

The remainder of this study is structured as follows. Section 2 provides an overview of the policy background for decarbonising the European housing sector. Section 3 outlines how we model 188 million EU households as a synthetic population. Section 4 examines the socio-spatial characteristics of EU households, focusing on differing starting points in reducing emissions from residential heating. Section 5 presents the distributional impact assessment of ETS2. Section 6 analyses whether available ETS2 revenues are sufficient for compensation and investment support. Section 7 concludes with key findings and policy recommendations.

2 Decarbonising the European housing sector

2.1 Buildings: Second-largest sector without carbon pricing

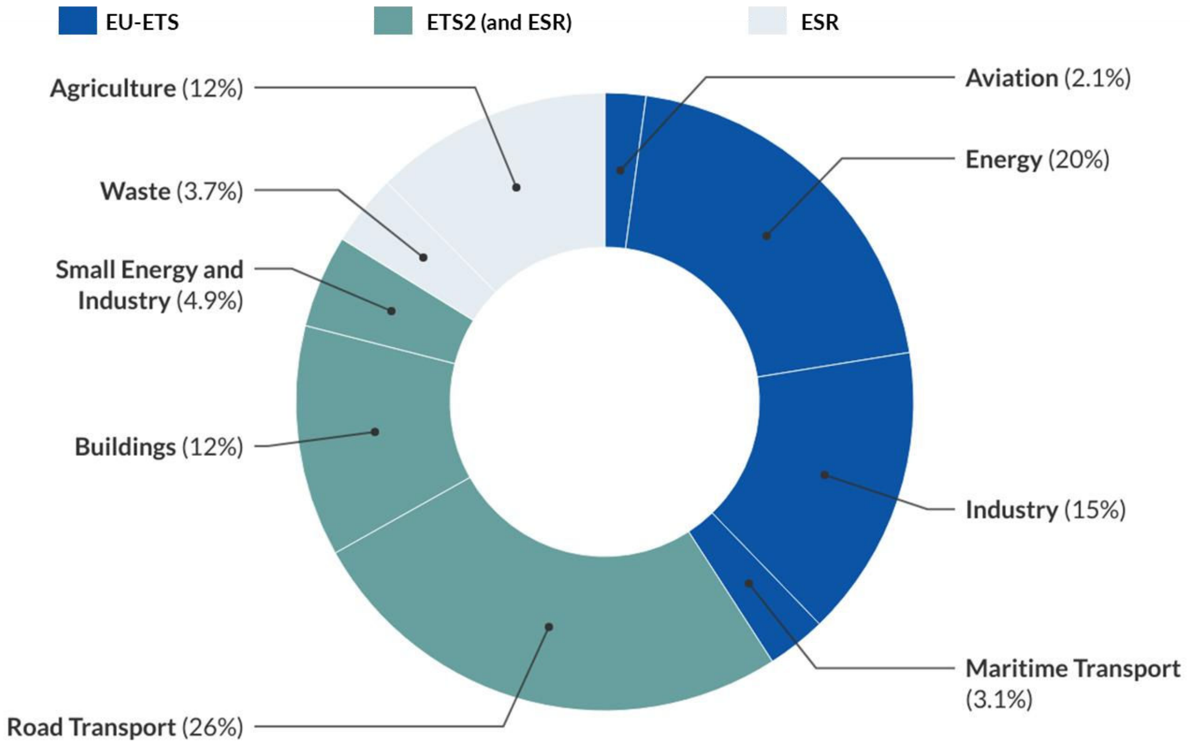
Since 2005, the European Union has applied carbon pricing under its emissions trading system (ETS) as its central climate policy instrument. Initially, the system covered emissions from large industrial facilities as well as electricity and heat generation. It later expanded to include aviation in 2012 and maritime transport in 2024.

Emissions from the transport and housing sectors are, however, still not subject to EU-wide carbon pricing under the system. Together with agriculture, waste and small industries, the two sectors are covered under the Effort Sharing Regulation (ESR), which sets binding national greenhouse gas reduction targets for each EU member state to be achieved by 2030. To date, the emission reductions delivered under this framework have been insufficient to place the EU on a credible pathway toward climate neutrality by 2050.

In 2024, total EU greenhouse gas emissions stood at 2,900 million metric tonnes of CO_2 equivalents (CO_2e), a metric that enables comparisons across different greenhouse gases by expressing their global warming impacts in terms of the equivalent amount of carbon dioxide.

The buildings sector plays a particularly significant role as one of the largest sources of carbon emissions in the EU. In 2024, buildings were responsible for about 351 million metric tonnes of CO_2e. This represents roughly 12% of all greenhouse gas emissions in the EU and makes buildings the second-largest sector not yet covered by carbon pricing (see Figure 1). Most of these emissions result from the direct combustion of fossil fuels such as natural gas, oil and coal used for heating and hot water in residential buildings, with a smaller share coming from commercial and institutional buildings. Housing and climate-neutral heating affects every European citizen directly and involves high adjustment costs for investments in fossil-free heating technologies, making this sector a key target for decarbonisation policies and the expansion of carbon pricing mechanisms.

Figure 1: Buildings are the second-largest source of EU carbon emissions not yet covered by carbon pricing



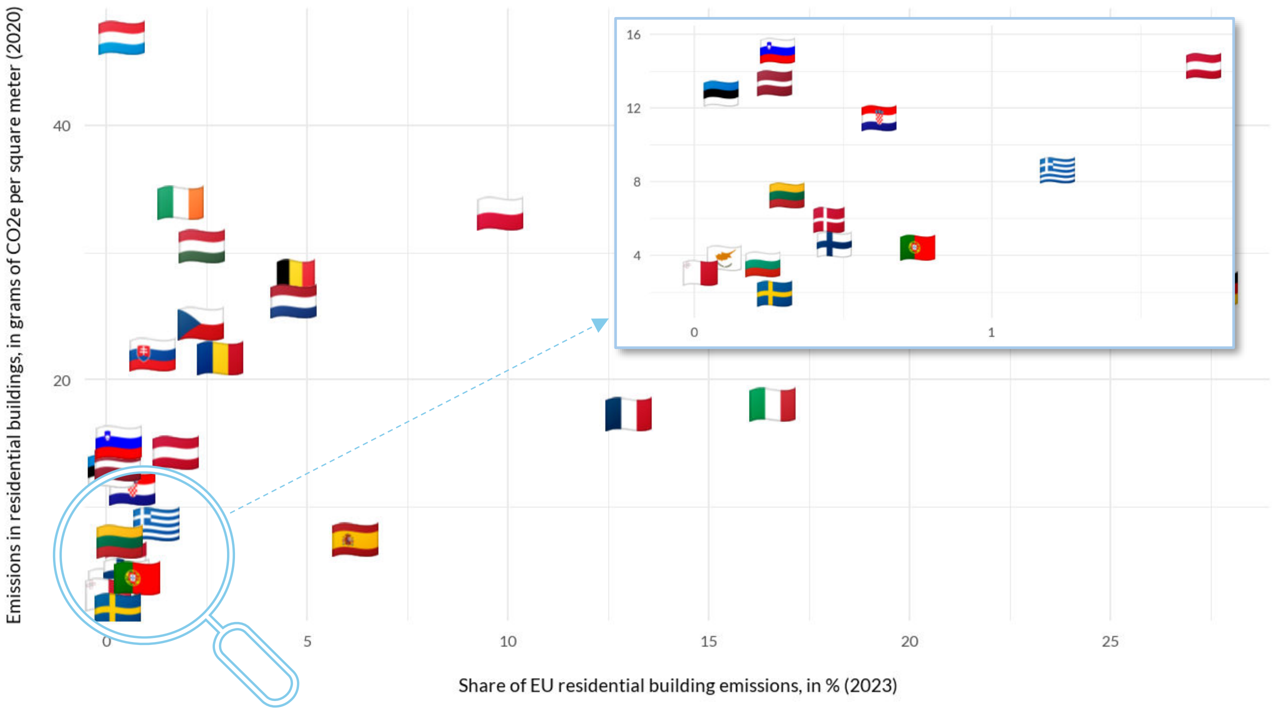
Notes: Greenhouse gas emissions for the year 2024 by category under the EU climate architecture. Total emissions of 2,900 million metric tonnes of CO_2e. Source: European Environment Agency (EEA 2025a and European Environment Agency (EEA 2025b).

The emissions from residential buildings are distributed very unevenly across the EU (see Figure 2), The four largest emitters, Germany, Italy, France and Poland, are responsible for about two-thirds of total EU residential emissions. Achieving carbon neutrality will therefore depend critically on substantial emission reductions in these four member states.

Carbon intensity in the residential building stock, measured as emissions per square metre of living space, also varies widely across the EU (see Figure 2). Luxembourg's building stock is by far the most carbon-intensive, followed by Ireland and Poland, each with an average of 33 grams of CO_2e per residential square metre. In Poland, this high intensity reflects the prevalence of coal-fired heating systems and unrenovated buildings. In Luxembourg and Ireland, it may be linked primarily to higher per capita income and corresponding energy use.

On average, EU residential buildings emit 18 grams of CO_2 equivalents per square metre. Germany shows above-average intensity of about 27 grams per square metre, while France and Italy despite their large total emissions, are close to the EU average. With some exceptions, Southern European and Scandinavian member states display significantly lower emission intensities. In Southern Europe, this pattern reflects lower heating needs due to milder climates. Scandinavian countries benefit from past policy efforts that promoted high energy efficiency in buildings and limited reliance on fossil fuels for heating (see Sections 2.3 and 4.1).

Figure 2: Germany, Italy, France and Poland account for two-thirds of total residential emissions. Luxembourg has the most emission-intensive residential building stock



Notes: National greenhouse gas emissions in residential buildings for the year 2020 in gram of CO_2e per square metre of living space (y-axis) and national share of total EU greenhouse gas emissions from residential buildings in percent for the year 2023 (x-axis). Sources: European Environment Agency (EEA), 2025 for residential building emissions by country and country shares of total EU residential emissions and Pezzutto et al., 2024 for residential living space per square metre.

2.2 Economic and political hurdles to decarbonize housing

Several interrelated factors make decarbonising Europe's building stock particularly challenging. Economic barriers are paramount. High upfront costs for renovations and heating system replacements are coupled with long payback periods, discouraging households from investing. Many consumers also focus on short-term costs and give less weight to long-run energy savings. Moreover, in many member states, fossil fuels remain significantly cheaper compared to electricity. Gas and oil prices often fail to reflect carbon costs, while electricity remains relatively overtaxed (Keliauskaitė et al., 2024), making heat pumps economically unattractive.

Financial constraints further hinder the shift away from fossil-fuel heating. High investment costs are beyond the reach of many households without debt financing. Low-income homeowners often lack access to credit, and existing subsidy programmes are insufficient to bridge the investment gap. The rental housing market also faces a split-incentive problem. Landlords bear renovation costs, but tenants benefit from lower energy bills, leading to chronic underinvestment (Melvin, 2018). Non-monetary barriers such as information deficits, administrative complexity and the inconvenience of construction work further slow progress in both owner-occupied and rented properties. In addition, housing costs have risen considerably over the past 10 years (European Parliament, 2025).

Decarbonising buildings is not only an economic challenge but also a politically sensitive issue. Carbon pricing under the forthcoming ETS2 is expected to generate stronger distributional effects in the heating sector than in transport (Endres, 2023). Rising heating costs tend to be more regressive than fuel price increases because household energy needs are less flexible and less dependent on income. Given the wide disparities in energy affordability across the EU, decarbonising the building sector risks exacerbating social and regional inequalities if not carefully managed.

2.3 Initiatives to decarbonize housing have so far fallen short

The EU building stock varies widely in its dependence on fossil fuels and in age. Most national heating regulations were introduced after the first oil crisis in 1973. France adopted its first thermal insulation standards in 1974, Sweden in 1975 and Germany in 1977. Others followed later, such as Portugal in 1990 and Ireland in 1991. EU-level harmonisation began only in 2002 with the Energy Performance of Buildings Directive (EPBD). As a result, buildings constructed before 1970 tend to be highly energy-inefficient and particularly costly to renovate.

Progress toward decarbonising domestic heating in the EU remains slow. Under the ESR, the EU aims to reduce greenhouse gas emissions in transport, buildings, small industry, agriculture and waste by 40% compared with 2005 levels by 2030. The regulation was first introduced in 2009 and updated in 2018 and 2023 to strengthen emission targets in line with the EU's enhanced 2030 climate ambition (European Parliament, 2023a). As a complementary climate governance system to the EU Emissions Trading System (ETS), it regulates the remaining 60% of EU emissions that are not yet subject to carbon pricing. Compared with the sectors under the EU ETS and with stated climate ambitions, emissions reductions in all ESR sectors have so far fallen short. One key reason is that the regulation relies on policy measures taken by individual member states, which often shy away from costly or unpopular interventions in these harder-to-abate sectors.

Collectively, member states are required to cut emissions by 40% compared with 2005 levels under the regulation. These reductions are distributed through national targets ranging from -10% to -50%, largely reflecting economic performance and cost-effectiveness. Wealthier member states such as Denmark, Germany or Luxembourg must achieve the most ambitious reductions, while economically weaker states such as Croatia, Romania or Bulgaria face lower targets.

Between 2005 and 2023, emissions from the EU buildings sector declined by 37%, but progress has been highly uneven. Some member states act as frontrunners, while others lag far behind. Reductions range from -72% in Sweden to just -4% in Lithuania (see Figure A.3 in the Appendix). Among the large member states that strongly influence the EU's overall decarbonisation trajectory, Poland, Italy and Germany show below-average reductions, while only France has managed to halve building-related emissions compared with 2005. In 10 member states, including Germany and the Benelux member states, more than 50% of the population still relies on fossil energy for heating, highlighting the slow pace of the heating transition.

Owing to historical developments and deliberate policy choices to centralise and decarbonise heat supply, district heating is widespread in the Scandinavian and Baltic states as well as in Austria, Czechia or Poland. While Scandinavian member states have largely decarbonised their district heating systems, others such as Poland and Czechia continue to rely heavily on fossil fuels, particularly coal, in their district heating mix (European Commission et al., 2022).

Achieving further emissions reductions in buildings will require the rapid rollout of climate-friendly heating technologies such as heat pumps and renewable-based district heating as well as extensive energy-efficiency renovations. These renovations involve improving thermal insulation or replacing fossil-fuel heating systems.

However, renovation rates remain far below what is needed. From 2016 to 2020, only 1% of the EU's residential building stock was renovated each year, mostly with minor efficiency improvements. Deep renovations, which bring buildings close to zero-emission standards, occurred in just 0.2% of residential buildings annually. As a result, about 75% of existing EU buildings remain energy inefficient today (European Scientific Advisory Board on Climate Change, 2024).

2.4 Pricing housing carbon emissions in ETS2

Rationale and scope of ETS2

Decarbonising Europe's housing sector poses acute political and economic challenges. Residential heating is emissions intensive, capital stocks turn over slowly and energy price increases directly affect households. To address these challenges while extending carbon pricing beyond large emitters, the European Union is introducing a second emissions trading system, ETS2.

As part of the Fit for 55 legislative package, the EU-Directive 2023/959, adopted in 2023, establishes the legal basis for ETS2 (European Parliament, 2023a). The directive must be transposed into national law by all 27 member states. However, implementation is still pending in most member states. Once operational, ETS2 will apply to fossil-fuel combustion in road transport, residential and commercial buildings and small industrial installations that are currently outside the scope of the existing EU ETS.

When fully implemented, ETS2 will cover about 60% of emissions that are not yet subject to EU-wide carbon pricing, making it one of the most consequential climate policy instruments introduced in the EU in recent years. It will also replace existing national carbon pricing schemes for residential building emissions in nine member states, Austria, Germany, France, Ireland, Luxembourg, Portugal and the Scandinavian member states.

Design features and emissions trajectory

ETS2 follows a cap-and-trade design with a fixed number of emission allowances issued each year. The cap, the maximum number of new allowances, is aligned with EU climate targets and is intended to deliver a 43% emissions reduction relative to 2005 levels by 2030 in the covered sectors. After ETS2 is introduced, the cap will decline annually, gradually tightening allowance supply.

According to current emission trajectories, no new allowances will be issued in the early 2040s, effectively defining a pathway toward climate neutrality in buildings and road transport (Graichen and Ludig, 2024). If emissions do not fall fast enough, the resulting scarcity of allowances will push up prices, reinforcing incentives to invest in efficiency improvements and climate-neutral heating systems.

Political sensitivity and price-stabilisation mechanisms

The legislation initially envisaged an ETS2 start date of Jan. 1, 2027. As this date approaches, concerns about price volatility and affordability have intensified. In particular, fears that sharp price increases for heating fuels and gasoline could provoke public backlash and undermine political support for climate policy culminated in a decision in November 2025 to postpone the introduction of ETS2 by one year.

The risk of sharp price increases at the start of ETS2 varies widely across the EU and was already addressed in the system's initial design. Member states without existing national carbon pricing schemes may experience abrupt price changes, while price effects are expected to be more muted in member states that already price carbon in buildings and transport (see Figure 3). To enhance market credibility, ETS2 includes several built-in price-stabilisation mechanisms (European Parliament, 2023a):

- **Frontloading of allowances:** In the first year of operation, auction volumes will be increased by 30% relative to the ETS2 cap to ensure sufficient initial supply. These frontloaded allowances will later be deducted from future auction volumes.
- **Market Stability Reserve:** If the number of allowances in circulation falls below a pre-defined threshold, up to 600 million additional allowances can be released from the reserve to stabilise prices.
- **Soft price cap:** If the ETS2 price exceeds 45 EUR/t CO_2 in 2020 prices, about 60 EUR in 2027, doubles within three months or triples within six, additional allowances are injected from the Market Stability Reserve. This mechanism can dampen short-term price spikes but does not impose a hard long-term ceiling on the price level of 60 EUR/t CO_2.

In October 2025, before the Council's decision to postpone ETS2, the European Commission proposed reforms to further strengthen price containment, including adjustments to the Market Stability Reserve and a revenue frontloading mechanism. If adopted, these reforms would substantially increase the volume of allowances available for short-term market intervention, reducing the risk of abrupt price surges.

Expected carbon price levels and risks of scarcity

Because of allowance frontloading, initial ETS2 prices are expected to be moderate, typically in the range of 50 to 75 EUR/t CO_2. Over the longer term, however, price developments are highly uncertain. By 2030, studies and market analysts project a wide range from 50 to 300 EUR/t CO_2 (see Appendix Section A.1.4).

The European Commission's impact assessment projects carbon prices of 48 to 80 euros in 2015 prices, corresponding to about 65 to 108 EUR in 2030 after adjusting for 2% annual inflation, depending on the scope and ambition of accompanying decarbonisation measures (European Commission, 2021).

After two years, the allowances frontloaded at the launch of ETS2 will be deducted from regular auction volumes. If emissions reductions lag and price-stabilisation mechanisms prove ineffective, this could create temporary scarcity and trigger sharp price increases. Further upward pressure may result from the fact that the cap reduction path was not adjusted when ETS2 was postponed.

Keeping the original reduction trajectory while delaying the policy instrument concentrates abatement pressure into a shorter period, pushing carbon prices higher over the medium to long term.

The role of complimentary policies

Over the medium to long term, complementary policies are the most effective and politically robust way to contain ETS2 prices. Technology subsidies, regulatory standards and infrastructure investments accelerate decarbonisation in buildings and transport, reducing demand for fossil fuels and, by extension, for ETS2 allowances.

Because emissions are unevenly distributed across the EU, the four highest-emitting member states – Germany, Italy, France and Poland – play a disproportionate role as price setters in the uniform ETS2 market. Early and ambitious action in these countries can materially reduce price pressure across the system.

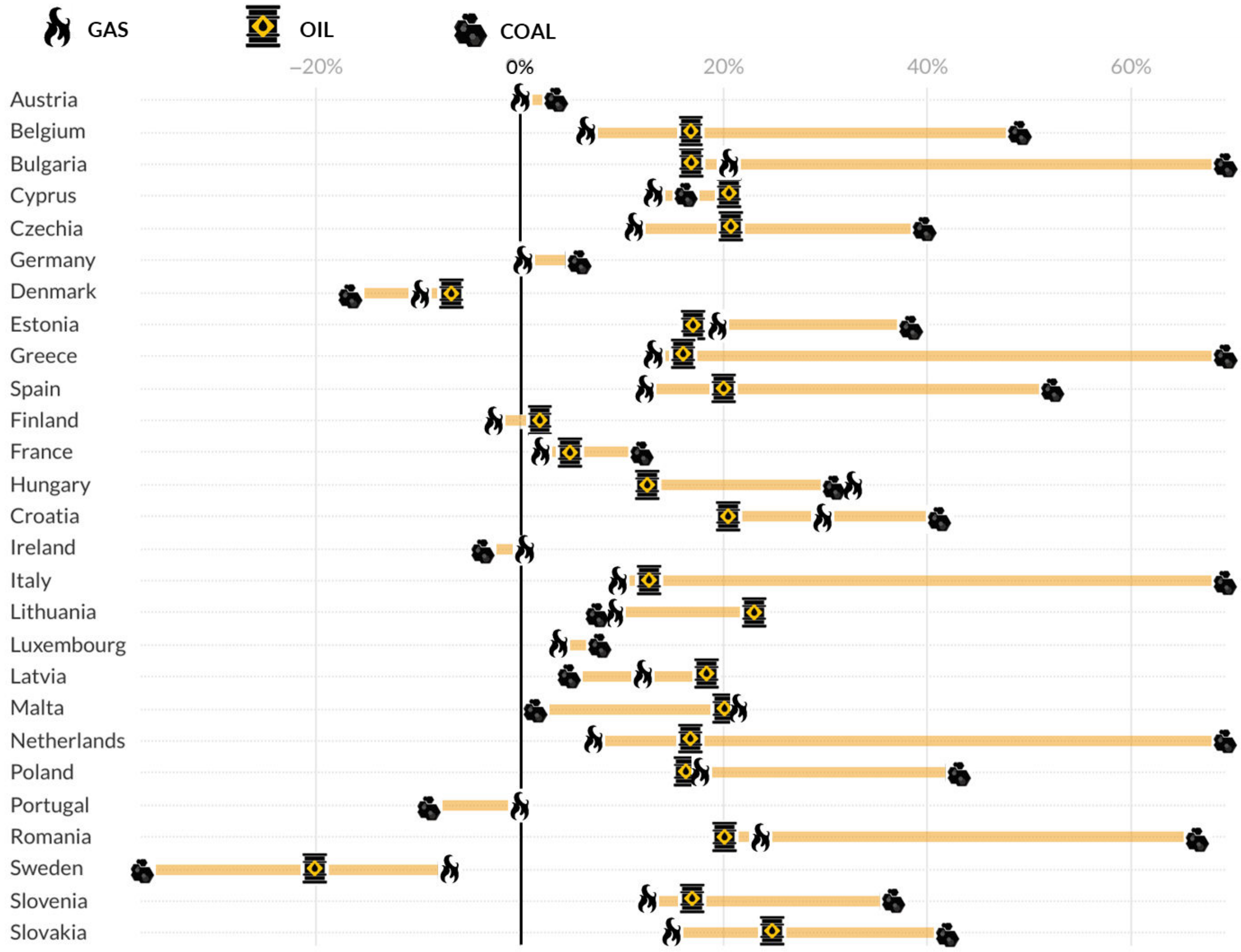
Complementary policies also reduce political risks. Without them, ETS2 would have to deliver the same emissions reductions on its own, resulting in higher prices. This would increase the likelihood of future political intervention and undermine confidence in carbon pricing as the EU's central climate policy instrument.

The earlier such measures are implemented, the more effective they are in keeping ETS2 prices in check. Recognizing this, the European Commission plans to make ETS2 revenues available before the system becomes operational. One option is revenue frontloading via the European Investment Bank, which would issue debt to finance early payouts and recover the funds later from auction revenues (EPICO Klimainnovation and Frontier Economics, 2025). This approach would expand short-term fiscal space for member states without increasing national debt. Early emissions reductions would help stabilise ETS2 prices once trading begins.

Effects on fossil energy prices and heating costs

Although ETS2 establishes a uniform carbon price, its impact on fossil energy costs varies widely across member states. Differences reflect national energy prices, existing taxes and levies applied on top of the carbon price and whether national pricing schemes are already in place. As a result, the effective price signal faced by households depends strongly on heating fuel type and member state (see Figure 3).

Figure 3: ETS2 introduction leads to highly diverse fossil price changes across the EU



Notes: Relative price changes for gas, oil and coal in the EU27 at a carbon price of 60 EUR/t CO_2. Further details are provided in Appendix Section A.1.5.4. Source: Authors' calculations based on statistical, tax and price data from Comtrade, 2025; European Commission, 2025a, 2025b; Eurostat, 2025a; Sustainable Energy Authority of Ireland, 2024.

At an ETS2 carbon price of 60 EUR/t CO_2, households in Sweden, Denmark, Ireland and Portugal could see a reduction in heating costs, assuming all other factors remain unchanged, because existing national carbon prices already exceed this level. In member states such as Austria, France or Germany, heating cost increases would be modest, typically below 5%, reflecting national carbon prices of about 50 EUR/t CO_2. By contrast, the largest impacts would occur in member states without national carbon pricing. In Poland, where nearly 20% of households still rely on coal for heating, coal prices could rise by about 42% compared with the status quo.

This pattern of divergent price effects persists at higher ETS2 carbon price levels. At a hypothetical 180 EUR/t CO_2, fossil-fuel prices are projected to increase between 13% for heating oil in Sweden and 100% for coal in Poland or natural gas in Hungary. Except for Sweden, Portugal and Denmark, all member states would see price hikes above 20% for their dominant heating fuel, underscoring the uneven distributional effects of ETS2.

2.5 How ETS revenues are distributed

Beyond putting a price on carbon emissions, ETS2 will generate substantial public revenue that is earmarked for financing complementary decarbonisation in heating and mobility. Revenue use is therefore central to both the effectiveness and social acceptance of ETS2.

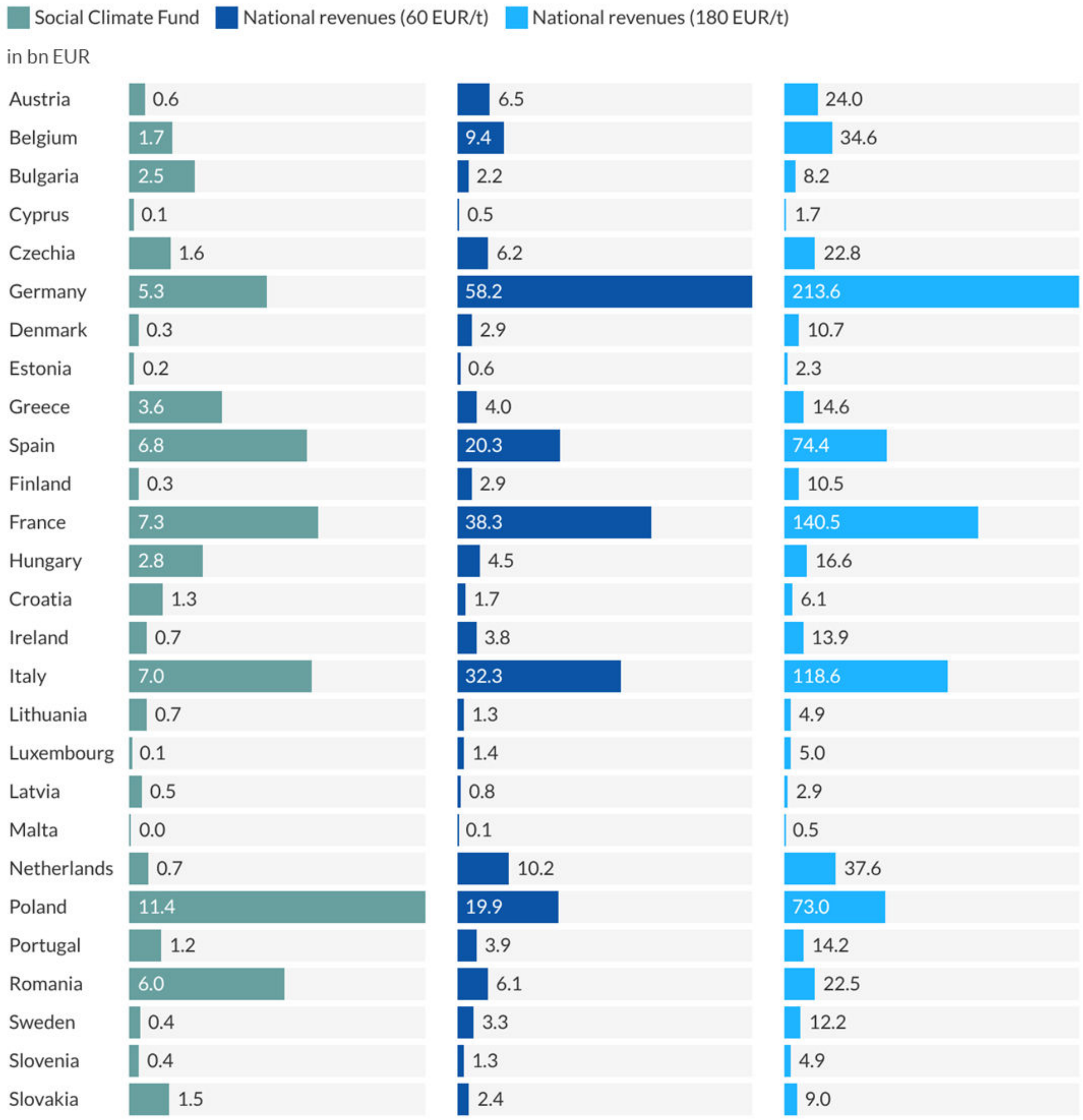
In institutional terms, ETS2 revenues are structured around two pillars:

- national revenues allocated directly to member states and
- the Social Climate Fund (SCF), which is designed to mitigate the uneven social impacts of carbon pricing across and within member states and support a just transition.

Most ETS2 revenues will flow to member states under the first pillar based on historical emissions in ETS2 sectors between 2016 and 2018. As a result, large and emissions-intensive countries receive the largest shares. Germany, the EU's largest emitter in ETS2 sectors, receives 23.7% of these funds. The total volume of national revenues depends on the ETS2 price level, with estimates ranging from 255 to 483 billion EUR for 2027 to 2032 (Jüngling et al., 2025). While use of these funds is not strictly earmarked, spending must demonstrably contribute to emissions reductions in ETS2-covered sectors, giving member states wide discretion in allocating resources.

Funds under the second pillar address the social impacts of ETS2 to ensure a just and inclusive transition (European Parliament, 2023b). Therefore, the Social Climate Fund aims to address the differentiated distributional effects of ETS2. To ensure solidarity between member states, it allocates a total of up to 65 billion EUR in auction revenues to member states between 2026 and 2032. The allocation follows a pre-defined mechanism by which more money goes to member states that have a higher proportion of households heavily affected by ETS2. In absolute terms, the largest beneficiaries of SCF funding are Poland, France, Italy, Spain and Romania (see Figure 4).

Figure 4: Larger member states benefit most from ETS2 revenues



Notes: Absolute allocation of ETS2 revenues to member states for 2026 to 2032. Source: Authors' calculations based on Graichen and Ludig, 2024; Agora Energiewende, 2023; European Parliament, 2023a.

Beyond solidarity between member states, the SCF also aims to ensure fairness within member states. Funds are earmarked to cushion carbon price impact on the most vulnerable households and small companies and to support their transition. All member states must submit Social Climate Plans detailing how they will spend their allocations and target vulnerable groups. These plans require approval by the European Commission before funds can be accessed. To address the roots of vulnerability and prevent fossil lock-ins, the plans should prioritise investment in climate-friendly alternatives. A maximum of 37.5% of total plan costs may be used for temporary direct income transfers.

In addition to the 65 billion EUR allocated to the SCF directly from auction revenues, each member state must co-finance its Social Climate Plan with at least 25% of total estimated costs (European Parliament, 2023b). In total, 87 billion EUR are earmarked for these measures during the first seven years of ETS2. Even so, in some member states these funds are likely to be insufficient to offset burdens on households in the lower income deciles (Jüngling et al., 2025). Because the SCF is capped at 65 billion EUR, it does not scale with rising carbon prices and may become less effective over time.

At present, it remains unclear how the one-year postponement of ETS2 decided in November 2025 will affect funding volumes and allocation rules. The directive states that if the system is delayed because of exceptionally high energy prices, the Social Climate Fund should be reduced to 54.6 billion EUR, or 76 billion EUR including national co-financing (European Parliament, 2023a). The November 2025 postponement does not meet this criterion, creating legal uncertainty over whether the fund should be cut by about 11 billion EUR. Resolving this issue is a key short-term challenge for the European Commission and will be critical for the credibility and social acceptance of ETS2.

3 A synthetic Europe: Modelling 188 million households

ETS2 will have far-reaching implications on European households that rely on fossil fuels, yet it remains unclear who will be affected, where and by how much. Persistent data gaps limit the precision of existing assessments. Although the spatial and social impacts of ETS2 have been widely studied (see, e.g., Perdana and Vielle, 2026), many analyses rely on household survey microdata that cover only small samples of the total population and therefore fail to capture important local and social differences.

This study overcomes these limitations by developing a synthetic population model for the EU. We construct an artificial population of about 200 million households whose characteristics closely mirror those of real households in every municipality. This provides a far more detailed and comprehensive data base than most existing studies. Our methodology builds on Többen et al. (2023), who generated a synthetic population of 38 million German households, and extends the method to all EU-27 member states.

The model combines household microdata from the EU Survey on Income and Living Conditions (SILC) and the Household Budget Survey (HBS) with population and housing counts from the 2021 Census, OECD local data and national statistics. Using statistical relationships between household characteristics, housing conditions, income and energy use, we simulate about 188 million households across roughly 100,000 municipalities. The synthetic population reflects the full EU population and captures regional differences in income, building stock, heating systems and climate conditions.

This synthetic population model approach offers three key advantages for analysing the spatial and distributional effects of ETS2:

1. It provides fine-grained spatial detail, reflecting regional variation in income levels, building stock, heating systems and local climate.
2. It ensures complete population coverage, enabling consistent identification of households most exposed to rising fossil energy prices and meaningful comparisons across countries, regions and social groups. This matters because many drivers of residential energy use are poorly represented in standard surveys.
3. It allows for differentiated behavioural responses by capturing differences in households' ability to cope with higher heating costs and their varying elasticities in reducing energy use.

On this basis, we simulate ETS2 by translating alternative carbon price scenarios into country- and fuel-specific price shocks that account for existing national carbon prices, energy taxes and markups. We then map these price changes onto the synthetic population to estimate household-specific impacts and behavioural responses, expressed as changes in energy spending and related emissions.

A detailed account of the data sources, modelling steps, assumptions and limitations is provided in the Appendix (Section A.2).

4 Substantial socio-spatial disparities in heating across the EU

Our synthetic population of about 188 million EU households reveals large regional differences in building characteristics, reliance on fossil-fuel heating systems and households' capacity to absorb higher energy prices. These disparities show that the effects of a uniform ETS2 carbon price will vary widely across Europe, both between and within member states.

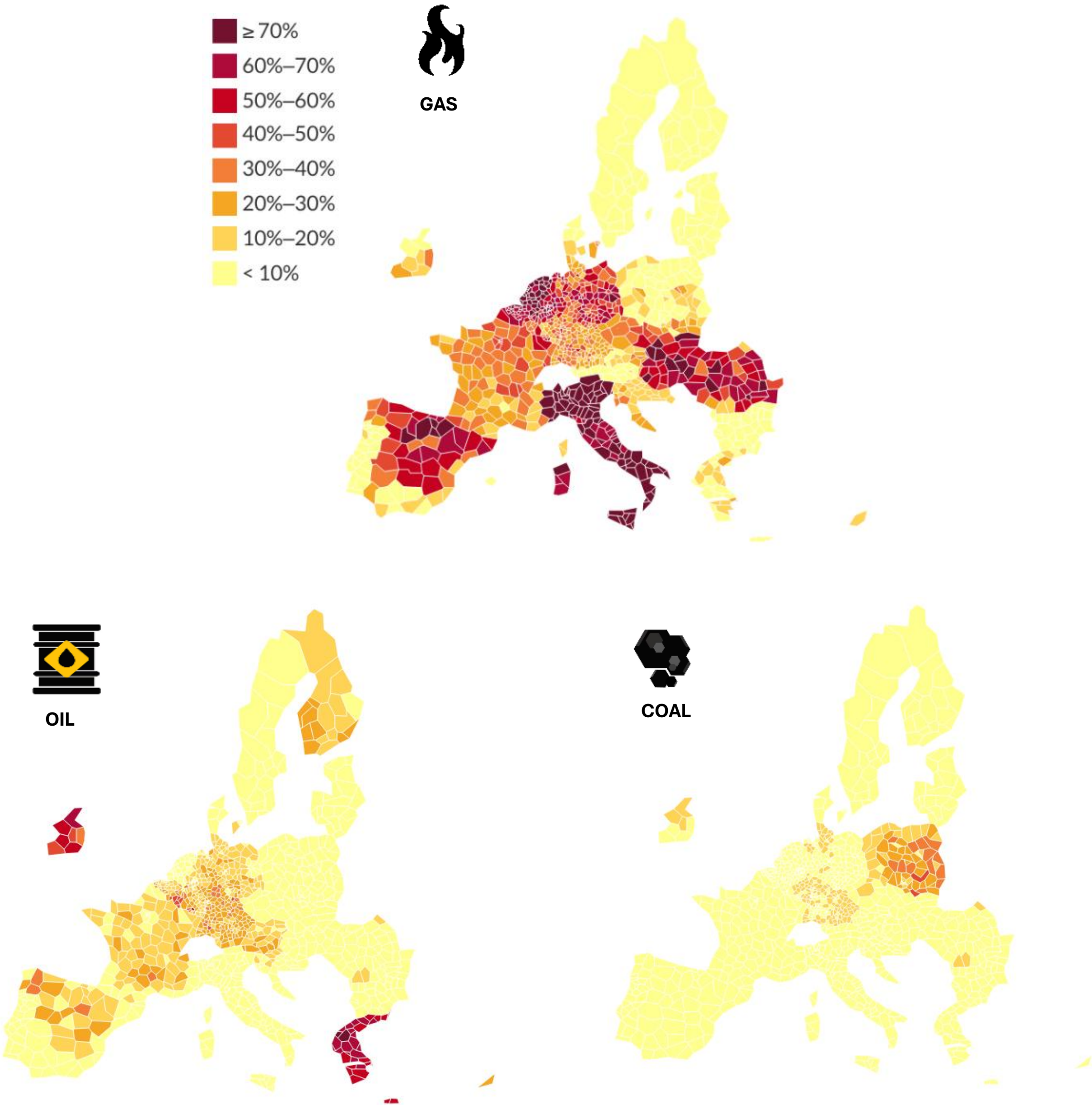
4.1 Heating remains largely fossil-fuel based

Fossil fuels remain the dominant source of heating energy in the EU. About 55% of households, roughly 103 million in total, rely on gas, oil or coal. As Figure 5 shows, the type and importance of these fuels differ sharply across regions and countries:

- Natural gas dominates in Italy, Germany, the Benelux countries, Spain, Slovakia, Hungary and Romania, where in many regions more than half of households use it for heating.
- Heating oil plays a major role in Greece and Ireland, with shares exceeding 60% of households. In parts of Belgium and Germany, more than one-third of households still rely on oil.
- Coal is rare in most of the EU, with one major exception. In central and eastern Poland, more than one-third of households still use coal for heating. Smaller pockets of coal use remain in parts of Czechia, Germany and Northern Ireland.

By contrast, member states such as Bulgaria, Portugal and the Nordic and Baltic states show low fossil-fuel shares, ranging from close to 0% in Sweden to just under 20% in Denmark. In these countries, renewable energy, electricity or district heating dominate the energy mix. While the latter two can be fossil-based, they fall under the EU ETS rather than ETS2.

Figure 5: High fossil-fuel heating use across the EU, with gas as the dominant energy source



Notes: Share of households using gas, oil or coal for heating relative to all households by NUTS-3 region. Source: Authors' calculations based on synthetic population.

Despite these strong regional differences across the EU, fossil-fuel heating is distributed evenly across income groups (see Figure 6). Across all national income deciles, the share of households using gas is 43% to 44%, oil 8% to 9% and coal 2% to 3%. The impact of ETS2 on heating is therefore highly regionally differentiated but largely uniform across income levels in terms of the number of affected households.

Figure 6: Fossil-fuel heating is evenly distributed across national income deciles

Notes: Income deciles are calculated at the member state level to avoid distortions from cross-country income differences.
Source: Authors' calculations based on synthetic population.

4.2 Eastern and northern regions already face highest heating expenditures

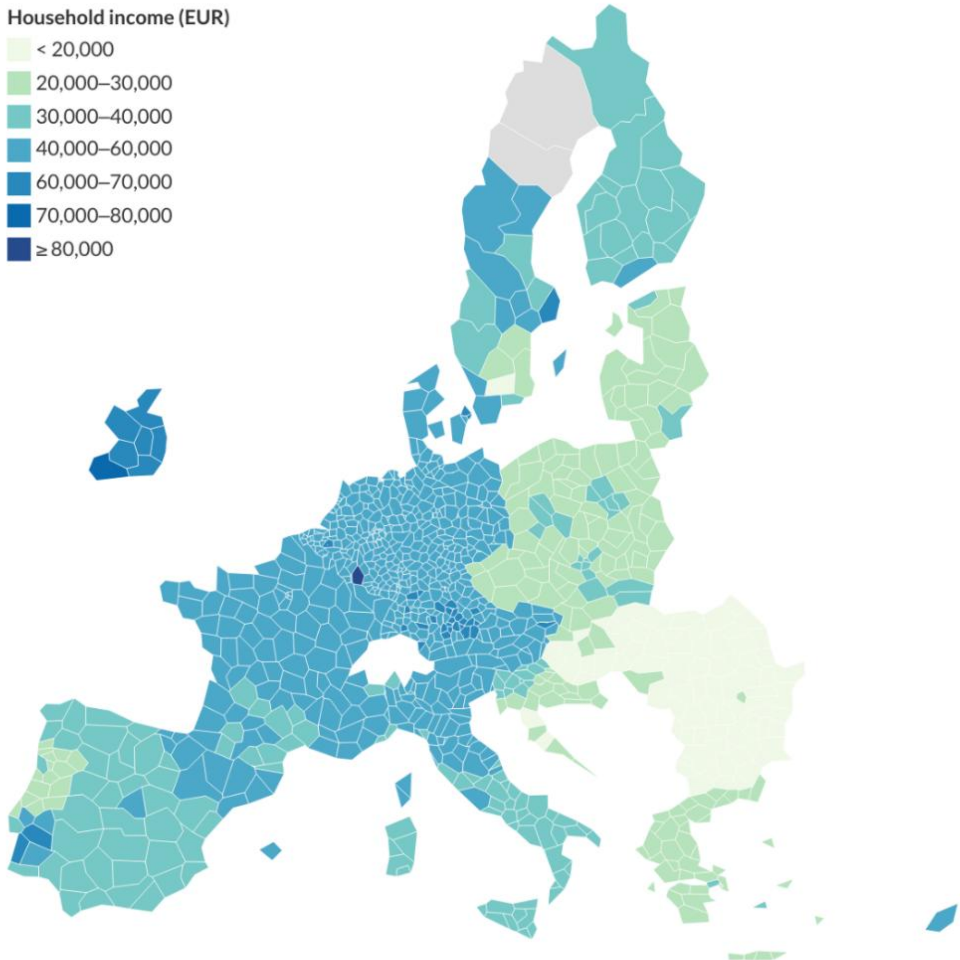
When fossil energy prices rise, households have three basic options:

- ➔ Adapt their consumption behaviour and reduce their heating demand.
- ➔ Accept rising fossil-fuel energy prices and bear higher utility costs.
- ➔ Replace their fossil-based heating system to escape higher energy prices.

The first option often reduces thermal comfort, while the latter two require financial resources. Disposable income is therefore a key determinant of how households respond and where vulnerabilities arise.

Mean disposable income among households using fossil-fuel heating varies widely across the EU (see Figure 7). Because fossil-fuel heating is not concentrated among specific income groups, average incomes of fossil-heated households closely mirror those of the overall population. The highest regional incomes are found in Luxembourg, followed by parts of Ireland, Germany and Belgium. At the lower end are regions in Bulgaria and Romania. The EU-wide mean disposable income of fossil-heated households is 42,700 EUR, slightly above that of non-fossil households at 41,000 EUR. All regions in eastern member states fall below the EU average.

Figure 7: Disposable incomes of fossil-fuel heated households are lowest in Eastern and Southern Europe

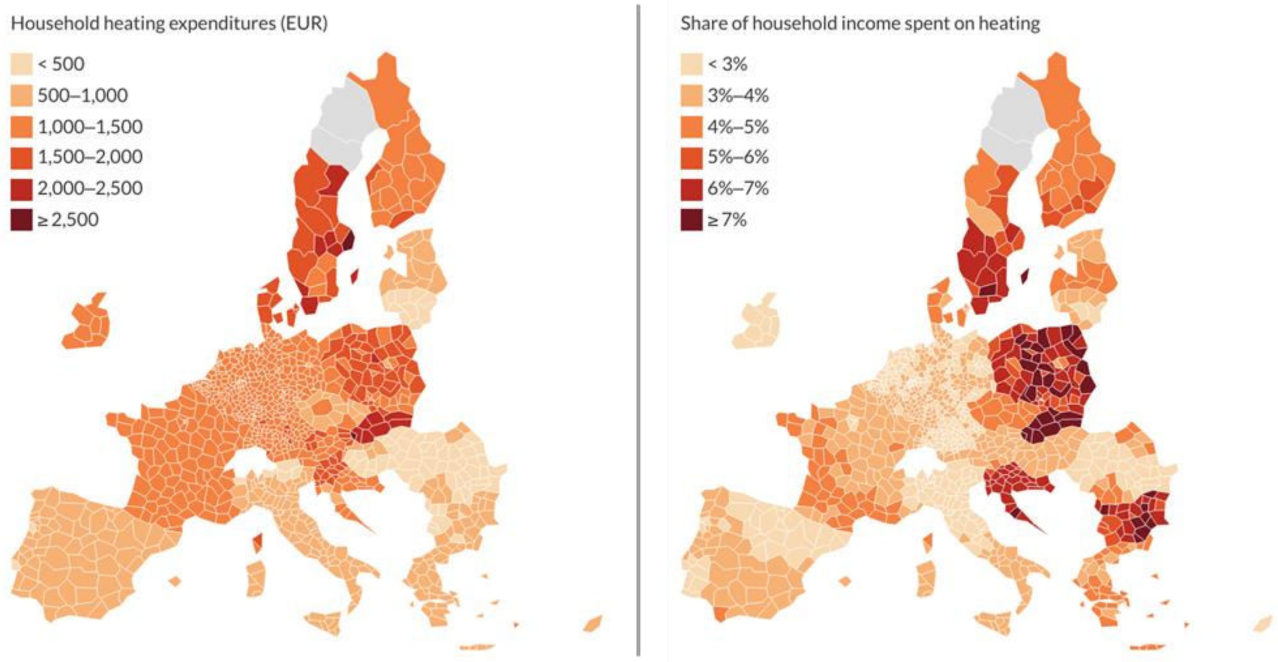


Notes: Mean disposable income of fossil-heated households by NUTS-3 region in euros. No data are shown for regions in northern Sweden because no households there use fossil-fuel heating. Disposable income is defined as annual income after taxes and social contributions. Source: Authors' calculations based on synthetic population.

Heating expenditures also vary sharply across Europe. Among fossil-heated households, absolute heating costs are highest in northern member states, reflecting higher heating demand. In parts of Eastern and Central Europe such as Slovenia, Slovakia, Poland, France and Germany, average annual costs for households with fossil-based heating systems are often around or 1,500 EUR (see Figure 8). The lowest heating costs for fossil fuels are paid by households in Bulgaria, Romania and Hungary.

For meaningful comparisons, however, these expenditures must be viewed relative to household disposable income. As shown in Figure 8, households using fossil-based heating in Eastern and Northern Europe spend a significantly larger share of their income on heating. In Slovakia, Poland and Bulgaria, they spend about 6.8% of disposable income on average. In southern Sweden, Croatia and Slovenia, the share is about 6.4%. Higher expenditure shares are also observed in rural France and in southern Greece.

Figure 8: Fossil-heated households in Eastern and Northern Europe spend most on heating



Notes: Absolute heating expenditures in EUR (left) and heating expenditure as a share of disposable income in % (right) by NUTS-3 region. No data are shown for regions in northern Sweden because no households there use fossil heating. Source: Authors' calculations based on synthetic population.

Several factors shape heating expenditures and households' ability to cope with rising prices. Among them, disposable income is the central socio-economic factor. In higher-income countries such as Germany, France, Ireland or the Benelux, heating costs are high in absolute terms but in many cases represent only a moderate share of household disposable income. As a result, heating is less of a financial burden for such households. In lower-income countries such as Poland, Bulgaria, Croatia and Slovakia, similar heating costs translate into much heavier burdens. Households are vulnerable to rising energy prices when energy costs absorb a large share of disposable income or when they risk losing access to adequate energy services, such as sufficiently heating or cooling their homes.

Other socio-economic factors also matter. Age, household size, composition and employment status influence both energy use and the capacity to adjust to rising fossil energy prices (Menyhért, 2022). Building characteristics such as construction period, energy efficiency and building type play an important role, as does whether households own or rent their homes (George et al., 2023). Finally, climate conditions and the regional heating demand have an impact on household heating expenditures (Perdana and Vielle, 2026).

5 Uneven impacts of uniform carbon pricing

The introduction of uniform carbon pricing through ETS2 will entail additional costs for fossil energy across the EU. At a possible initial carbon price of 60 EUR/t CO_2, we estimate additional heating expenditures of 6.27 billion EUR EU-wide per year. Looking further ahead, a hypothetical long-run ETS2 price of 180 EUR/t CO_2 would raise heating costs by 29.51 billion EUR per year, assuming today's fossil-based heating systems remained in place. Because a core objective of ETS2 is to incentivise the replacement of fossil-fuel heating systems, this long-run estimate should be interpreted as an upper bound rather than a realistic outcome.

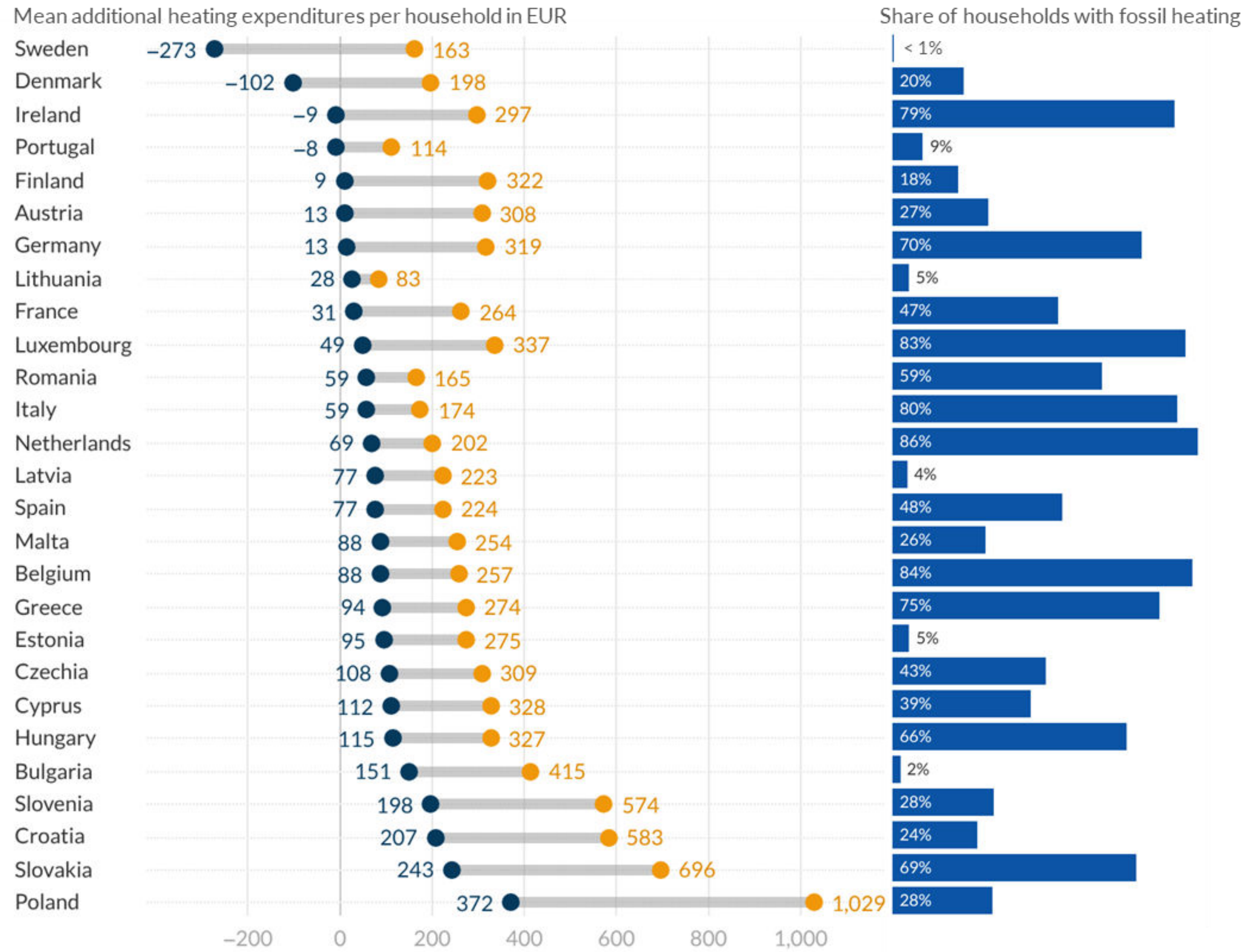
5.1 Heating costs increase most for Eastern European households

On average, an ETS2 price of 60 EUR/t CO_2 would increase heating costs for EU households that rely on fossil-fuelled heating systems by approximately 61 EUR. These additional costs, however, are distributed very unevenly across member states, reflecting substantial differences in the structure and decarbonisation status of national building sectors (see Figure 9).

Households in member states with already higher national carbon prices — Sweden, Denmark, Ireland and Portugal — would experience declining heating costs at a price level of 60 EUR/t CO_2 if ETS2 replaces existing price levels. As a result, additional costs would remain low even at higher long-run ETS2 prices. In three of these member states, the share of households relying on fossil heating is relatively small, while Ireland still has a high number of households using gas or oil heating.

In most other member states, the introduction of ETS2 would increase household heating costs, with average additional expenditures ranging from 9 EUR to 372 EUR per household per year. The magnitude of these impacts depends on several interacting factors, including the fossil heating fuel used, the presence and level of national carbon pricing already in place, which is relevant in nine member states, heating demand and household-specific behavioural responses to higher energy prices.

Figure 9: Cost increases vary across member states, with reductions for a few (million euros)



Notes: Average additional costs per household resulting from an ETS2 price of 60 EUR/t CO_2 (left, in blue) and 180 EUR/t CO_2 (right, in orange), in euros. The share of households with fossil heating in Sweden is close to zero. Source: Authors' calculations based on synthetic population.

At an ETS2 price level of 60 EUR/t CO_2, several distinct patterns emerge across member states:

- Cost reductions in Sweden, Denmark, Ireland and Portugal, where current national carbon prices exceed 60 EUR/t CO_2.
- Very small cost increases–up to 50 EUR per household, in richer member states such as Austria, France, Germany, Finland and Luxembourg, which operate national carbon pricing systems with price levels slightly below the expected initial ETS2 price.
- Small cost increases, up to 100 EUR per household per year, in nine member states, several of which currently show low heating expenditures.
- Moderate cost increases of up to 150 EUR in most other Eastern and Southern member states.
- Larger cost increases exceeding 200 EUR per household on average in Slovenia, Croatia and Slovakia.
- The highest cost increases in Poland, where coal continues to play a major role in residential heating, resulting in average additional costs of 372 EUR per household. However, only 28% of households are affected, a lower share than in many other member states.

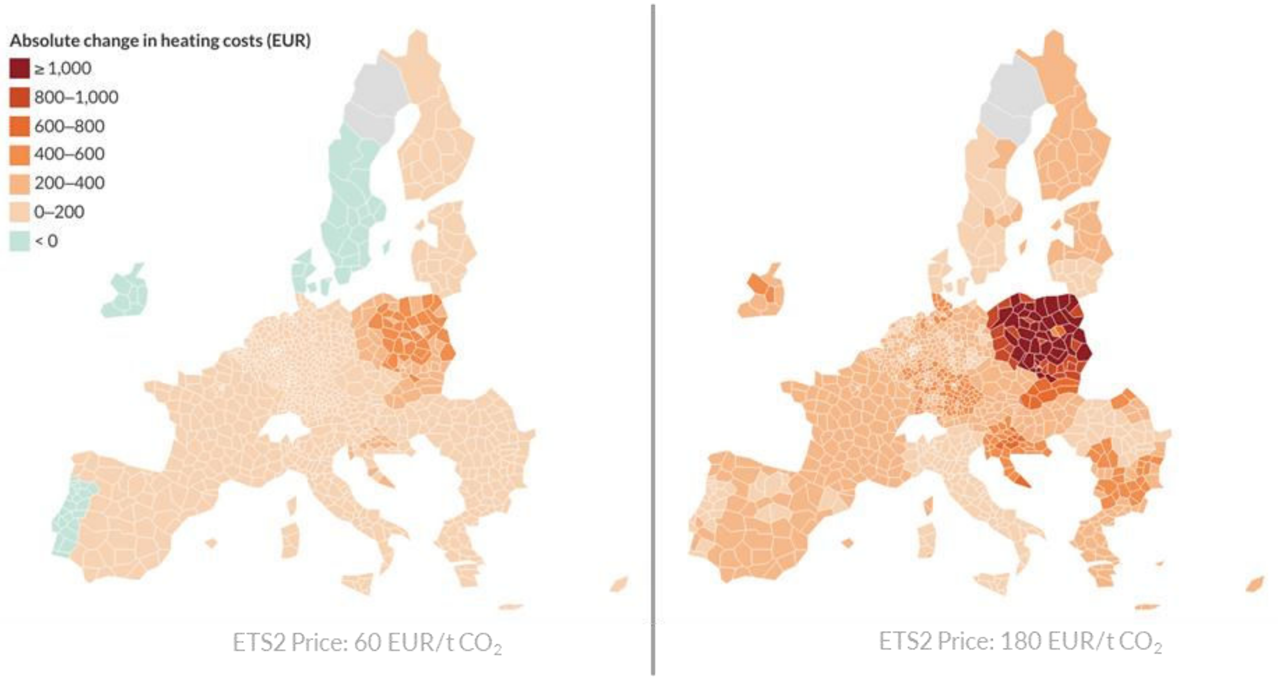
Of the roughly 188 million households in the EU, about 103 million are affected by ETS2 because they rely on fossil fuels for heating. Among these households, 89% would face an increase in annual heating expenditure of less than 100 EUR following the introduction of ETS2, including households in the four member states where a uniform ETS2 price would reduce heating costs.

At higher ETS2 price levels, such as 180 EUR/t CO_2 in the long run, the overall pattern remains broadly similar. Average annual additional heating costs, however, increase substantially, ranging from 83 to 1,029 EUR per household. At this price level, no household experiences cost reductions, although a large majority, 84%, of EU households with fossil-fuel heating systems still face additional costs of less than 400 EUR per year.

Beyond national averages, cost increases vary widely within member states, reflecting differences in household characteristics, heating technologies, dwelling conditions and energy consumption patterns. As a result, national averages mask important within-country differences in the distributional impact of ETS2 that become more pronounced at a more granular, sub-national level.

While households in Eastern Europe are generally most affected, the analysis identifies distinct geographical hot spots with particularly high cost increases (see Figure 10). At a moderate ETS2 starting price of 60 EUR/t CO_2, the absolute change in heating costs per household ranges from a reduction of 500 EUR in Stockholm to an increase of 570 EUR in the region surrounding Poland's capital, Warsaw.

Figure 10: Hot spots of cost increases in eastern and rural parts of the EU



Notes: Change in heating costs for fossil heating compared with the status quo, in euros. Source: Authors' calculations based on synthetic population.

At a hypothetically high ETS2 price level of 180 EUR/t CO_2, the spatial pattern remains similar, but the regional concentration of cost increases becomes more pronounced:

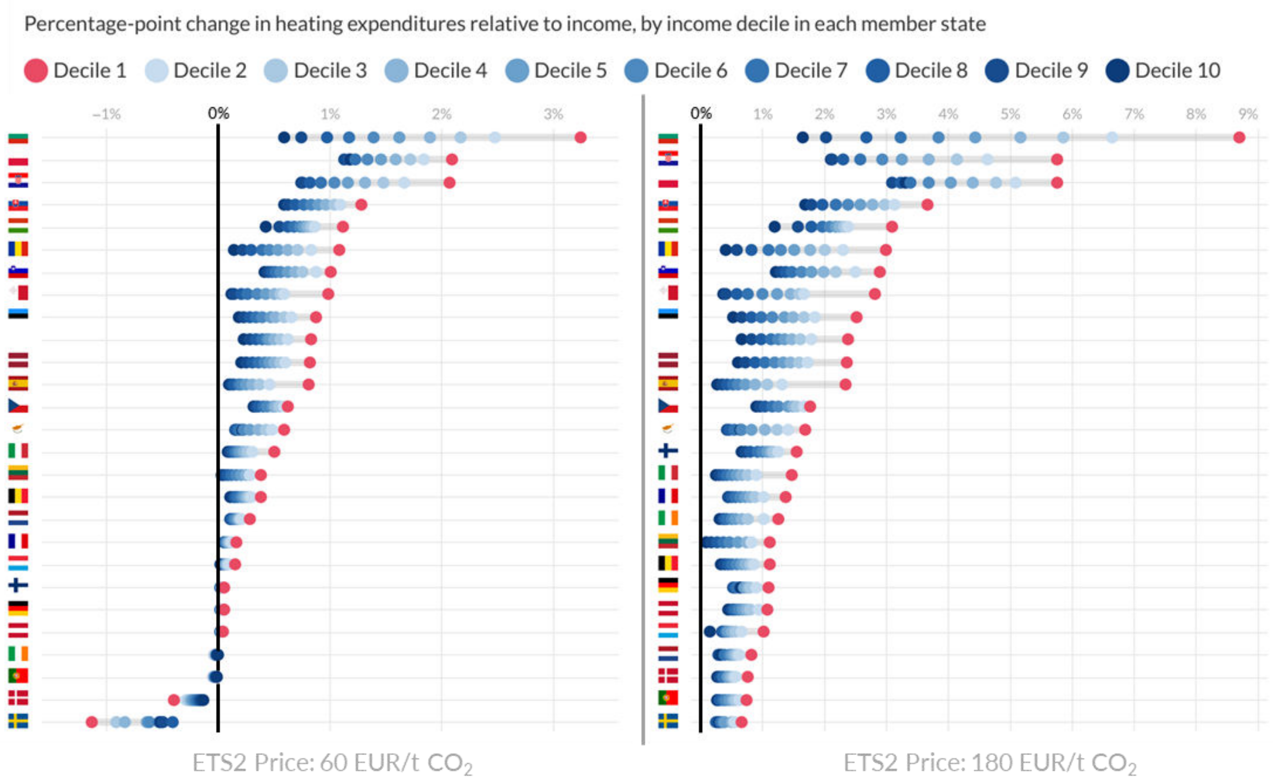
- ➔ In most EU regions, households face moderate additional expenditure of between 100 and 400 EUR per year.
- ➔ Additional annual costs range from about 1,600 EUR in central Poland to less than 100 EUR mainly in Lithuania and parts of Romania.
- ➔ Cost increases exceeding 400 EUR per household are concentrated in some rural areas of Germany, parts of Romania and Bulgaria and in Croatia, Poland, Slovakia and Slovenia.
- ➔ In Poland, 44% of households using fossil-fuel heating face particularly large cost increases, exceeding 1,000 EUR per year.

5.2 Low-income households face the highest increases in heating cost burdens

Examining the share of heating expenditure in household disposable income helps clarify the extent to which heating costs constrain a household's financial flexibility. It is therefore a suitable indicator of the financial burden imposed by high and rising fossil energy costs. Both within and across member states, the introduction of ETS2 has a regressive effect: when ETS2 raises national heating energy prices, low-income households experience the largest increase in the share of heating expenditure in their income. At the same time, households in lower-income member states are, on average, more severely affected relative to their income than households in richer member states.

The additional heating cost burden relative to income is highest in low-income member states (see Figure 11). For households with fossil heating in Bulgaria, the introduction of ETS2 at 60 EUR/t CO_2 would increase the share of heating costs in income by an average of 1.6 percentage points, while Polish households would pay 1.5 percentage points more of their income for heating. Higher additional burdens, defined as increases in the heating cost share above 0.5 percentage points, are also observed in Croatia, Slovakia, Slovenia, Hungary and Romania, again eastern member states with national income levels below the EU average. In most higher-income member states, the share of household income spent on heating rises only moderately, by up to 0.2 percentage points. In Ireland, Denmark and Sweden, which are among the highest-income member states, as well as in Portugal, households would experience financial relief following the introduction of an ETS2 price of 60 EUR/t CO_2.

Figure 11: Low-income member states and households face the highest additional burden



Notes: Change in the share of heating expenditure in disposable household income, in percentage points, for fossil-fuel households by income decile in each member state. Income deciles are based on the full national population. Source: Authors' calculations based on synthetic population

In addition to the uneven distribution of average additional burdens for fossil-heating households across EU member states, burdens relative to disposable income are also unevenly distributed across the income distribution within member states (see Figure 11). Wherever the introduction of ETS2 leads to higher fossil-fuel costs, low-income households face the greatest additional burden relative to their income. Differences across national income deciles tend to be larger in member states that also experience stronger overall effects of ETS2 on the share of heating costs in income and smaller in member states with generally lower average changes in relative burdens:

- ➔ In Bulgaria, households in the top income decile (10) pay an additional 0.6 percentage points of their income for heating under ETS2, while households in the lowest decile (1) face an additional burden of 3.2 percentage points, five times as much.
- ➔ In Romania, low-income households experience an increase in the share of income spent on heating that is 10 times larger than the increase for high-income households.
- ➔ In France, low-income households pay 0.2 percentage points more of their income for heating under ETS2, while high-income households face an increase of 0.1 percentage points.
- ➔ In Germany and Austria, where the absolute change in heating costs is even smaller, the additional relative burden for households with the lowest incomes rises by less than 0.05 percentage points.
- ➔ Where ETS2 reduces fossil-heating costs, households with lower incomes experience the largest reductions in expenditure relative to disposable income.

Higher carbon prices significantly exacerbate regressivity both between and within member states. At an ETS2 price of hypothetical 180 EUR/t CO_2, households in the highest income deciles in Bulgaria, Croatia and Poland face increases in their relative burden that exceed those of low-income households in 14 other member states, mainly those with higher national incomes. At this very high carbon price, some households pay a substantial additional share of their income for heating while others continue to face only modest increases. The rise in the share of income spent on heating ranges from almost 9 percentage points for low-income households in Bulgaria to less than 0.3 percentage points for households in the highest income deciles in Denmark, Ireland, Italy, Lithuania, Luxembourg, Portugal and Spain. In 14 member states, the average increase in the share of household disposable income spent on heating remains below 1 percentage point.

5.3 Strongly affected households: who they are and where they live

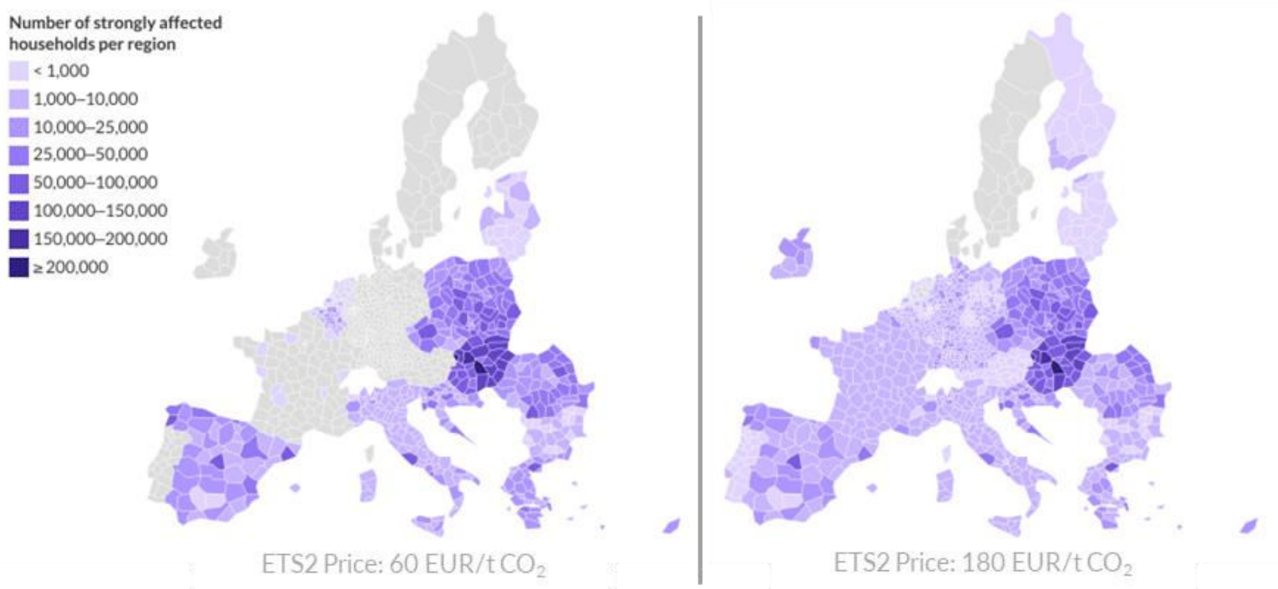
While cost increases following the introduction of ETS2 are moderate in most parts of the EU and for most households, a smaller subset faces a substantial additional burden. We define the most strongly affected households as the 10% of EU households experiencing the largest increase in the share of heating expenditure relative to disposable income. This group comprises about 10 million households across the EU and is of particular relevance for policy design, as these households will require the greatest support to cope with higher heating costs under ETS2 and to overcome fossil lock-in.

These households are unevenly distributed across member states (see Figure 12). At an initial ETS2 price of 60 EUR/t CO_2, eight of the 27 member states have no households among the 10% most affected: Austria, Denmark, Finland, Germany, Ireland, Luxembourg, Portugal and Sweden. Notably, these are the same member states that already operate national carbon pricing systems covering heating emissions.

Across the remaining 19 member states, the spatial distribution of strongly affected households varies considerably:

- In higher-income member states such as Belgium, France, Italy and the Netherlands, only small numbers, typically a few thousand households per region, fall into the most strongly affected group.
- Smaller clusters of strongly affected households are also found in southern member states, including Spain, Italy and Greece.
- By contrast, eastern member states show much higher concentrations. Parts of Slovakia and Hungary record more than 100,000 strongly affected households per region, while several regions in Romania and Poland contain more than 50,000 such households.

Figure 12: Most strongly affected households are concentrated in eastern EU member states



Notes: Regional distribution of the 10% most strongly affected households under ETS2. These households face the largest increases in heating expenditure relative to disposable income. Source: Authors' calculations based on synthetic population.

Although only about 50% of EU households rely on fossil fuels for heating, this group is broadly similar to the overall population in terms of household and building characteristics. By contrast, households most strongly affected by ETS2 differ markedly from both the full population and the broader group of fossil-heating households (see Table 1).

Most notably, the 10% most affected households have significantly lower financial resources. Their average disposable income is about 20,000 EUR, roughly half the EU average. While they are concentrated in the bottom three income decile in the respective member state, they are present across all deciles. Even before ETS2, these households spent only slightly more on heating in absolute terms than the average fossil-heating household. Because of their limited financial leeway, however, their heating cost burden relative to income already exceeds 5%.

The introduction of ETS2 substantially worsens the situation. For the most affected households, heating expenditure increases by up to three times more than for the average household using fossil heating. As a result, these households spend on average more than 7% of their disposable income on heating. At high ETS2 prices, the share of heating expenditure in income rises to almost 9% for the most affected households. By comparison, heating expenditure for the average fossil-heating household accounts for about 2.5% to 3% of disposable income.

Beyond income, more than 80% of the most strongly affected households are owner-occupiers, compared with an EU average ownership rate of 67%. These households are therefore more likely to live in single-family or two-family homes rather than flats. While owner-occupiers in detached housing theoretically have greater autonomy in choosing and upgrading their heating systems, they often lack the financial means to undertake the required investments. Given their low incomes and already high cost pressures, this constraint is particularly pronounced among the most affected households.

The 10% most affected households also stand out in terms of household characteristics. They tend to be larger than the average EU household and are more likely to include female and elderly members. This supports findings from other studies identifying age and gender as two important risk factors for energy poverty in the EU (Habersbrunner et al., 2024; Papadimitriou et al., 2023).

Table 1: Most affected households tend to be poorer, larger, older and are more likely homeowners

		Full population	Fossil heaters	10% most affected at 60 EUR/t CO_2	10% most affected at 180 EUR/t CO_2
Income and expenditures					
Disposable household income (EUR)		41,001.02	42,706.82	18,508.80	21,808.41
Heating expenditures (EUR)	currently	778.36	1,014.51	1,116.94	1,162.98
	additional at 60 EUR/t CO_2		60.59	221.84	
	additional at 180 EUR/t CO_2		284.99		716.89
Heating expenditures in income (%)	currently		2.4 %	6.0 %	5.3 %
	at 60 EUR/ t CO_2		2.5 %	7.2 %	
	at 180 EUR/t CO_2		3.0 %		8.6 %
Household details					
Household members	Total	2.28	2.24	2.41	2.34
	Females	1.17	1.15	1.26	1.22
	Elderly	0.48	0.49	0.59	0.58
	Active in labour market	1.03	1.02	0.96	0.96
Ownership rate		66.6 %	66.2 %	87.0 %	83.2 %
Building characteristics					
Building type	Single or Double Home	46.5 %	46.3 %	61.3 %	64.1 %
	Housing Block	53.4 %	53.7 %	38.6 %	36.0 %
Space of living in square meter	30-59	18.2 %	17.1 %	21%	19.4 %
	60-119	47%	49.2 %	48.2 %	46.3 %
	120 and more	26.8 %	26.4 %	28 %	30.1 %
Period of construction	before 1961	29.4 %	30.1 %	25.2 %	26.6 %
	1961-2000	53.8 %	54.1 %	58.2 %	55.9 %
	after 2000	16.7 %	15.8%	16.6%	16.6 %

Notes: Heating expenditure for the full population does not include households that heat with electricity. Elderly household members are aged 65 and over. The most affected households face the largest increases in heating expenditure relative to disposable income. Source: Authors' calculations based on synthetic population.

Overall, households across the EU are affected very differently by the introduction of a uniform carbon price on heating. About 90% of households would face annual additional costs of less than 100 EUR at the expected initial price level of 60 EUR/t CO_2. On average, EU households would spend 2.5% of their disposable income on fossil heating, only 0.1 percentage points more than without ETS2. For much of the population, the additional financial burden from ETS2 is manageable.

For a smaller but significant group, however, the impact is considerably more severe. The 10% most affected households experience an increase in the share of disposable income spent on heating of more than 1 percentage point, starting from an already high level of about 6%. Even at a moderate ETS2 price, these households would spend more than 7% of their income on heating, making heating costs a much heavier burden. For this group, the additional ETS2 costs can become unmanageable. Support measures to reduce the burden for these households are therefore necessary.

This calls for targeted income and investment support to reach those most in need.

6 From compensation to transformation with limited revenues

Introducing ETS2 not only raises fossil energy costs for households but also generates substantial public revenues. These revenues are intended to support decarbonisation of the affected sectors and to mitigate adverse social impact. Their effective use serves two complementary objectives. First, revenues can prevent vulnerable households from being overburdened by rising energy costs through targeted compensation measures. Second, they can finance the transition away from fossil heating systems for households that cannot afford the required investments on their own.

The preceding analysis shows that while ETS2 leads to moderate cost increases for most households, a comparatively small but highly vulnerable group faces a substantial rise in heating cost burdens. The central policy questions are therefore whether ETS2 revenues are sufficient to address both short-term distributional impacts and longer-term transformation needs and how compensation and investment support should be designed to effectively reach households most in need. As the results indicate, this is highly member state-specific, as the number and characteristics of affected households and the degree of impact vary across the EU.

Although the overall volume of future ETS2 revenues remains uncertain, as it depends on the carbon price level and behavioural responses by households, the distribution of revenues across member states is already defined. Funds are allocated through two main channels (see Section 2.5 for an overview):

1. The Social Climate Fund, which is designed to support vulnerable households and promote social cohesion across member states.
2. National ETS2 revenues, which member states are required to use for decarbonisation measures, and which are largely allocated based on historical emissions in the covered sectors.

Building on the identification of the most strongly affected households in the previous section, the following analysis assesses whether the fiscal space created by ETS revenues is sufficient to finance both short-term compensation for additional heating costs and medium- to long-term investment support at different ETS2 price levels.

6.1 Sufficient funds to prevent household overburdening

A central question for the implementation of ETS2 is whether the revenues generated are sufficient to prevent unmanageably high cost burdens for households. This is essential to uphold the EU's commitment to a just transition and to ensure that no one is left behind. Figure 13 therefore compares the additional heating-related costs borne by the most strongly affected households under ETS2 between 2027 and 2032 with the funds available for national Social Climate Plans at price levels of 60 EUR/t CO_2 and 180 EUR/t CO_2.

Because the Social Climate Fund does not scale with the ETS2 price, the volume of funding available in each member state for implementing its Social Climate Plan remains constant across price levels. It consists of the SCF allocation to each member state plus the mandatory 25% co-financing (see Section 2.5 for details).

As Social Climate Plans are explicitly intended to support vulnerable households during the transition, comparing the additional heating burdens of the most affected households with available funding provides an indication of whether these plans are financially equipped to meet this objective. The ratio of additional heating costs for the 10% most affected households to available Social Climate Plan funding varies widely across member states, primarily because strongly affected households are concentrated in a small number of countries, most notably Hungary, Poland, Romania and Slovakia.

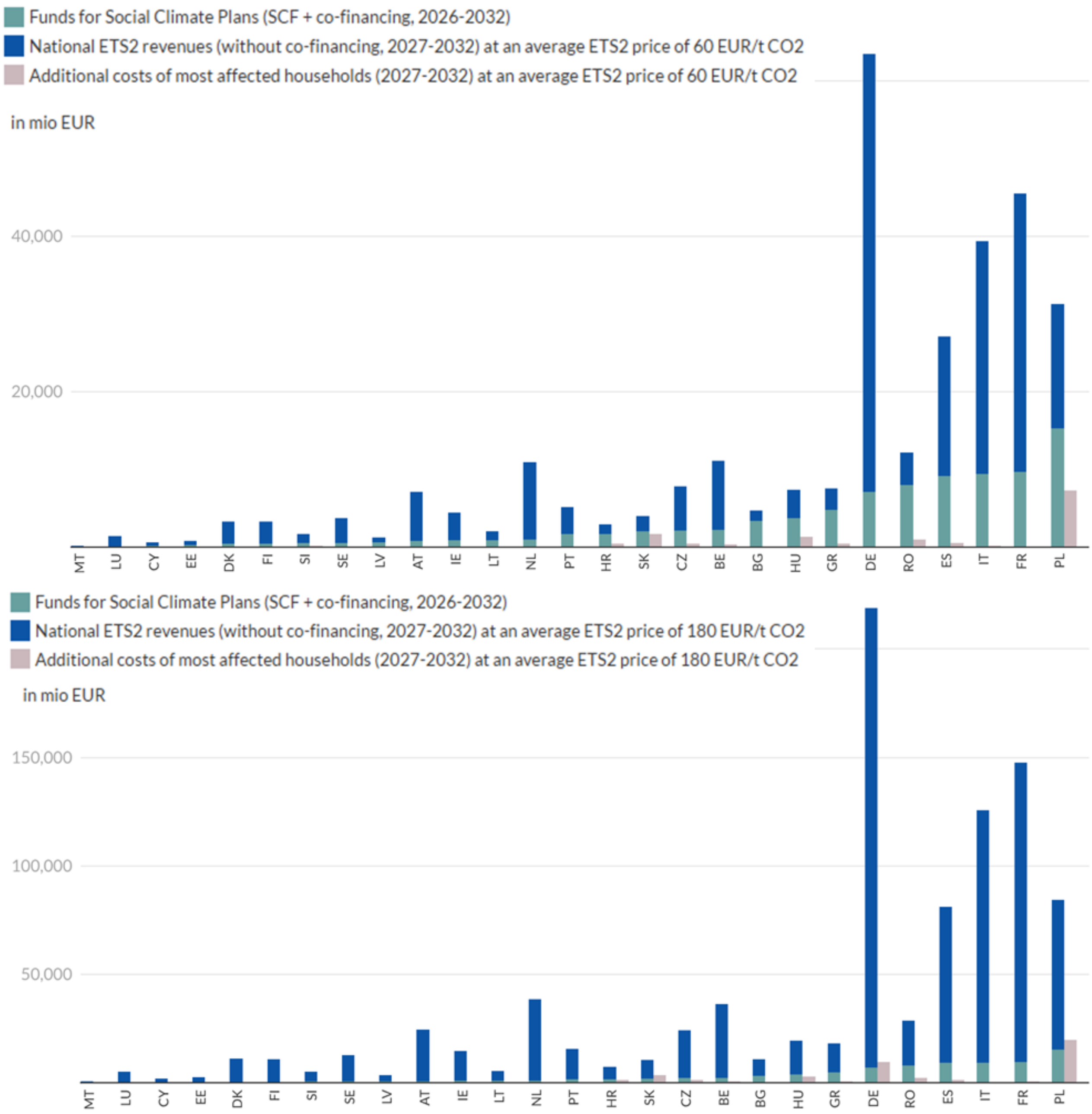
At a moderate ETS2 price of 60 EUR/t CO_2, the funds available under the Social Climate Plans exceed the projected additional heating costs of the most affected households in all member states. In principle, this means that every household in the top 10% most affected group could be fully compensated for the additional heating expenditure caused by ETS2.

This result, however, requires careful interpretation. Social Climate Plan funds are intended to mitigate additional burdens from both heating and transport emissions under ETS2, while the costs shown in Figure 13 relate only to heating. At a moderate initial ETS2 price of 60 EUR/t CO_2, this distinction is not critical in most member states. SCF allocations and co-financing appear sufficient to prevent overburdening of the most affected households even after accounting for transport-related support needs. Still, some member states may struggle to adequately compensate both heating- and transport-related burdens using Social Climate Plan funds alone, most notably Slovakia and potentially Croatia, Hungary and Poland.

If direct income support for households most affected by ETS2 absorbs a large share of total Social Climate Plan resources, fewer funds remain to compensate other vulnerable groups or to support investments in modern heating systems. Such investment support is essential to avoid fossil lock-in, particularly for households with limited financial means. For this reason, SCF rules cap the share of national Social Climate Plan expenditure that may be used for temporary direct income support at 37.5% of total plan costs. While this safeguard shifts more resources towards structural transformation, it limits the scope for relying solely on Social Climate Plan funds to offset high cost burdens for the most affected households.

As a result, some member states will need to complement their Social Climate Plan resources with additional financing, most importantly national ETS2 revenues, to ensure adequate compensation for heating-related costs while also addressing transport-sector impacts.

Figure 13: Sufficient fiscal space to compensate the most affected households



Notes: Funds for Social Climate Plans include allocations from the Social Climate Fund plus mandatory national co-financing. Source: SCF allocations based on European Parliament, 2023b, additional costs of most affected households calculated by authors based on synthetic population.

At higher ETS2 price levels, the imbalance between additional heating burdens for the most strongly affected households and available Social Climate Plan funds becomes more pronounced and extends to more member states. While heating-related costs rise in proportion to higher carbon prices, the SCF is capped at 65 billion EUR and does not scale with the ETS2 price. As a result, its capacity to protect and support vulnerable households declines as carbon prices increase.

This dynamic is illustrated in the lower panel of Figure 13. In the hypothetical long-run scenario of a high ETS2 price of 180 EUR/t CO_2, the additional heating costs of the most affected households alone exceed total Social Climate Plan funds in three member states, Slovakia, Germany and Poland, and account for more than 50% of these funds in another four, Croatia, Czechia, Hungary and

Slovenia. In these cases, it becomes especially important that sufficient shares of national ETS2 revenues are earmarked for targeted support of vulnerable households.

In all other member states, SCF and co-financing resources appear sufficient to prevent unmanageable burdens for the most affected households while also allowing compensation for transport-related costs under ETS2.

Overall, the analysis shows that preventing household overburdening is financially feasible in most member states, particularly at moderate ETS2 price levels. Available funds, however, are limited and must be used strategically. National compensation schemes should therefore prioritise the most affected households, which face the highest and potentially unmanageable heating cost burdens under ETS2. Compensating all households in full for higher fossil energy costs should be avoided. The key challenge is therefore less the overall availability of funds than the effective design of compensation mechanisms that reach vulnerable households in a timely, targeted and administratively efficient manner.

6.2 Insufficient funds to support replacement of heating systems adequately

While ETS2 revenues appear largely sufficient to prevent overburdening of households most affected by higher heating costs, they fall well short of covering the long-term investment needs associated with replacing fossil-fuel heating systems. Achieving the decarbonisation objectives of ETS2 ultimately depends on enabling households to adopt zero-emission heating technologies.

Investment needs in the EU housing sector are substantial. The costs of replacing heating systems vary widely depending on building characteristics, access to energy infrastructure, national construction costs, resource prices and the need for complementary renovation measures. In many cases, total investment costs amount to several tens of thousands of euros, far exceeding the annual burden induced by ETS2. Installing a heat pump, for example, typically costs between 10,000 and 30,000 EUR or more (European Commission et al., 2025; Winskel et al., 2024). For many households, such investments would absorb a large share of disposable income or even exceed it.

As a result, the number of households that struggle to finance heating system replacements is much larger than the number that face heating expenditure of about 3% of disposable income or more (see Section 5.3). Public financial support for heating system replacement is therefore indispensable.

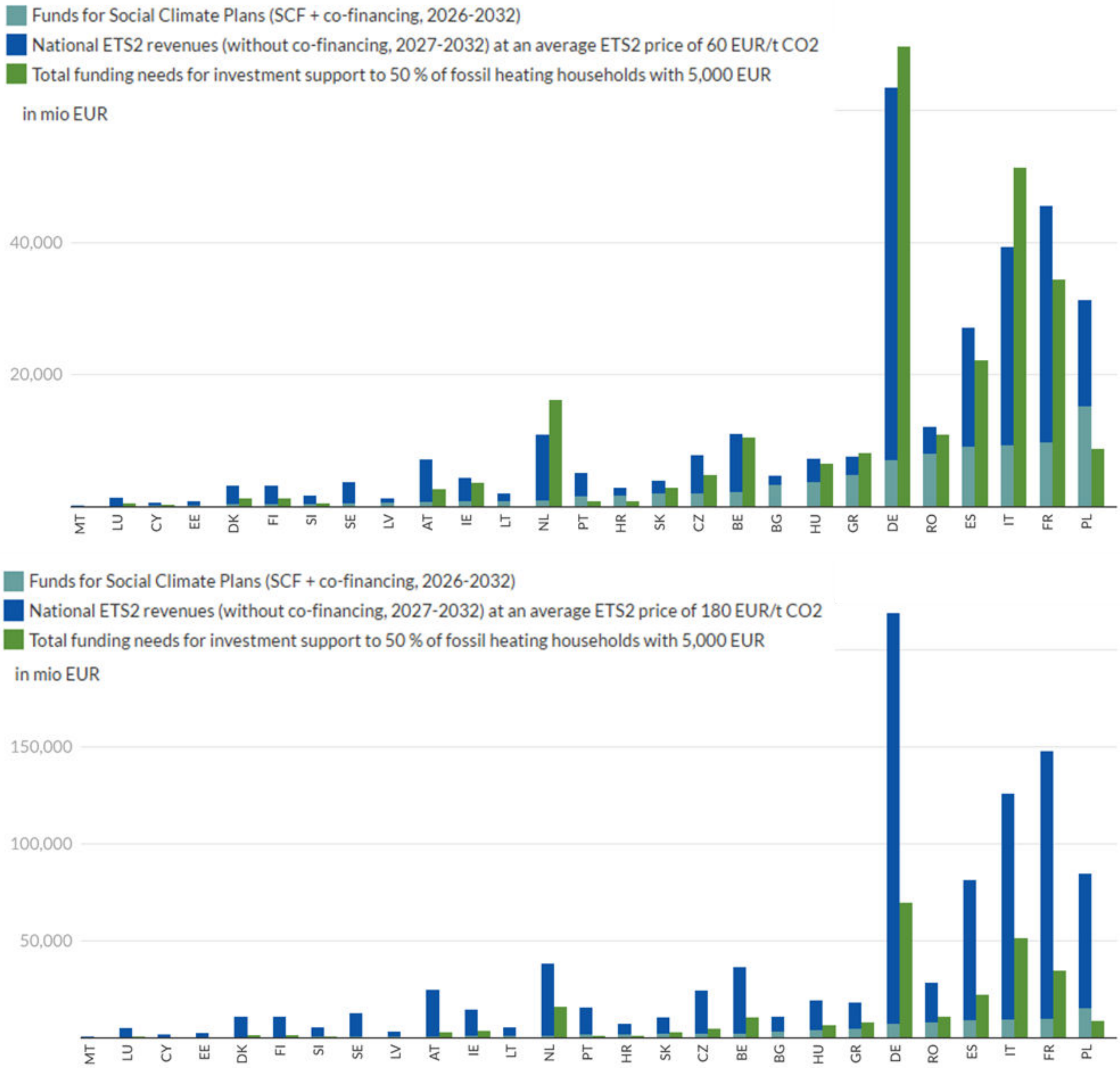
To illustrate the scale of the challenge, we apply a stylised calculation. We assume a modest public support level of 5,000 EUR to every second household, covering only a small share of typical replacement costs, for half of all fossil-heating households in each member state. While actual policy designs will vary widely in terms of support volumes, eligibility criteria and instruments such as direct investment grants, tax incentives or subsidised loans, this exercise provides a useful benchmark for the funding required.

Figure 14 illustrates the gap between available ETS2 revenues, combining SCF and national ETS2 revenues, and the estimated investment support needed for heating system replacements. At a moderate carbon price of 60 EUR/t CO_2, such an investment programme would exceed total ETS2 revenues in most member states. In many others, it would absorb a large share of available revenues, leaving little fiscal space for household compensation or transport-sector measures. This mismatch between revenues and investment needs is particularly pronounced in larger member states with high numbers of fossil-heating households such as the Netherlands, Germany, Italy and France.

Poland is a notable exception. Despite its continued reliance on carbon-intensive heating fuels, the number of fossil-heating households relevant for this stylised calculation is comparatively small, resulting in a more favourable ratio of investment needs to total expected ETS2 revenues. Poland also receives the largest allocation from the SCF. Similarly, several smaller member states with low shares of households using fossil heating such as Bulgaria and Lithuania appear to have sufficient ETS2 revenues to finance meaningful investment support schemes.

At higher ETS2 price levels in the long run, such as 180 EUR/t CO_2, the funding gap narrows as revenues rise sharply. The underlying challenge, however, persists. Higher carbon prices increase revenues but also expand the need for compensation and intensify distributional pressures, not only in the heating sector but also in transport. As a result, even under very high price assumptions, ETS2 revenues alone are insufficient to finance large-scale heating system replacements once competing demands on these funds are taken into account.

Figure 14: Funding needs for investments exceed available ETS2 revenues at moderate ETS2 prices



Notes: Total revenues include allocations from the Social Climate Fund and national ETS2 revenues. Total investment needs are calculated by providing a 5,000 EUR support payment to half of all fossil-heating households in each member state. Source: Revenue data from Agora Energiewende, 2023 and Graichen and Ludig, 2024. Funding needs for subsidising investments are calculated by authors based on synthetic population.

7 Conclusions and policy recommendations

A uniform European carbon price on emissions from domestic heating will affect households unevenly across the EU. Regional climate conditions, socio-economic factors such as disposable income and building characteristics such as insulation quality vary widely between and within member states. By applying a novel approach to close existing data gaps, this analysis provides an unprecedentedly granular assessment of ETS2's effects on European households. It draws on household- and building-specific circumstances together with household-specific behavioural responses to rising heating prices for 188 million households across Europe.

About half of European households will be directly affected by ETS2 because they rely on fossil-fuel heating systems. The distribution of fossil heating is highly uneven across member states. Scandinavian countries have already made substantial progress in phasing out fossil fuels, while dependence remains high in many other parts of Europe. Fuel use patterns also differ. Natural gas remains common across large parts of the continent, oil use is concentrated in Western Europe as well as Finland, Greece Ireland, and Spain and coal heating persists primarily in Poland. In addition, several mostly wealthier member states, including the Scandinavian countries, France and Germany, already operate national carbon pricing systems that impose similar or higher costs than the expected ETS2 starting price of 60 EUR/t CO_2. In many other member states, ETS2 represents the first major pricing scheme for carbon emissions from buildings.

As a result, the financial burden of ETS2 on households and member states will be far from uniform. In several Northern and Central European member states, impacts on heating expenditure will be minor or negligible. By contrast, substantial additional burdens arise particularly in Eastern Europe. The availability of district heating powered by fossil fuels, mostly covered under the EU ETS and therefore already subject to carbon pricing, further contributes to regional differences. Overall, about half of European households will face additional costs under ETS2, with similar shares of affected households across income groups at the EU level.

At an ETS2 carbon price of 60 EUR/t CO_2, we estimate average additional heating costs of about 60 EUR per household per year. Around 89% of households will face annual costs of less than 100 EUR, typically corresponding to less than 0.1% of disposable income. This represents a noticeable but manageable burden for the large majority of these households. In member states with existing national carbon pricing schemes such as France or Germany, ETS2 would create costs similar to those households already face. Even at a much higher ETS2 price of 180 EUR/t CO2–a hypothetical price level that could, if at all, only be realised in the long term–average annual additional costs remain moderate at about 285 EUR, with more than 84% of households paying less than 400 EUR.

The burden, however, is not evenly distributed. The 10% most affected households face significantly higher average costs of about 220 EUR at an ETS2 price of 60 EUR/t CO_2 and about 715 EUR at 180 EUR/t CO_2. These households can be classified as vulnerable because they already spend a higher share of disposable income on heating. They are characterised not only by lower incomes but also by a higher likelihood of homeownership, larger household size and a greater presence of female and elderly household members. Disposable income alone is therefore an insufficient indicator of vulnerability to rising fossil energy prices.

Targeted support for strongly affected households is essential to prevent overburdening and to ensure social fairness. The Social Climate Fund, implemented through national Social Climate Plans, is the primary instrument designed to cushion these burdens and ensure public support for ETS2. It acts as a solidarity mechanism across and within member states, channelling ETS2 revenues to people and places most affected. Our analysis shows that at a moderate price level of 60 EUR/t CO_2, Social Climate Plan resources are sufficient to compensate the most affected households in most member states but may be inadequate at a hypothetical price level of 180 EUR/t CO_2.

The introduction of ETS2 will not overburden the majority of European households, yet a meaningful minority faces high burdens. The policy debate should therefore move from speculation about price levels to the design of effective and socially balanced support measures. Additional financial burdens created by ETS2 are manageable in most cases, even at an unrealistically high price of 180 EUR/t CO_2, provided support is well targeted.

However, policy debates in many member states focus on broad, untargeted lump-sum transfers. Prominent examples include the per-capita ‘Klimageld’ in Germany–which was extensively debated but never introduced–and the Austrian ‘Klimabonus’, which combines a uniform base payment to everyone with a broad regionally differentiated supplement based on place of residence. While such instruments are politically attractive and administratively easier to implement, they risk wasting scarce public resources by compensating households that do not need require direct income support. At the same time, they fail to adequately protect those households that are most exposed to the price increases induced by carbon pricing.

Instead, member states should prioritise targeted support for the most affected households. Crucially, support should focus on households facing high ETS2-induced heating cost burdens relative to income–and not on low-income households alone. Designing such targeted support is challenging and requires:

1. Granular data and detailed analysis to identify who is most affected and where these people live. Our study demonstrates that this is feasible at a high spatial and socio-demographic resolution and gives important information on the characteristics of households most affected.
2. Institutional infrastructure that enables governments to identify eligible households and reach them effectively. In practice, this is often difficult as verifying eligibility often requires combining income, housing, energy use and household composition data held by different authorities. This process is costly, time-consuming and constrained by data-protection regulations.
3. A pragmatic balance between targeting precision and administrative complexity. Given the challenges outlined above, perfect targeting may be neither achievable nor desirable. This may justify favouring simple, automatically delivered schemes based on broader eligibility criteria over application- or verification-based processes, even if this comes at the cost of some over-inclusion.

To ensure that targeted compensation reaches those who need it most, member states need to invest in data systems, administrative capacity, and delivery channels timely. Without this institutional architecture, ETS2-related support risks remaining blunt, inefficient, and socially ineffective.

Importantly, ETS2 revenues and Social Climate Plans should be used to compensate exclusively for burdens caused by ETS2, ensuring that carbon pricing does not generate new social disparities.

These funds and the corresponding measures are not intended to address pre-existing structural challenges such as high housing costs, tight rental markets, or long-standing energy poverty problems. Such issues require broader social and housing policies at both national and EU level, including measures to expand affordable housing supply, strengthen tenant protection, and accelerate building renovations. Policymakers should ensure that these policies remain aligned with climate objectives.

The newly established Social Climate Fund is a key instrument for ensuring that support reaches those who need it most. Its design introduces several important innovations for a just transition: a clear focus on vulnerable groups, solidarity-based redistribution across member states and a strong emphasis on investment rather pure compensation. As such, the SCF addresses not only short-term affordability concerns but, more importantly, the structural fossil lock-ins that drive long-term vulnerability. The success of the SCF, however, ultimately depends on whether funds are used as intended. The European Commission therefore plays a central role in ensuring that the Social Climate Fund serves as a blueprint for a socially just transition.

Through its approval of national Social Climate Plans, the European Commission has a powerful lever to ensure targeted and effective use of SCF resources. Member states must specify in their Social Climate Plans how they will allocate funds, which households they will target, and how measures will prevent excessive burdens while enabling households to exit from fossil heating. The European Commission reviews and approves these plans before funds are disbursed. This approval authority implies three concrete responsibilities for the European Commission:

1. It should strictly enforce the requirement that national Social Climate Plans prioritise vulnerable households and do not rely primarily on non-targeted measures. This should be the main criterion in the assessment and approval process.
2. It should coordinate and align spending streams–SCF expenditures and national ETS2 revenues– to avoid inefficient or contradictory policy mixes and to exploit economies of scale wherever possible.
3. It should actively promote capacity-building and cross-country learning in the development of Social Climate Plans. While target groups differ across member states, political obstacles and administrative challenges are often similar, making cross-national learning a core and yet underused strength of the SCF architecture.

To date, implementation of Social Climate Plans has been slow. Most member states missed the June 2025 deadline for submitting their national plans, and only one plan–Sweden's– has been formally adopted by the Commission. This reflects administrative complexity, political uncertainty, and unresolved questions surrounding ETS2 implementation. To overcome these barriers, the Commission should intensify coordination and knowledge-sharing efforts. For example, it could establish a public EU-level registry of best-practice SCF measures, including information on budgets and target groups, or organize structured exchanges among member states on shared challenges, such as financing building renovations for low-income households with limited access to credit.

Compensating higher heating costs, however, is only part of the challenge. The core purpose of ETS2 is to accelerate the shift away from fossil heating by changing relative prices. This transition requires substantial investment, often amounting to tens of thousands of EUR, which many households cannot shoulder alone.

In a stylised scenario in which half of fossil-heating households receive a 5,000 EUR investment subsidy, ETS2 revenues prove insufficient to finance these investment needs. This underscores that investment support needs to be scaled up and frontloaded, going beyond ETS2 revenues alone. Replacing heating system involves long-term investment decisions and therefore requires stable, long-term financing frameworks. Public investment support should primarily reduce upfront investment barriers and, where appropriate, allow for partial repayment over time. Despite long-term savings and climate benefits, many households are likely to postpone or forgo investment altogether in the absence of adequate support.

The study shows that additional financing sources will be needed to unlock the emissions reductions ETS2 is intended to deliver. Without further support, many households risk becoming trapped in fossil lock-in, exposed to rising carbon prices without a viable path out. To mobilise investment at scale, member states and the EU institutions must expand complementary financing instruments, including grants, concessional loans, and guarantees. While primary responsibility lies with member states, EU-level resources–most notably cohesion funds–should play a central supporting role.

Cohesion policy already reflects the European Commission's new emphasis on affordable housing as a cross-cutting priority. This is backed financially by incentives to double the current cohesion funding for housing from 10.5 billion EUR (7.5 billion EUR plus 3 billion EUR of national co-financing) to over 20 billion EUR. As affordable heating is an integral component of affordable housing, prioritising energy efficiency measures and heating system replacement in residential buildings within Cohesion Policy is important to meet the demands of social housing policy at the EU level.

Looking ahead to the next Multiannual Financial Framework, it will be crucial to secure sufficient resources for housing within National and Regional Partnership plans (NRRP), which will form the new umbrella for cohesion and agricultural funds at the EU level. In practice, this can be implemented through earmarking, but also by integrating explicit targets for heating system replacements or energy efficiency renovations into the output and performance indicators. One such target could be the doubling of the EU-wide building renovation rate from currently around 1% to a minimum of 2% within the next years.

At the same time, climate policy–and ETS2 in particular–requires immediate action. Early and targeted investment reduces emissions faster, lowers households' long-term exposure to carbon prices, and limits upward pressure on ETS2 prices. Frontloading investment support is therefore both socially and economically efficient—and should be a policy priority now. In this context, the EU Commission's plans to make ETS2 revenues available from 2026 onwards are welcome. Revenue frontloading should be designed to establish a strong and reliable financial foundation for early investment and should once again prioritize households that are unable to shoulder these costs alone.

Targeted support for the most affected households is critical not only to secure public backing for ETS2 but also to achieve climate objectives cost-effectively. Enabling vulnerable households to switch away from fossil heating early reduces emissions, limits long-term exposure to carbon prices, minimises the need for ongoing income compensation and reduces pressure on ETS2 price levels. Ultimately, a fair and well-designed ETS2 can deliver both environmental and social benefits while supporting Europe's path to climate neutrality.

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Appendix

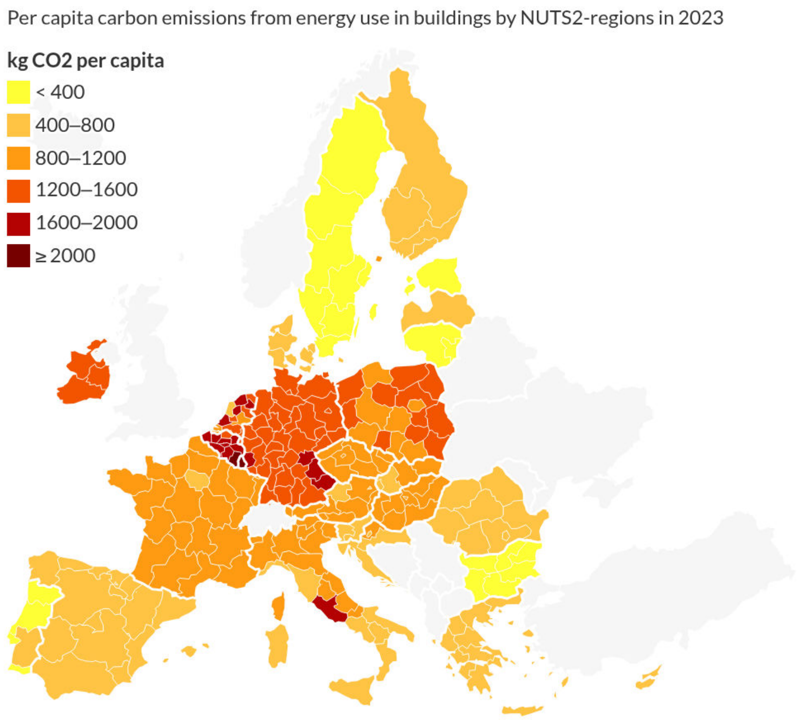
A.1 Decarbonizing the European housing sector

A.1.1 Carbon emissions from buildings

Per capita carbon emissions from buildings vary widely across EU member states (see Figure A1). On average, emissions from energy use in buildings amount to 960 kg CO_2 per capita in the EU. Particularly high emission levels are observed in Luxembourg, large parts of Belgium and the Netherlands, Germany, Ireland, several regions in Poland and the area around Rome.

Many regions in central and parts of eastern Europe cluster around the EU average, including areas in Austria, Poland, Hungary, Czechia and Slovakia as well as large parts of France and Italy, with the exception of southern Italy. By contrast, numerous regions in southern and eastern Europe, along with the Scandinavian and Baltic member states, record significantly lower emissions, typically below 800 kg CO_2 per capita. The lowest buildings emissions are found in Estonia, Lithuania, Bulgaria, Sweden, parts of Portugal and Malta.

Figure A1: Carbon emissions from buildings are highest in Benelux and German regions

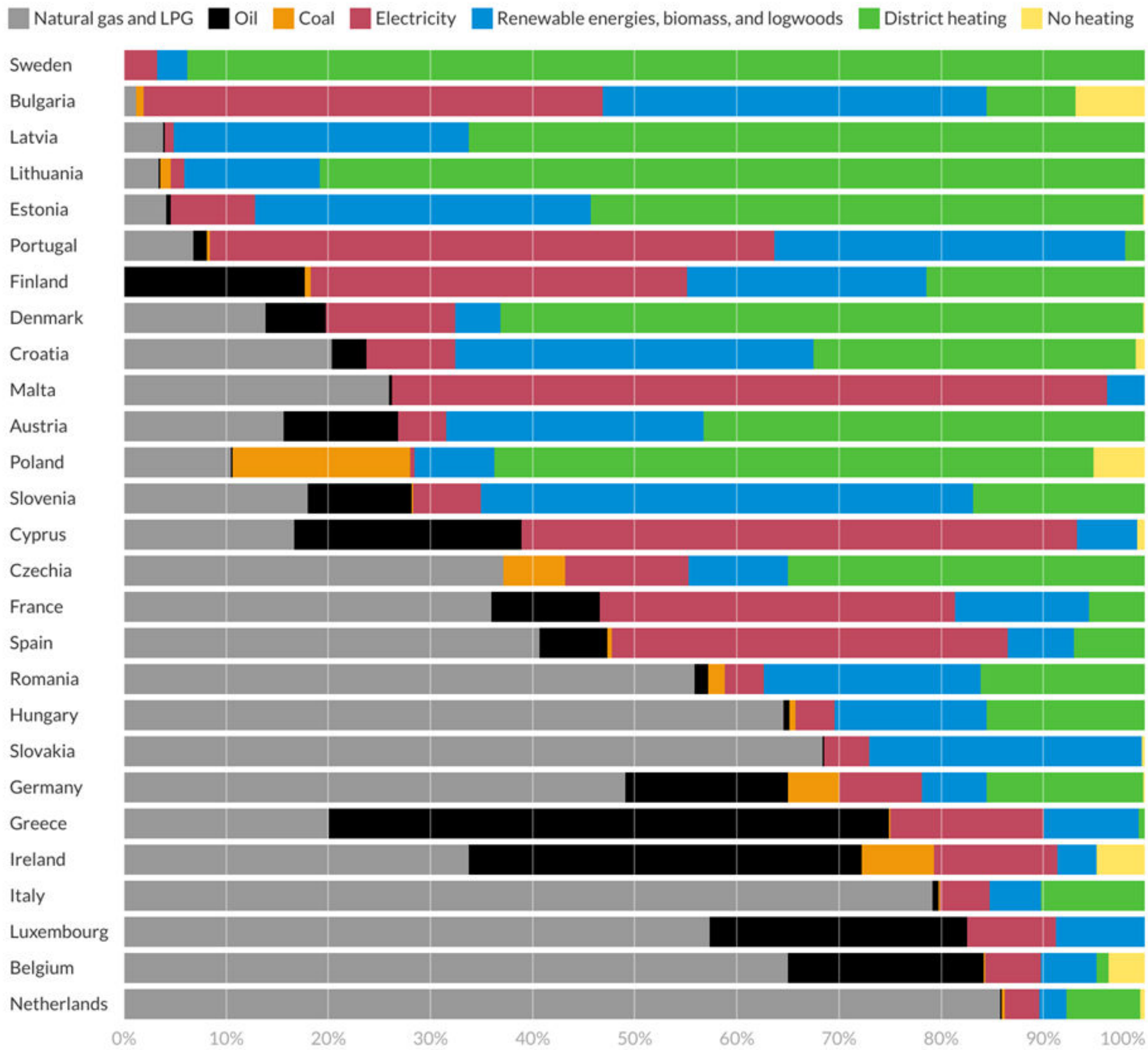


Notes: NUTS-2 2021 version. Source: Pagani et al., 2023, European Environment Agency 2024b and Eurostat 2025b.

A.1.2 Fossil heating by member state

As with per capita emissions from buildings, the use of fossil fuels for heating varies widely across member states (see Figure A2). In 10 member states, including Germany and the Benelux, more than half of the population relies on fossil energy for heating. District heating plays a major role in the Scandinavian and Baltic states as well as in member states such as Austria and Poland. In Scandinavia, district heating is largely renewable, whereas in other member states it remains heavily fossil-based. Poland and Czechia, for example, continue to rely heavily on coal in their district heating systems (European Commission et al., 2022).

Figure A2: Fossil fuels remain dominant for heating residential homes

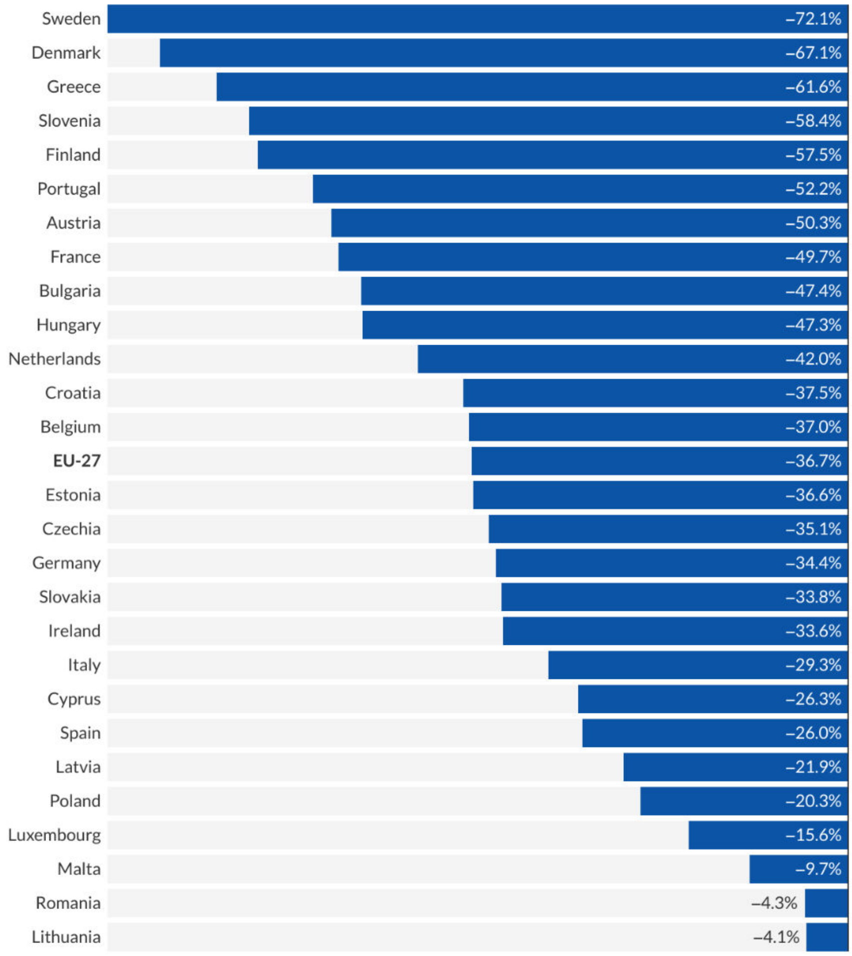


Notes: Gas, oil, coal, electricity, renewable energies, biomass, and logwoods categories account only for households with individual and central heating. Source: Authors' calculations based on synthetic population.

A.1.3 Progress in reducing carbon emissions in housing

Member states that have achieved substantial decarbonisation since 2005 generally show low housing emission intensities today (see Figure A3). By contrast, Luxembourg, despite being the EU's richest member state, has made limited progress and now has the most carbon-intensive building stock. Only Malta, Romania and Lithuania have reduced emissions even less since 2005. Among major emitters critical to EU-wide progress, Poland, Italy and Germany show below-average reductions of -20%, -29% and -34%, respectively, while France stands out as the only large member state to have halved building-related emissions

Figure A3: Member states have made uneven progress in reducing building-sector emissions (2005-2023)



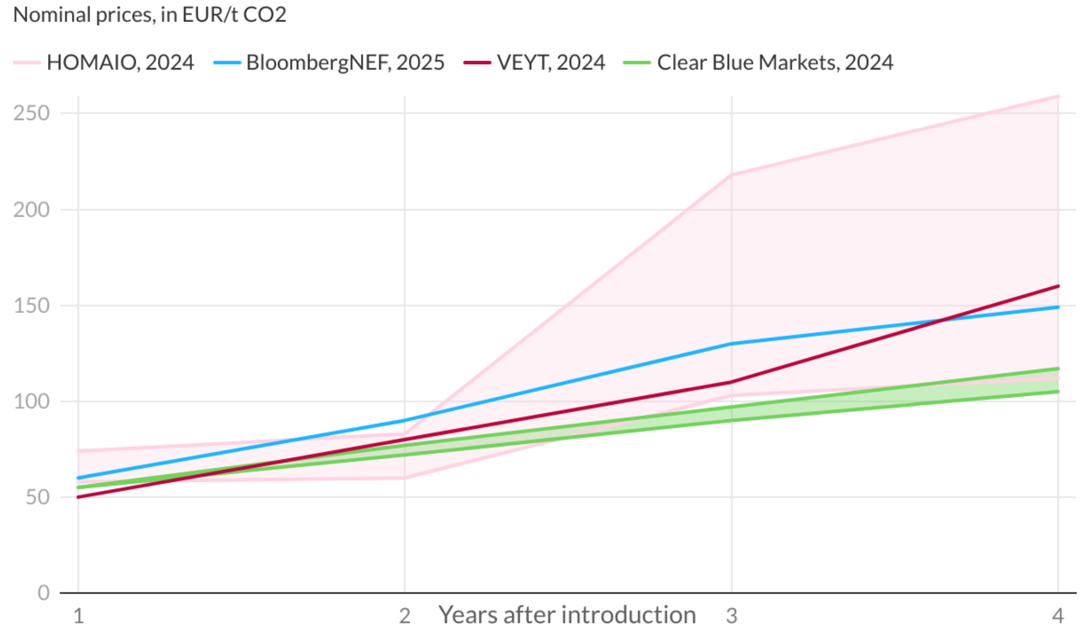
Notes: Reduction in national greenhouse gas emissions from the buildings sector by 2023 relative to 2005-levels. Source: European Environment Agency (EEA), 2025.

A.1.4 Carbon pricing: Developments and projections

As a market-based cap-and-trade system, ETS2 prices cannot be predicted precisely. Nevertheless, scientific and market-based projections provide a useful indication of likely trends (see Figure A4 for an overview). Because these projections do not yet reflect recent reforms to price-stabilisation mechanisms, they should be interpreted as an upper-bound price path.

Most projections suggest that the European Commission’s soft price cap of 45 EUR/t CO_2 in 2020 prices could be exceeded two to three years after the introduction of ETS2, triggering allowance releases from the Market Stability Reserve. Under the original rules, up to 20 million allowances per year could be released, with limited impact on prices. Recent reforms raise this volume to 80 million allowances, substantially strengthening the MSR’s ability to contain price increases above 45 EUR/t CO_2.

Figure A4: ETS2 carbon prices are likely to surge after a gentle start

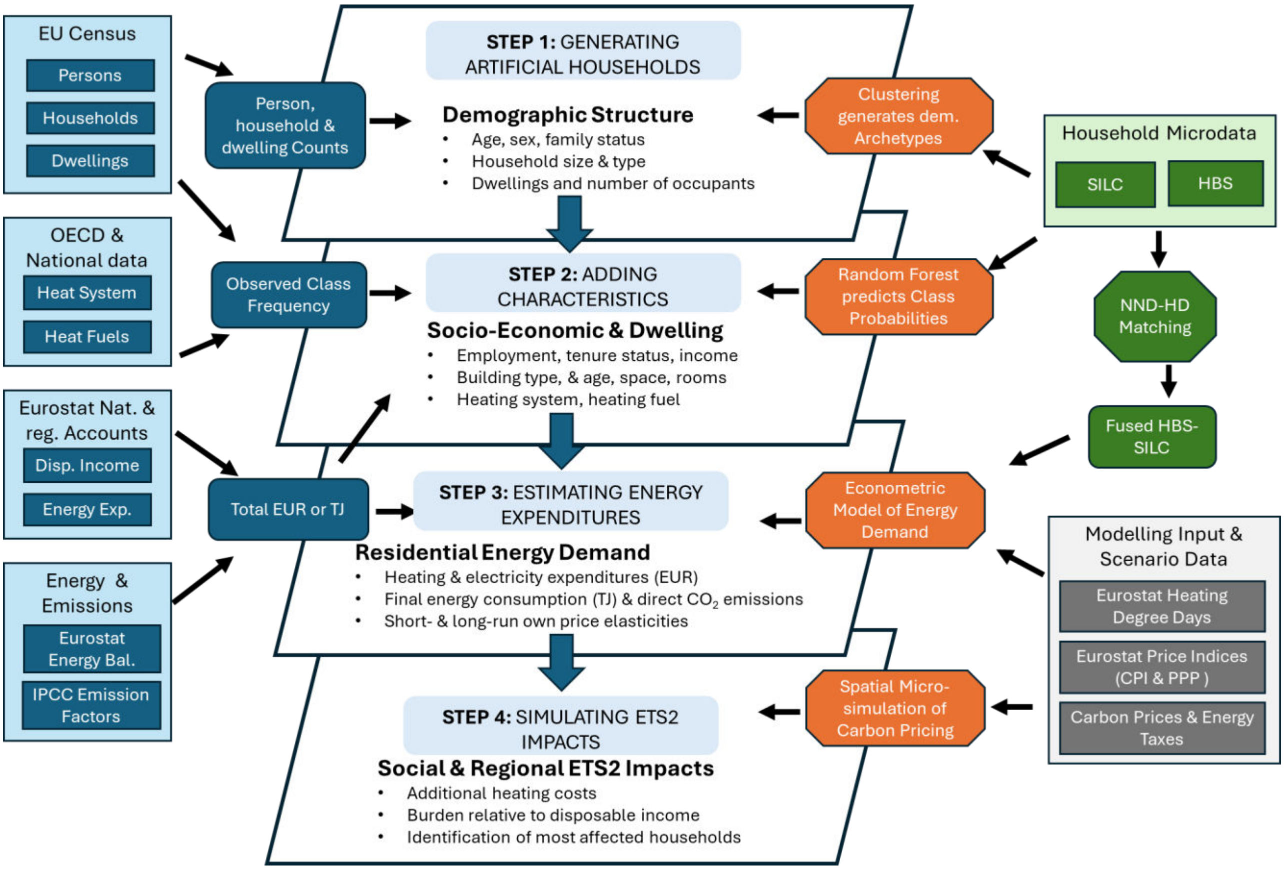


Notes: These price projections do not consider the latest reform of ETS2 market rules. Sources: HOMAIO, 2024; BloombergNEF, 2025; VEYT, 2024; Clear Blue Markets, 2024.

A.2 Synthetic population and methodological framework

Figure A5 provides an overview of the four main steps involved in generating the EU synthetic population data, steps 1 to 3 covering the creation of artificial households, the assignment of socio-economic and dwelling characteristics and the estimation of energy expenditure, and step 4 simulating the impacts of ETS2.

Figure A5: Overview of the framework for the synthetic population model



Source: Author's illustration.

Each of the first three steps involves two main components:

1. Estimating models using household microdata to predict the probability of specific outcomes for each household, such as the likelihood of being a homeowner.
2. Adjusting these predicted probabilities to match observed counts of the corresponding variables in each local population, such as the number of homeowners in a region.

The following section outlines the data sources used (Section A.2.1). Subsequently, the methodological procedures applied across the four steps are discussed (Section A.2.2).

A.2.1 Data

We constructed a synthetic EU population by integrating household microdata with subnational aggregate statistics. This section outlines the main data processing steps, highlights key gaps and inconsistencies and discusses conceptual differences across data sources.

Ideally, a harmonised panel of household microdata covering demographic and socio-economic characteristics, housing conditions, energy performance, income and expenditure on electricity and heating fuels would be available for all EU member states. In practice, these variables are spread across several datasets, primarily EU-SILC, the Survey on Income and Living Conditions, and the Household Budget Survey, with gaps in country coverage, years and variable definitions. In particular, definitions of primary heating fuel differ across datasets. To address these issues, we harmonised variables and statistically fused EU-SILC and HBS data using a matching algorithm (see Section A.2.1.1).

For aggregate constraints, we ideally require harmonised subnational data on population, households, dwellings, income and energy use at a common spatial resolution. Most non-energy variables are drawn from the 2021 EU Census, which provides rich cross-tabulations at varying spatial scales. Energy-related variables, such as heating systems, fuels and expenditure, were sourced from Eurostat, the OECD and national statistical offices, where coverage is often uneven and frequently limited to the national level (see Section A.2.1.2).

Section A.2.1.3 summarises remaining conceptual inconsistencies across input datasets, including differences in population counts, household definitions and heating fuel classifications. To estimate household responses to energy price shocks and to simulate ETS2 impacts, we also compiled data on consumer prices, energy prices and carbon prices (see Section A.2.1.4).

A.2.1.1 Household microdata

Most synthpop variables have been derived from EU-SILC waves from 2019 to 2023. EU-SILC was chosen because of its large sample sizes, recent coverage aligned with the 2021 census and detailed dwelling and heating variables. By contrast, the HBS suffers from gaps in country coverage, especially in 2020, and lacks several key housing variables. EU-SILC, however, does not report residential energy expenditure, which is essential for analysing ETS2 impacts.

To address this limitation, we constructed fused HBS-SILC datasets for 2010, 2015 and 2020, combining expenditure data from the HBS with income and dwelling characteristics from SILC. Table A1 summarises the variables used and the matching structure. EU-SILC serves as the donor dataset, providing disposable income, dwelling characteristics and, where available, higher regional resolution. Missing variables in the HBS have been imputed using a hot deck matching approach based on nearest-neighbour distances (see subsection c).

Table A1: Used variables from SILC and HBS microdata used in the fused data set

Name	Description	Var SILC	Var HBS	Fused HBS-SILC
rid	region ID	HB020	NUTS1	SILC
member state	ISO2 member state code	HB020	MEMBER STATE	SILC
rsize	Degree of urbanity	DB100	HA09	HBS
age	Age group	RB080	HB051, HB052, HB053, HB054, HB055, HB056, HB057 (hhs lvl var)	HBS
sex	Sex	RB090		
fst	Family status	derived from RB220, RB230, RB240		
hhs	Size of household	#hhs members	HB05	HBS
hht	Type of household	derived from RB220, RB230, RB240	HB075	HBS
eas	Economic activity status	RB210, RB211	HB0761 (hhs level var)	HBS
tenure	Tenure status	HH021	EUR_HE042	HBS
inc_disp	Disposable income	HY020	EUR_HH099	SILC
btype	Type of building	HH010		SILC
bage	Period of construction	HC005		
space	Floor space	HC020		
room	Number of rooms	HH030		SILC
heat	Type of heating system	HC001		
heatfuel	Primary heating fuel	HC002	derived from EUR_HE0451, EUR_HE0452 EUR_HE0453, EUR_HE0454, EUR_HE0455	HBS
elec_eur	Electricity expenditures		EUR_HE0451	HBS
heating_eur	Heating expenditures		sum of EUR_HE0452 EUR_HE0453, EUR_HE0454, EUR_HE0455	HBS
housing_eur	Total housing cost	HH070	EUR_HE042	HBS

Notes: Grey-shaded areas indicate joint matching variables in the HBS-SILC fusion.

a) Survey on income and living conditions (SILC)

EU-SILC data from multiple waves from 2019 to 2023 were pooled to increase statistical robustness and to exploit the 2023 ad hoc energy efficiency module, which provides key variables such as heating system, primary heating fuel, floor space and building age. Regional coverage varies widely across member states and years, with some countries lacking any subnational detail and others reporting censored variables (see Table A.2).

From the 2023 energy efficiency module, only the variables heat for type of heating system and heatfuel for primary heating fuel are consistently available across member states. Coverage of district heating varies considerably. Some member states omit information on the fuel used to generate district heat. Because district heating is not subject to ETS2 carbon pricing, households using it were recorded in heatfuel as category 5, renewable, biomass or district heating. Among variables with major gaps, only building age (bage), was retained, supported by regional census data (see Section A.2.1.2).

Table A2: Number of observations, regional detail and notable data gaps in SILC waves from 2019 to 2023

Member state	No. Obs	Regional granularity	Gaps
AT	61,549	NUTS1	rsize censored to 1 = dense & 3 = rural,
BE	77,817	NUTS1	
BG	86,417	NUTS1	
CY	53,663	NUTS0	
CZ	92,522	NUTS2	missing: bage
DE	272,755	NUTS1	rsize censored to 1 = dense & 3 = rural, hhs top-censored to 6+, missing: bage, rid in 2019, rsize in 2019, 2020
DK	66,259	NUTS0	
EE	71,056	NUTS0	rsize censored to 1 = dense & 3 = rural, missing: bage
EL	145,728	NUTS1	
ES	257,229	NUTS2	missing: bage
FI	110,815	NUTS2	
FR	159,520	NUTS2	missing: bage, rid in 2022, 2023
HR	97,175	NUTS0	
HU	82,083	NUTS1	
IE	55,375	NUTS0	missing: bage
IT	215,090	NUTS1	
LT	59,394	NUTS0	missing: bage
LU	48,003	NUTS0	
LV	63,224	NUTS0	rsize censored to 1 = dense & 3 = rural, missing: bage
MT	50,480	NUTS0	rsize censored to 1 = dense & 3 = rural in 2019, 2020, 2021
NL	148,040	NUTS0	missing: rsize, bage
PL	223,586	NUTS1	missing: bage
PT	151,481	NUTS2	
RO	83,735	NUTS1	
SE	91,896	NUTS1	missing: bage
SI	115,298	NUTS0	missing: rsize, bage
SK	68,782	NUTS0	

b) Household Budget Survey (HBS)

We used HBS waves from 2010, 2015 and 2020. Several variables were recoded or derived to ensure consistency with the synthetic population structure, including household composition and tenure status. The most critical challenge concerned identifying a household's primary heating fuel, as many households reported expenditure on multiple fuels and electricity use for heating is not directly observed.

To approximate a primary heating fuel consistent with EU-SILC, households spending less than one-third of total energy expenditure on heating fuels were classified as using electricity or renewables. Households above this threshold were assigned the dominant fuel based on expenditure shares. This threshold reflected the bimodal distribution of heating expenditure observed in many member states (see Section A.2.1.3). Coverage gaps remain in several HBS waves, notably for Austria, Romania, Poland and Sweden.

c) Fused SILC-HBS Data

HBS and SILC were fused using a nearest-neighbour hot deck algorithm, a standard approach in the literature (Eurostat, 2013). Matching variables included degree of urbanity, household size and composition, tenure status and total housing costs. For each HBS household, donor variables from SILC, such as disposable income, building type and number of rooms, were randomly drawn from the *k* nearest neighbours to preserve variability.

A.2.1.2 Aggregate subnational data

Aggregate data provided structural constraints for the synthetic population. The 2021 EU Census supplied detailed counts of persons, households and dwellings at multiple spatial levels. While municipality-level data were limited to basic demographics, NUTS2 and NUTS3 levels offered rich cross-tabulations linking demographic, socio-economic and housing characteristics.

To ensure internal consistency, household counts by size were scaled to match dwelling-based population totals, as the latter were fully consistent with census population figures across all member states. Additional constraints included tenure status, economic activity, building type and age, floor space and heating system type, applied at the highest spatial resolution available.

Heating fuel distributions were primarily sourced from the OECD Local Data Portal and supplemented by national statistics for member states not covered. Where necessary, data were harmonised across spatial scales and fuel categories. For Sweden, fuel shares were derived from final energy consumption rather than household counts.

A.2.1.3 Data gaps, member state particularities and limitations

Despite extensive harmonisation, several conceptual inconsistencies persist within and across data sources. These include discrepancies between census- and register-based population counts, divergent national definitions of households and household types and challenges in identifying primary heating fuels where multiple fuels are used simultaneously.

Population discrepancies are particularly pronounced in Bulgaria and Slovakia, while household definition differences affect a smaller but non-negligible share of households in member states such as Latvia, Poland and Romania. Mixed fuel use is widespread in several eastern member states, complicating the interpretation of “primary heating fuel” variables reported.

Table A3 summarises the main inconsistencies and their magnitude across member states. Where possible, adjustments were applied to ensure internal consistency and cross-country comparability.

Table A3: Inconsistencies and conceptual differences between data sources, in %

Member State	#Population	#Households	Large Cpl HHS	Multiple Fuels
AT	1.60	0.39	5.49	11.46
BE	1.63	1.72	2.55	8.60
BG	10.32	9.24	0.00	9.81
CY	-2.36	1.30	7.35	50.87
CZ	5.91	6.82	3.44	34.45
DE	2.95	0.04	4.74	8.77
DK	2.35	0.10	3.44	18.78
EE	1.20	0.81	0.00	17.11
EL	4.82	0.42	6.37	23.97
ES	1.03	0.05	0.00	13.33
FI	2.65	0.01	2.11	10.98
FR	5.40	17.94	0.00	12.59
HR	6.17	0.17	7.88	34.87
HU	4.13	0.10	0.00	52.45
IE	-0.61	0.03	0.00	26.37
IT	2.81	1.72	4.12	15.54
LT	0.39	0.16	6.52	47.43
LU	0.90	0.81	8.28	10.68
LV	4.48	1.68	11.47	74.21
MT	1.49	0.02	0.87	0.34
NL	6.23	6.51	1.35	1.84
PL	5.82	0.00	14.06	32.22
PT	1.45	0.22	6.13	7.81
RO	3.39	4.09	12.96	14.20
SE	3.89	2.97	3.22	0.15
SI	4.85	18.75	5.38	18.53
SK	8.25	11.42	0.00	49.97

Notes: Columns show (1) the deviation of the synthetic population from register-based Eurostat population data, (2) the deviation in household counts relative to census data, (3) the share of couple households with more than two members and (4) the share of households reporting expenditure on more than one heating fuel.

A.2.1.4 Model input and scenario data

Additional model inputs included consumer prices, energy prices, taxes and carbon pricing. Consumer Price Indices and Comparative Price Level Indices from Eurostat were combined to construct consistent cross-country time series by energy carrier. Heating degree days were sourced from Eurostat at the NUTS3 level.

Retail prices for fossil heating fuels were compiled at member-state level and complemented by VAT rates and existing national carbon prices. Fuel-specific price impacts of carbon pricing were calculated using standard emission factors, enabling conversion from EUR/t CO_2 to EUR/kWh. Table A4 summarises existing national carbon prices as of June 2025.

Table A4: Existing national carbon prices in EU27

Member state	Carbon price [EUR/t CO_2]	Carbon price [EUR/kWh] Gas oil	Natural gas	Coal	Source
AT	55.00	0.01451	0.01012	0.01873	Herndler, 2025
DE	55.00	0.01451	0.01294	0.02145	Bundesministerium für Wirtschaft und Energie, 2025
DK	100.00	0.02639	0.0184	0.03406	Den Danske Regering, 2022
FI	147.81 (coal), 64.00 (gas, oil)	0.01481	0.01294	0.02145	Vero - Finnish Tax Administration, 2022
FR	44.60	0.01177	0.00821	0.01519	Connaissance des Énergies, 2024
IE	63.50	0.01676	0.01168	0.02163	Citizens Information Board, 2024
LU	40.00	0.01056	0.00736	0.01362	The Luxembourg Government, 2024
PT	67.40	0.01779	0.0124	0.02295	Secretária de Estado dos Assuntos Fiscais, 2024
SE	134.00	0.03536	0.02466	0.04564	Regeringskansliet, 2018

Notes: Retail household fuel prices and VAT rates were compiled at member-state level, with prices from Q1 2024 unless stated otherwise. Gas oil prices are from the European Commission's Weekly Oil Bulletin (European Commission, 2025b); natural gas prices from the European Commission (European Commission, 2024), with missing values imputed using neighbouring-country averages and data from myLPG.eu (2025) used for Malta and Cyprus where no gas grid exists. Coal prices are based on national data for Poland and otherwise on import-unit values for anthracite from WITS (Comtrade, 2025), representing lower-bound estimates, with remaining gaps filled using neighbouring-country averages. Existing national carbon prices were collected from multiple sources. Fuel-specific price effects were derived using standard emission factors (Sustainable Energy Authority of Ireland, 2024), cross-checked with (Juhrich, 2022) and the Winnipeg Sewage Treatment Program (2012) to convert €/t CO_2 into €/kWh, with VAT applied to the ETS2 carbon-price increment (European Commission, 2025a).

A.2.2 Creating a synthetic EU population

As illustrated in Figure A5, for each variable to be added to the synthetic population, we first use statistical models for predicting initial variable outcomes, which are afterwards reconciled with regional aggregate data using iterative proportional fitting, IPF. A detailed description of our general approach and the IPF algorithm is provided in Section A.2.1.1. Afterwards, we provide details on the four major steps:

1. Local demographic structure: Regional distributions of household archetypes were estimated and reconciled with census counts using iterative proportional fitting, IPF, see Section A.2.2.2.
2. Socio-economic, housing and energy variables: Socio-economic characteristics, such as economic activity, tenure and income, as well as housing and energy attributes were assigned using random forest models and adjusted to regional aggregates via IPF, see Section A.2.2.3.
3. Energy demand and expenditures: Household shares of heating expenditures in disposable income were estimated econometrically, see Section A.2.2.4.
4. Price shocks and microsimulation: Country- and fuel-specific ETS2 price shocks were applied using household-specific price elasticities, yielding distributional impacts, see Section A.2.2.5.

A.2.2.1 Iterative proportional fitting and overall synthesis logic

The objective was to approximate the joint distribution of demographic variables x, socio-economic variables y and other attributes z at the regional level:

$$p(x, y, z) = p(x)\, p(y|x)\, p(z|x, y), \tag{1}$$

where $p(x)$ denotes the distribution of demographic household archetypes and $p(y|x)$ and $p(z|x, y)$ are conditional distributions (see Münnich et al., 2021).

Because these distributions are not directly observable, we first predicted the frequency of demographic household archetypes $q(x)$ as well as conditional probabilities $q(y|x)$ and $q(z|x, y)$ using household microdata. n their own, these predictions would merely replicate sample properties and may fail to reflect regional correlations or aggregate statistics. At the same time, census and administrative data provide partial information on marginal and joint distributions at different spatial levels.

To ensure consistency with observed regional data, we adjusted the model-based predictions to multiple constraints using IPF (Fienberg, 1970; Jaynes, 1957). IPF modifies predicted distributions so that they match multiple observed regional totals, such as population counts by age and sex or household counts by size and type, while remaining as close as possible to the original model estimates.

Table A5 summarises all regional data constraints applied in constructing the synthetic population. Dependent variables constrained by each dataset are shown in bold. For constraints applied to conditional distributions, non-bold variables refer to characteristics generated in earlier synthesis steps.

Table A5: Summary of data constraints on the EU synthetic population

No	Source	Unit	Regional granularity	Variables	Availability by member state	Year	Processing steps
1	Census	#hhs	NUTS3	**hhs, hht**	all	2021	scaled to number of dwellings by number of occupants at NUTS3
2	Census	#person	NUTS3	**age, sex, fst**	all	2021	
3	Census	#person	NUTS3	**age, sex, hst**	all	2021	
4	Census	#person	LAU	**age, sex**	all	2021	
5	Census	#hhs	LAU	**hhs**	all	2021	scaled to constraint 1
6	Census	#hhs	LAU	**hht**	all	2021	scaled to constraint 1
7	Census	#hhs	NUTS2	**eas**, age, sex, fst	all	2021	share of eas outcomes (EMP, UNE, INAC) by age, sex, fst from census applied to #persons by age, sex, fst in synthpop
8	Census	#hhs	NUTS3	**tenure**, hhs, hht	all	2021	share of tenure outcomes (OWN, RENT) by hht, hhs from census applied to #hhs by hhs, hht in synthpop
9	Census	#dwelling	NUTS2	**btype**, hhs, tenure	all	2021	share of btype outcomes (RES1, RES2, RES_GE3) by #occupants and tenure from census applied to #hhs by tenure, hhs in synthpop

No	Source	Unit	Regional granularity	Variables	Availability by member state	Year	Processing steps
10	Census	#dwelling	LAU	**btype**	all	2021	share of btype outcomes (RES1, RES2, RES_GE3) from census applied to #dwellings in synthpop
11	Census	#dwelling	NUTS3	**bage**, btype	all	2021	share of bage outcomes (Y_LT1946, Y_1946-1960, Y_1961-1980, Y_1981-2000, Y_GT2001) by btype from census applied to #dwellings by btype in synthpop
12	Census	#dwelling	NUTS3	**btype**, hhs, space	all, but BE, IE, FR, CY, HU, LU, MT, PL, SK	2021	share of space outcomes (SQM_LT30, SQM_30-39, SQM_40-49, SQM_50-59, SQM_60-79, SQM_80-99, SQM_100-119, SQM_120-149, SQM_GT150) by btype and #occupants from census applied to #hhs by btype, hhs in synthpop
13	Census	#dwelling	NUTS2	**heat**	all	2021	share of heating types (1+2, 3, 4) in #dwellings from census applied to #hhs in synthpop
14	OECD	#dwelling	LAU	**heat**	CZ, DE, DK, FI, FR, HU, IE, LU, NL, SK	2019-2022	share of fuels (1, 2, 3, 4, 5) in #dwellings applied to #hhs with central or indivdual heating (2|3) in synthpop
15	OECD	#dwelling	LAU	**heatfuel**	CZ, DE, DK, FI, FR, HU, IE, LU, NL, SK	2019-2022	share of fuels (1,2,3,4,5) in #dwellings applied to #hhs with central|indivdual heating (2|3) in synthpop
16	Statistics Austria	#dwelling	NUTS2	**heatfuel**	AT	2021	share of fuels (1, 2, 3, 4, 5) in #dwellings applied to #hhs with central or indivdual heating (2|3) in synthpop
17	Statistics Italy	#dwelling	NUTS2	**heatfuel**	IT	2021	share of fuels (1, 2, 3, 4, 5) in # dwellings applied to #hhs with central or indivdual heating (2|3) in synthpop
18	Statistics Sweden	MWh	LAU	**heatfuel**	SE	2021	share of fuels (1, 2, 3, 4, 5) in #dwellings applied to #hhs with central or indivdual heating (2|3) in synthpop
19	Statistics Romania	#dwelling	NUTS3	**heatfuel**	RO	2021	share of fuels (1, 2, 3, 4, 5) in #dwellings applied #hhs with central or indivdual heating (2|3) in synthpop
20	Statistics Poland	#dwelling	NUTS3	**heatfuel**	PL	2021	share of fuels (1, 2, 3, 4, 5) in #dwellings applied to #hhs with central or indivdual heating (2|3) in synthpop
21	Statistics Spain	#dwelling	LAU	**heatfuel**	ES	2021	share of fuels (1, 2, 3, 4, 5) in #dwellings applied to #hhs with central or indivdual heating (2|3) in synthpop
22	Eurostat	EUR	NUTS2	**inc_disp**	all	2020	sum of disposable income of all households in NUTS2 synthpop scaled to Eurostat total disposable household income (B6N)
23	Eurostat	EUR	NUTS0	**en_cost**	all	2020	sum of energy expenditures of all households in member state synthpop scaled to Eurostat SNA total household expenditures (COICOP 045)
24	Eurostat	TJ	NUTS0	**en_cons_TJ**	all	2020	sum of final energy consumption for electricity and heating fuels in member state synthpop scaled to totals in energy balances

Notes: Dependent variables appear in boldface.

A.2.2.2 Step 1: Setting up the local demographic structure

We first constructed synthetic households by size and type for each municipality and assigned demographic characteristics to household members so that local population size and structure matched the 2021 census.

To this end, we derived demographic household archetypes from EU-SILC using a clustering approach (Meraner et al., 2016; Többen et al., 2023). In total, more than 15,000 unique archetypes were identified, combining household type and size with the age, sex and family status of members. EU-SILC defined the set of feasible household–person combinations, avoiding implausible configurations. Because the number of possible combinations grows rapidly with household size, we retained only combinations observed in EU-SILC by member state rather than enumerating all theoretical possibilities.

Empirical archetype frequencies were then adjusted to regional census totals using IPF. We retained 66 household type–size categories and 40 person archetypes. The resulting distribution of archetypes was highly skewed. Larger and less restrictive household types, such as multi-person households, allowed substantially more demographic combinations than smaller or more structured types, such as couples with young children. Table A6 summarises the number of unique archetypes by household type and size.

Table A6: Unique demographic archetypes for household type – size combinations

Type of household	Household size					
	1	2	3	4	5	6+
Single	10					
Couple (no children)		33	171	194	54	21
Couple (young children)			75	158	193	550
Couple (old children)			34	49	53	21
Lone parent (young children)		24	293	843	1271	2165
Lone parent (old children)		33	256	408	187	86
Multi-family			125	498	784	1256
Multi-person		103	580	1372	1436	2261
Institutional	12					

Source: Authors' computations.

Demographic constraints were applied using census data at both municipality, LAU, and county, NUTS3, levels. At the NUTS3 level, cross-tabulations were available for household and person archetypes, while at the LAU level only marginal distributions, persons by age and sex and households by size and type, could be used. IPF was therefore implemented jointly for each NUTS3 region and its municipalities to exploit all available information across spatial scales.

Finally, because household counts by size were inconsistent with person counts in several member states, household totals were scaled to dwelling counts by number of occupants at the NUTS3 level, which were fully consistent across member states.

A.2.2.3 Step 2: Adding socio-economic and housing variables

In the second step, we enriched the synthetic population with socio-economic variables, economic activity status, tenure and disposable income, as well as dwelling attributes including building type, floor space, heating system and primary heating fuel.

For each variable, we estimated random forest classifiers using EU-SILC data to predict class probabilities at the person or household level. Predictions were conditioned on demographic, household and regional characteristics and were then adjusted to match observed regional distributions using IPF. Most socio-economic and housing constraints were derived from the 2021 census, while heating systems and fuels were constrained using data from the OECD Local Data Portal and national statistical offices.

Variables were assigned sequentially, each conditional on previously generated characteristics and constrained to regional aggregates, following the availability of cross-tabulations:

1. Economic activity status and tenure, using rich cross-tabulations with demographics at the NUTS3 and NUTS2 levels
2. Building characteristics, type, age and floor space, linked to household size and tenure
3. Heating system and primary heating fuel, using census data at the NUTS2 level and OECD and national data at finer spatial scales
4. Disposable income, scaled to NUTS2 income totals

For each member state, random forest classifiers estimated conditional class probabilities:

$$q_i^r\left(yy_i = Y_j | x\right) = \mathrm{RF}(y_{SILC} | x_{SILC}) \tag{2}$$

where q_i^r denotes the probability that household or person i in region r belongs to class Y_j, given a vector of characteristics x. Models are trained with 500 trees, 5-fold cross-validation, an 80/20 train-test split, and Gini impurity as the accuracy criterion. The resulting predicted distributions are reconciled with regional aggregates using IPF.

Table A7 summarises model specifications, covariate importance and prediction errors. Demographic variables dominate predictions of economic activity status, while geographic and building characteristics are most influential for heating systems and primary fuels. In general, demographic variables are more informative than socio-economic variables, except for energy-related variables, where building attributes and regional context play a larger role.

Table A7: Specifications, relative variable importance and prediction errors of random forest models

	dependent variable							
	eas	tenure	btype	bage	space	heat	heatfuel	inc_disp
year	0.0326	0.0664	0.0331	0.0000	0.0693	0.0000	0.0000	0.0000
rid	0.0140	0.0402	0.0501	0.0440	0.0405	0.0550	0.0473	0.0530
rsize	0.0136	0.0728	0.2488	0.0584	0.0450	0.0779	0.0979	0.0638
gdp_rel	0.0253	0.0747	0.2116	0.0906	0.0696	0.1013	0.1159	0.1002
age	0.4297							
sex	0.0240							
fst	0.1071							

	dependent variable							
	eas	tenure	btype	bage	space	heat	heatfuel	inc_disp
hht	0.0559	0.1943	0.0703	0.1384	0.1138	0.0774	0.0884	0.1459
hhs	0.0612	0.1501	0.0773	0.1008	0.0939	0.0608	0.0694	0.1280
n_LT15	0.0377	0.1345	0.0243	0.0676	0.0418	0.0361	0.0439	0.0733
n_GE65	0.1901	0.1335	0.0359	0.1114	0.0587	0.0435	0.0545	0.0865
n_active		0.0550	0.0462	0.1195	0.0829	0.0661	0.0780	0.1315
n_unemp		0.0784	0.0161	0.0498	0.0377	0.0440	0.0279	0.0606
tenure			0.1860	0.0788	0.0807	0.0553	0.0429	0.0605
btype				0.1407	0.1980	0.3117	0.1098	0.0970
bage					0.1153	0.1194	0.1110	
heat							0.1584	
prediction error	0.1533	0.1391	0.2180	0.4840	0.5653	0.1794	0.2576	0.9601

Notes: gdp_rel is the ratio of regional GDP per capita to that of the corresponding member state

After prediction, class probabilities were adjusted to census and other regional constraints using IPF. Because the number of households and persons in the synthetic population could deviate slightly from census totals, all constraints were rescaled to the corresponding synthetic population counts at the relevant spatial level. For example, census shares of economic activity status by age, sex and family status were applied to the synthetic population with the same characteristics, while dwelling-based shares were applied under the assumption that each household occupied one dwelling.

A.2.2.4 Step 3: Econometric model of residential energy consumption

Residential energy consumption was modelled using two separate econometric demand equations, one for heating fuels and one for electricity. Following the household demand literature (Tovar Reaños and Wölfing, 2018), the dependent variables were the shares of heating and electricity expenditure in disposable income.

We estimated flexible Engel curve specifications in which budget shares depended on income, energy prices and household, dwelling and geographic characteristics:

$$s_i = \alpha_{i,cou} + \sum_l \alpha_l z_l + \sum_{r=1}^{R=4} \beta_r \, log(y)^r + \gamma_0 log(p_i) + \sum_{r=1}^{R=4} \gamma_r \, log(y)^r log(p_j) + \sum_l \theta_l \, z_l \, log(p_j) + \varepsilon \quad (3)$$

where y denotes disposable income, p_i the relevant energy price index, and z_l a set of geographic, socio-economic and housing characteristics. Prices entered directly and through interactions with income and selected household and dwelling characteristics.

The model controls for:

1. Income: Nonlinear Engel curves specified by a fourth-degree polynomial in log disposable income.
2. Energy prices: Electricity or heating fuel price indices.
3. Household and dwelling characteristics: Including household type and size, tenure, building type and age, and floor space.

4. Geographic characteristics: Including degree of urbanity, population density and heating degree days.

To capture heterogeneity in behavioural responses, we included interaction terms between prices and income as well as between prices and selected household and dwelling characteristics. These interactions allowed us to derive household-specific income and price elasticities, which were essential for the microsimulation of ETS2 impacts. Interactions were restricted to variables expected to affect households' capacity to respond to price changes.

Because heating expenditure often spanned multiple fuels, we applied Lewbel's method (Lewbel, 1989) to construct household-specific heating price indices. These are computed as expenditure-share-weighted averages of fuel-specific price indices.

We computed household-specific prices for heating by taking a weighted average of fuel price indices, using each fuel's share of total heating expenditure as the weight.

a) Estimation results

Table A8 reports estimation results for both models. Both showed good explanatory power, with adjusted R-squared values of 0.51 for heating fuels and 0.59 for electricity. Most coefficients were statistically significant and had the expected signs.

A few exceptions are noteworthy. Country–fuel fixed effects were estimated less precisely where specific fuels were rarely used. Price interactions with household type and density were weaker in the heating model and insignificant in the electricity model, as was the interaction between electricity prices and building type. Overall, demographic and dwelling characteristics play a central role in shaping energy demand, while price interactions capture meaningful heterogeneity in household responses.

Table A8: Estimation results for heating fuel and electricity models

term	heating fuels	electricity
intercept	-8.4446 *** (1.1919)	-4.4065 *** (0.5367)
year	-0.0037 *** (0.0003)	
country x fuel (mean)	0.0174 * (0.0033)	-0.0062 * (0.0005)
rsize (mean)	-0.0019 *** (0.0002)	-0.0003 *** (0.0001)
hht (mean)	0.0142 *** (0.0013)	0.0183 *** (0.001)
btype (mean)	-0.0013 *** (0.0002)	-0.0009 *** (0.0001)
tenure	-0.0068 *** (0.0002)	-0.0037 *** (0.0001)
hdd	-0.0001 *** (0.0000)	-0.0001 *** (0.0000)
n_GE65	0.0022 *** (0.0001)	0.0004 *** (0.0001)
n_active	0.0016 *** (0.0001)	0.0022 *** (0.0001)

term	heating fuels	electricity
density	0.0005 *** (0.0001)	0.0011 *** (0.0001)
y	3.8099 *** (0.489)	2.3068 *** (0.224)
y^2	-0.6103 *** (0.075)	-0.4053 *** (0.0349)
y^3	0.0421 *** (0.0051)	0.0299 *** (0.0024)
y^4	-0.0011 *** (0.0001)	-0.0008 *** (0.0001)
p_elec	0.0036 *** (0.0005)	8.0097 *** (1.8677)
p_heating	25.6938 *** (3.0677)	-0.0064 *** (0.0003)
y x p_i	-11.1384 *** (1.2617)	-3.5062 *** (0.776)
y^2 x p_i	1.795 *** (0.1941)	0.5763 *** (0.1206)
y^3 x p_i	-0.1275 *** (0.0132)	-0.0419 *** (0.0083)
y^4 x p_i	0.0034 *** (0.0003)	0.0011 *** (0.0002)
hht x p_i	0.0068 * (0.0039)	0.0077 (0.0023)
btype x p_i	0.0022 *** (0.0005)	0.0002 (0.0003)
tenure x p_i	-0.0023 *** (0.0005)	-0.0038 *** (0.0003)
density x p_i	-0.0007 ** (0.0003)	-0.0001 (0.0002)
Res. std. error:	0.0339	0.0245
Degrees of Freedom	511627	515053
Adjusted R-squared	0.5057	0.5853

Notes: *** denote p-values < 0.1%, ** denote p-values < 1%, * denote p-values < 5%. The time fixed effect is omitted in the electricity model because electricity prices vary only by country and year. Including both a country–fuel fixed effect and a time fixed effect would induce multicollinearity.

A.2.2.5 Step 4: Microsimulation of energy price shocks

In the final step, we translated ETS2 carbon price scenarios into country- and fuel-specific price shocks, accounting for existing national carbon prices, energy taxes and VAT. These price shocks were then applied to the synthetic population to simulate household-level impacts and behavioural responses.

Using the econometric results from step 3, we simulated ETS2 effects for about 188 million EU households. Impacts were measured as changes in household energy expenditure, accounting for demand responses driven by household-specific own-price elasticities. We distinguished between short-run and long-run responses and differentiated price shocks by fuel type and member state.

Demand responses were modelled using household-specific own-price and expenditure elasticities. Cross-price effects were not considered. For each household *h*, the own price elasticity for energy category *i* was derived from the estimated budget share equation:

$$OPE_{i,h} = \{\frac{\partial s_{i,h}}{\partial logp_i}\frac{1}{s_{i,h}}\} - 1 = \frac{(\gamma_0 + \sum_r \gamma_r y + \sum_l \theta_l z_l)}{s_{i,h}} - 1 \quad (4)$$

where $s_{i,h}$ denotes the budget share of heating or electricity, and elasticities depend on household income and characteristics.

Because the econometric model was estimated using data spanning a decade, the resulting elasticities were interpreted as long-run elasticities, reflecting both behavioural adjustments and structural changes, such as changes in heating systems or building efficiency. Short-run elasticities were obtained by scaling long-run elasticities using fuel-specific ratios from a meta-analysis (Labandeira et al., 2017):

Gas: 0.39
Oil: 0.32
Solid fuels: 0.37

This implies that short-run responses are roughly one-third of long-run responses.

We considered two ETS2 carbon price scenarios: 60 and 180 EUR/t CO_2. Fuel- and country-specific price increases were derived following the approach in Section A.1.2.3, incorporating existing national carbon prices, energy taxes and VAT.

Table A9 reports relative price increases by member state and heating fuel. Price impacts were smallest for gas and largest for coal, reflecting differences in emission factors. In the 60 EUR/t scenario, variation was largely driven by pre-existing national carbon prices, with some member states experiencing price reductions where national carbon pricing already exceeded the ETS2 level.

Table A9: Relative price increases by heat fuel, member state and CO_2 price level

	Gas		Oil		Coal	
Member state	60 EUR/t CO_2	180 EUR/t CO_2	60 EUR/t CO_2	180 EUR/t CO_2	60 EUR/t CO_2	180 EUR/t CO_2
AT	0.9	21.4	1.4	35.9	2.3	56.8
BE	6.6	19.9	17.4	52.1	48.1	144.3
BG	20.4	61.2	17.8	53.3	68.1	204.4
CY	13.9	41.7	19.4	58.3	16.9	50.6
CZ	11.9	35.7	20.5	61.5	38.7	116.1
DE	1	24.5	1.5	38.3	4.5	113.5
DK	-8.3	16.5	-7.6	15.3	-15.6	31.1
EE	18.4	55.2	17.8	53.4	37.2	111.5
EL	13.9	41.7	16.2	48.7	68.1	204.4
ES	13	38.9	20.2	60.6	51.1	153.3
FI	-1.7	17.7	0.9	29.6	-1.2	45.6
FR	2.9	25.5	4.3	37.4	10.8	94.6
HU	31.6	94.7	13.5	40.4	31.4	94.3
HR	30	89.9	21.4	64.2	39.9	119.6
IE	-0.5	16.7	-1.1	37.4	-2.5	83.5
IT	10.4	31.3	13.7	41	68.1	204.4
LT	9	27	21.8	65.3	8.5	25.5
LU	4.6	32.4	6.4	45.1	6.6	46.5
LV	13.7	41	17	50.9	5.8	17.3
MT	20.8	62.3	20.6	61.8	2	6.1
NL	8.1	24.2	18	54	68.1	204.4

	Gas		Oil		Coal	
Member state	60 EUR/t CO_2	180 EUR/t CO_2	60 EUR/t CO_2	180 EUR/t CO_2	60 EUR/t CO_2	180 EUR/t CO_2
PL	18.6	55.9	17.4	52.3	41.9	125.8
PT	-1	15.3	-1.5	22.4	-8	122.7
RO	23.4	70.2	20.3	60.8	65.4	196.2
SE	-8	4.9	-20.4	12.7	-36	22.4
SI	13.3	39.9	17.6	52.9	35.5	106.6
SK	15.6	46.7	24.7	74	40.9	122.6

Household impacts were measured as changes in heating expenditures after accounting for demand responses. Given a household-specific elasticity OPE_h and a relative price change $\Delta p(scen)$, the quantity adjustment is:

$$\Delta exp_h = exp_h * (1 + \Delta p(scen)^{OPE_h}) \quad (5)$$

where exp_h denotes baseline expenditures. This captures the change in consumption at constant prices.

Total heating expenditures at new prices was then calculated as:

$$exp_h(scen) = (exp_h + \Delta exp_h) * \big((1 + \Delta p(scen)\big) \quad (6)$$

and the additional costs imposed by ETS2 were therefore:

$$cost_h(scen) = exp_h(scen) - exp_h \quad (7)$$

A.3 Results by region

Table A10: Results by NUTS3 region

NUTS3	Region	Fossil heaters (%)	Avg. additional heating costs (€) ETS2 60 EUR/t	ETS2 180 EUR/t
AT111	Mittelburgenland	34.1	12.72	305.71
AT112	Nordburgenland	35.5	12.67	303.43
AT113	Südburgenland	35.0	12.38	297.30
AT121	Mostviertel-Eisenwurzen	29.4	12.84	309.58
AT122	Niederösterreich-Süd	31.3	12.08	290.75
AT123	Sankt Pölten	38.8	10.94	259.57
AT124	Waldviertel	30.4	12.06	291.18
AT125	Weinviertel	31.1	13.28	320.96
AT126	Wiener Umland/Nordteil	31.7	13.45	323.67
AT127	Wiener Umland/Südteil	37.8	11.67	277.51
AT130	Wien	26.1	8.29	192.67
AT211	Klagenfurt-Villach	21.0	15.98	393.25
AT212	Oberkärnten	26.7	15.61	386.02
AT213	Unterkärnten	27.2	17.42	430.33
AT221	Graz	22.3	14.31	348.03
AT222	Liezen	25.1	14.45	356.11
AT223	Östliche Obersteiermark	24.1	14.62	358.93
AT224	Oststeiermark	25.8	18.56	456.89
AT225	West- und Südsteiermark	25.8	17.69	435.42
AT226	Westliche Obersteiermark	25.5	14.30	351.89
AT311	Innviertel	25.0	15.75	384.93
AT312	Linz-Wels	23.6	12.40	299.13
AT313	Mühlviertel	24.5	15.24	372.64
AT314	Steyr-Kirchdorf	29.3	12.45	300.43
AT315	Traunviertel	25.9	14.86	362.48
AT321	Lungau	23.0	15.14	374.55
AT322	Pinzgau-Pongau	21.3	14.86	366.17
AT323	Salzburg und Umgebung	20.3	15.50	379.23
AT331	Außerfern	32.1	15.44	380.87
AT332	Innsbruck	24.2	12.93	316.93
AT333	Osttirol	33.6	14.28	352.85
AT334	Tiroler Oberland	33.2	14.41	356.27
AT335	Tiroler Unterland	32.1	14.73	361.72
AT341	Bludenz-Bregenzer Wald	26.4	13.89	340.12
AT342	Rheintal-Bodenseegebiet	23.5	16.48	402.80
BE100	Arr. de Bruxelles-Capitale/Arr. Brussel-Hoofdstad	80.4	64.14	188.35
BE211	Arr. Antwerpen	86.3	80.72	236.90
BE212	Arr. Mechelen	86.1	90.29	264.74
BE213	Arr. Turnhout	85.5	94.80	277.78
BE223	Arr. Tongeren	86.5	98.89	289.39
BE224	Arr. Hasselt	83.5	79.43	233.57
BE225	Arr. Maaseik	85.7	103.71	303.29
BE231	Arr. Aalst	85.6	96.72	283.26
BE232	Arr. Dendermonde	85.6	97.98	286.93
BE233	Arr. Eeklo	83.9	104.65	305.97
BE234	Arr. Gent	85.6	85.19	249.93
BE235	Arr. Oudenaarde	84.1	108.68	317.69
BE236	Arr. Sint-Niklaas	78.9	80.24	236.09
BE241	Arr. Halle-Vilvoorde	87.0	95.63	280.62
BE242	Arr. Leuven	84.0	81.53	239.77
BE251	Arr. Brugge	87.5	72.00	211.90
BE252	Arr. Diksmuide	82.6	110.92	323.78
BE253	Arr. Ieper	84.5	110.79	323.44
BE254	Arr. Kortrijk	87.0	81.42	239.20
BE255	Arr. Oostende	85.2	80.30	235.32
EL631	Αιτωλοακαρνανία	63.0	102.64	298.93
EL632	Αχαΐα	72.6	87.31	254.42
EL633	Ηλεία	61.3	104.87	305.43
EL641	Βοιωτία	68.1	111.19	324.30
EL642	Εύβοια	73.0	102.27	297.77
EL643	Ευρυτανία	65.0	93.68	273.05
EL644	Φθιώτιδα	68.5	98.31	286.46
EL645	Φωκίδα	65.1	98.09	285.93
EL651	Αργολίδα, Αρκαδία	67.6	99.46	289.81
EL652	Κορινθία	71.7	102.31	298.15
EL653	Λακωνία, Μεσσηνία	65.2	101.85	296.81
ES111	A Coruña	49.1	89.97	260.77
ES112	Lugo	73.2	97.50	282.89
ES113	Ourense	66.0	101.12	293.24
ES114	Pontevedra	61.9	113.35	328.11
ES120	Asturias	62.7	80.47	233.29
ES130	Cantabria	63.5	71.53	207.88
ES211	Araba/Álava	85.0	63.34	185.01
ES212	Gipuzkoa	68.8	73.04	213.06
ES213	Bizkaia	71.3	85.73	249.65
ES220	Navarra	84.4	73.41	213.98
ES230	La Rioja	85.5	66.67	194.18
ES241	Huesca	81.9	76.17	221.73
ES242	Teruel	80.1	81.87	238.29
ES243	Zaragoza	83.7	78.22	227.56
ES300	Madrid	76.5	68.38	199.67
ES411	Ávila	77.5	76.91	223.40
ES412	Burgos	81.6	59.75	174.13
ES413	León	70.5	75.97	220.53
ES414	Palencia	82.4	60.92	177.58
ES415	Salamanca	72.3	85.86	248.94
ES416	Segovia	60.9	84.33	244.96
ES417	Soria	70.4	88.33	256.14
ES418	Valladolid	82.5	62.14	181.09
ES419	Zamora	72.7	75.33	218.93
ES421	Albacete	70.7	82.68	239.98
ES422	Ciudad Real	70.6	89.27	259.00
ES423	Cuenca	72.5	86.63	251.35
ES424	Guadalajara	72.1	63.95	186.29
ES425	Toledo	65.1	83.03	241.22
ES431	Badajoz	44.5	89.30	259.02
ES432	Cáceres	56.3	82.63	239.77
ES511	Barcelona	62.7	63.84	186.23
ES512	Girona	53.4	69.76	203.45
ES513	Lleida	55.1	57.58	168.08
ES514	Tarragona	40.7	79.96	232.58
ES521	Alicante/Alacant	18.0	88.61	256.50
ES522	Castellón/Castelló	14.5	83.15	241.06
ES523	Valencia/València	36.1	78.81	228.71
ES531	Eivissa y Formentera	30.6	85.55	248.15
ES532	Mallorca	2.9	119.19	342.80
ES533	Menorca	54.1	199.75	564.76
ES611	Almería	7.0	94.10	272.20
ES612	Cádiz	16.7	112.91	326.64
ES613	Córdoba	1.7	85.27	246.04

			Avg. additional heating costs (€)	
NUTS3	Region	Fossil heat-ers (%)	ETS2 60 EUR/t	ETS2 180 EUR/t
BE256	Arr. Roeselare	87.3	81.93	240.75
BE257	Arr. Tielt	86.6	85.75	251.89
BE258	Arr. Veurne	83.9	90.56	264.84
BE310	Arr. Nivelles	84.4	88.79	260.61
BE323	Arr. Mons	85.2	79.05	231.49
BE328	Arr. Tournai-Mouscron	85.0	89.22	260.93
BE329	Arr. La Louvière	84.8	79.56	233.07
BE32A	Arr. Ath	83.0	101.19	295.37
BE32B	Arr. Charleroi	85.5	75.22	220.49
BE32C	Arr. Soignies	84.1	91.03	266.22
BE32D	Arr. Thuin	83.7	97.52	284.69
BE331	Arr. Huy	82.8	117.94	343.74
BE332	Arr. Liège	85.0	86.91	254.20
BE334	Arr. Waremme	81.1	131.97	384.19
BE335	Arr. Verviers – communes francophones	83.9	98.26	286.91
BE336	Bezirk Verviers – Deutschsprachige Gemeinschaft	82.0	111.01	323.57
BE341	Arr. Arlon	83.8	103.87	303.21
BE342	Arr. Bastogne	80.3	129.52	376.97
BE343	Arr. Marche-en-Famenne	82.2	119.77	348.83
BE344	Arr. Neufchâteau	82.0	121.61	354.25
BE345	Arr. Virton	82.5	126.92	369.63
BE351	Arr. Dinant	80.4	127.96	372.30
BE352	Arr. Namur	82.9	103.67	302.62
BE353	Arr. Philippeville	81.2	127.58	371.29
BG311	Видин	1.8	145.75	396.16
BG312	Монтана	1.7	145.02	394.91
BG313	Враца	2.0	120.66	332.36
BG314	Плевен	1.6	166.07	450.60
BG315	Ловеч	2.0	164.53	448.17
BG321	Велико Търново	2.0	146.30	398.80
BG322	Габрово	2.0	99.25	278.51
BG323	Русе	2.0	136.51	374.18
BG324	Разград	2.0	187.92	510.32
BG325	Силистра	1.5	173.14	472.88
BG331	Варна	1.6	136.70	377.31
BG332	Добрич	1.7	164.48	446.58
BG333	Шумен	1.3	175.69	476.38
BG334	Търговище	1.7	169.23	460.94
BG341	Бургас	1.9	143.89	396.35
BG342	Сливен	1.9	190.67	520.62
BG343	Ямбол	2.0	166.23	452.91
BG344	Стара Загора	2.1	154.11	420.54
BG411	София (столица)	2.3	144.35	403.04
BG412	София	3.5	148.27	408.54
BG413	Благоевград	2.4	149.59	410.61
BG414	Перник	2.5	147.98	406.11
BG415	Кюстендил	2.5	135.01	370.29
BG421	Пловдив	2.2	152.29	416.52
BG422	Хасково	2.0	183.14	498.33
BG423	Пазарджик	2.0	175.29	477.33
BG424	Смолян	1.9	125.01	342.47
BG425	Кърджали	1.8	175.79	478.07
CY000	Κύπρος	38.9	111.62	328.05
CZ010	Hlavní město Praha	36.4	83.93	244.19
CZ020	Středočeský kraj	47.7	133.56	381.56
CZ031	Jihočeský kraj	34.1	129.95	369.91
CZ032	Plzeňský kraj	43.8	118.25	337.93
CZ041	Karlovarský kraj	34.0	103.46	296.11
CZ042	Ústecký kraj	35.7	113.89	325.09

			Avg. additional heating costs (€)	
NUTS3	Region	Fossil heat-ers (%)	ETS2 60 EUR/t	ETS2 180 EUR/t
ES614	Granada	26.1	86.84	252.06
ES615	Huelva	28.8	100.09	290.06
ES616	Jaén	2.0	77.28	223.81
ES617	Málaga	4.8	88.96	257.04
ES618	Sevilla	9.9	96.78	280.34
ES620	Murcia	14.1	93.97	272.39
ES630	Ceuta	0.2	318.77	882.01
ES640	Melilla	3.6	96.93	279.62
ES703	El Hierro	59.6	0.00	0.00
ES704	Fuerteventura	59.4	209.70	589.81
ES705	Gran Canaria	2.2	138.71	392.04
ES706	La Gomera	59.8	195.96	551.59
ES707	La Palma	60.0	214.92	605.18
ES708	Lanzarote	0.5	320.22	882.05
ES709	Tenerife	1.8	294.82	811.47
FI193	Keski-Suomi	16.5	9.00	287.52
FI194	Etelä-Pohjanmaa	22.0	9.93	317.09
FI195	Pohjanmaa	23.8	9.90	325.00
FI196	Satakunta	27.2	9.30	316.80
FI197	Pirkanmaa	22.0	9.35	308.94
FI1B1	Helsinki-Uusimaa	15.5	10.59	381.62
FI1C1	Varsinais-Suomi	25.4	9.32	316.82
FI1C2	Kanta-Häme	20.3	8.76	300.70
FI1C3	Päijät-Häme	15.8	9.21	296.63
FI1C4	Kymenlaakso	27.1	9.20	310.35
FI1C5	Etelä-Karjala	22.7	8.58	307.12
FI1D1	Etelä-Savo	13.6	8.65	277.71
FI1D2	Pohjois-Savo	11.5	8.60	275.37
FI1D3	Pohjois-Karjala	10.0	8.29	265.44
FI1D5	Keski-Pohjanmaa	23.4	9.53	305.17
FI1D7	Lappi	15.4	7.27	234.17
FI1D8	Kainuu	10.5	7.98	254.53
FI1D9	Pohjois-Pohjanmaa	13.7	8.30	275.08
FI200	Åland	32.6	12.11	390.56
FR101	Paris	37.9	27.37	233.97
FR102	Seine-et-Marne	48.4	31.73	271.22
FR103	Yvelines	56.3	30.96	264.50
FR104	Essonne	50.1	32.18	275.66
FR105	Hauts-de-Seine	49.3	31.39	268.51
FR106	Seine-Saint-Denis	49.3	27.12	231.75
FR107	Val-de-Marne	48.3	30.08	256.60
FR108	Val-d'Oise	49.8	30.66	262.27
FRB01	Cher	47.8	31.85	270.35
FRB02	Eure-et-Loir	47.3	34.18	290.00
FRB03	Indre	44.0	35.00	296.45
FRB04	Indre-et-Loire	46.2	30.01	255.18
FRB05	Loir-et-Cher	45.9	33.47	283.81
FRB06	Loiret	46.8	30.06	255.78
FRC11	Côte-d'Or	52.9	28.04	238.21
FRC12	Nièvre	43.1	33.35	282.41
FRC13	Saône-et-Loire	52.7	30.75	261.13
FRC14	Yonne	46.8	33.50	283.99
FRC21	Doubs	53.2	30.24	256.46
FRC22	Jura	48.2	34.58	292.60
FRC23	Haute-Saône	44.5	36.34	307.31
FRC24	Territoire de Belfort	65.0	28.77	244.52
FRD11	Calvados	46.9	30.88	262.05
FRD12	Manche	36.0	35.69	301.82
FRD13	Orne	43.5	37.51	316.74

NUTS3	Region	Fossil heaters (%)	Avg. additional heating costs (€) ETS2 60 EUR/t	ETS2 180 EUR/t
CZ051	Liberecký kraj	47.5	113.29	323.41
CZ052	Královéhradecký kraj	42.5	120.69	344.48
CZ053	Pardubický kraj	51.0	107.28	307.65
CZ063	Kraj Vysočina	49.2	118.63	339.04
CZ064	Jihomoravský kraj	54.4	89.44	259.73
CZ071	Olomoucký kraj	48.5	92.86	267.77
CZ072	Zlínský kraj	48.2	90.81	262.74
CZ080	Moravskoslezský kraj	36.2	109.71	314.26
DE111	Stuttgart, Stadtkreis	79.4	9.80	236.51
DE112	Böblingen	68.5	17.67	428.27
DE113	Esslingen	74.1	15.38	371.91
DE114	Göppingen	75.6	15.83	380.87
DE115	Ludwigsburg	73.8	16.05	388.18
DE116	Rems-Murr-Kreis	77.9	15.52	376.35
DE117	Heilbronn, Stadtkreis	88.4	11.44	277.31
DE118	Heilbronn, Landkreis	65.2	24.25	582.99
DE119	Hohenlohekreis	67.4	21.04	508.58
DE11A	Schwäbisch Hall	65.4	18.23	441.92
DE11B	Main-Tauber-Kreis	64.6	17.54	421.81
DE11C	Heidenheim	70.7	14.44	345.23
DE11D	Ostalbkreis	65.1	21.79	523.64
DE121	Baden-Baden, Stadtkreis	87.1	11.66	283.07
DE122	Karlsruhe, Stadtkreis	67.6	10.77	260.34
DE123	Karlsruhe, Landkreis	68.4	20.22	482.25
DE124	Rastatt	71.3	18.36	439.97
DE125	Heidelberg, Stadtkreis	57.7	12.12	290.68
DE126	Mannheim, Stadtkreis	33.6	11.29	273.83
DE127	Neckar-Odenwald-Kreis	66.8	19.78	475.46
DE128	Rhein-Neckar-Kreis	68.5	18.58	444.42
DE129	Pforzheim, Stadtkreis	61.7	11.13	270.50
DE12A	Calw	69.9	18.82	453.65
DE12B	Enzkreis	66.5	20.27	485.30
DE12C	Freudenstadt	68.5	16.93	411.51
DE131	Freiburg im Breisgau, Stadtkreis	71.2	10.13	244.92
DE132	Breisgau-Hochschwarz-wald	59.5	23.95	567.61
DE133	Emmendingen	57.7	25.20	596.75
DE134	Ortenaukreis	64.9	21.62	516.88
DE135	Rottweil	69.5	16.73	404.40
DE136	Schwarzwald-Baar-Kreis	71.7	15.90	381.15
DE137	Tuttlingen	68.8	19.27	465.36
DE138	Konstanz	66.4	17.51	417.06
DE139	Lörrach	61.1	22.69	537.35
DE13A	Waldshut	62.3	21.17	504.28
DE141	Reutlingen	67.1	16.66	399.84
DE142	Tübingen, Landkreis	69.3	14.57	352.90
DE143	Zollernalbkreis	73.8	17.37	422.15
DE144	Ulm, Stadtkreis	54.5	10.32	250.62
DE145	Alb-Donau-Kreis	67.5	18.65	448.86
DE146	Biberach	65.6	19.82	479.42
DE147	Bodenseekreis	68.5	18.70	446.81
DE148	Ravensburg	68.0	18.05	433.43
DE149	Sigmaringen	65.3	17.93	429.48
DE211	Ingolstadt, Kreisfreie Stadt	51.7	27.62	663.21
DE212	München, Kreisfreie Stadt	60.0	10.17	246.65
DE213	Rosenheim, Kreisfreie Stadt	55.7	12.03	293.66
DE214	Altötting	59.7	25.45	617.29
DE215	Berchtesgadener Land	67.1	18.69	449.22
DE216	Bad Tölz-Wolfratshau-sen	61.2	23.49	561.46
DE217	Dachau	68.4	18.68	449.38

NUTS3	Region	Fossil heaters (%)	Avg. additional heating costs (€) ETS2 60 EUR/t	ETS2 180 EUR/t
FRD21	Eure	43.8	32.98	279.62
FRD22	Seine-Maritime	50.3	27.66	235.19
FRE11	Nord	65.7	24.44	208.66
FRE12	Pas-de-Calais	60.6	27.01	229.92
FRE21	Aisne	53.9	32.57	276.13
FRE22	Oise	50.1	31.82	270.31
FRE23	Somme	53.5	32.16	272.62
FRF11	Bas-Rhin	55.7	33.13	280.66
FRF12	Haut-Rhin	63.8	31.23	265.22
FRF21	Ardennes	59.7	29.47	250.37
FRF22	Aube	49.5	29.45	250.24
FRF23	Marne	52.0	27.10	230.33
FRF24	Haute-Marne	46.2	33.03	279.63
FRF31	Meurthe-et-Moselle	62.0	25.72	219.14
FRF32	Meuse	51.3	33.23	281.31
FRF33	Moselle	69.2	28.24	240.24
FRF34	Vosges	50.6	30.93	262.02
FRG01	Loire-Atlantique	44.7	28.95	246.44
FRG02	Maine-et-Loire	43.6	33.17	281.27
FRG03	Mayenne	41.8	36.28	307.00
FRG04	Sarthe	46.5	30.46	258.74
FRG05	Vendée	34.9	40.10	339.13
FRH01	Côtes-d'Armor	38.7	38.80	327.78
FRH02	Finistère	44.3	36.94	312.46
FRH03	Ille-et-Vilaine	45.4	30.33	257.61
FRH04	Morbihan	40.6	34.39	291.37
FRI11	Dordogne	39.5	38.29	323.62
FRI12	Gironde	43.2	28.18	240.21
FRI13	Landes	28.9	34.14	289.77
FRI14	Lot-et-Garonne	43.3	37.88	320.47
FRI15	Pyrénées-Atlantiques	49.1	28.35	241.51
FRI21	Corrèze	44.7	36.02	305.00
FRI22	Creuse	40.1	38.19	322.35
FRI23	Haute-Vienne	49.9	32.25	273.58
FRI31	Charente	44.6	34.64	293.40
FRI32	Charente-Maritime	32.3	36.19	306.46
FRI33	Deux-Sèvres	44.2	40.32	340.86
FRI34	Vienne	43.7	36.85	311.72
FRJ11	Aude	25.4	34.20	289.77
FRJ12	Gard	36.8	34.25	290.25
FRJ13	Hérault	32.0	29.39	249.86
FRJ14	Lozère	37.0	43.06	362.26
FRJ15	Pyrénées-Orientales	25.2	31.09	263.70
FRJ21	Ariège	35.8	31.01	262.92
FRJ22	Aveyron	46.1	37.92	320.23
FRJ23	Haute-Garonne	43.3	28.08	239.55
FRJ24	Gers	35.5	40.52	342.05
FRJ25	Lot	40.0	42.30	356.51
FRJ26	Hautes-Pyrénées	43.3	26.99	229.45
FRJ27	Tarn	42.9	38.12	322.37
FRJ28	Tarn-et-Garonne	35.6	39.88	337.09
FRK11	Allier	52.4	30.42	258.24
FRK12	Cantal	45.1	36.86	311.29
FRK13	Haute-Loire	47.3	36.22	306.37
FRK14	Puy-de-Dôme	53.0	28.57	242.94
FRK21	Ain	46.5	34.41	291.66
FRK22	Ardèche	37.6	41.04	346.45
FRK23	Drôme	46.6	32.91	279.10
FRK24	Isère	42.5	30.35	257.46

			Avg. additional heating costs (€)	
NUTS3	Region	Fossil heat-ers (%)	ETS2 60 EUR/t	ETS2 180 EUR/t
DE218	Ebersberg	52.5	26.89	641.64
DE219	Eichstätt	63.3	26.87	644.88
DE21A	Erding	51.9	26.77	640.65
DE21B	Freising	64.9	21.33	514.90
DE21C	Fürstenfeldbruck	60.8	22.88	547.94
DE21D	Garmisch-Partenkirchen	62.4	19.58	467.08
DE21E	Landsberg am Lech	59.7	24.92	598.30
DE21F	Miesbach	59.1	23.04	549.86
DE21G	Mühldorf a. Inn	56.3	26.93	643.52
DE21H	München, Landkreis	42.7	28.84	690.62
DE21I	Neuburg-Schroben-hausen	55.2	28.33	677.34
DE21J	Pfaffenhofen a. d. Ilm	65.2	22.45	541.30
DE21K	Rosenheim, Landkreis	60.9	25.02	597.49
DE21L	Starnberg	75.0	18.43	445.65
DE21M	Traunstein	56.6	25.00	599.42
DE21N	Weilheim-Schongau	58.3	24.20	580.87
DE221	Landshut, Kreisfreie Stadt	54.6	22.81	541.90
DE222	Passau, Kreisfreie Stadt	87.8	10.12	245.88
DE223	Straubing, Kreisfreie Stadt	58.2	22.06	520.96
DE224	Deggendorf	62.1	21.11	503.29
DE225	Freyung-Grafenau	60.0	21.91	524.60
DE226	Kelheim	64.9	21.44	512.68
DE227	Landshut, Landkreis	59.4	24.09	572.88
DE228	Passau, Landkreis	59.7	22.85	543.73
DE229	Regen	61.7	21.03	500.83
DE22A	Rottal-Inn	58.7	21.42	512.03
DE22B	Straubing-Bogen	62.2	23.74	568.30
DE22C	Dingolfing-Landau	58.7	25.36	607.95
DE231	Amberg, Kreisfreie Stadt	56.5	22.30	527.88
DE232	Regensburg, Kreisfreie Stadt	81.6	8.20	197.87
DE233	Weiden i. d. Opf, Kreis-freie Stadt	91.1	9.41	228.41
DE234	Amberg-Sulzbach	63.8	20.60	493.46
DE235	Cham	62.5	21.05	503.32
DE236	Neumarkt i. d. OPf.	68.4	19.53	468.90
DE237	Neustadt a. d. Waldnaab	63.4	20.10	482.63
DE238	Regensburg, Landkreis	63.4	22.34	533.69
DE239	Schwandorf	61.9	20.32	484.24
DE23A	Tirschenreuth	62.2	19.78	474.81
DE241	Bamberg, Kreisfreie Stadt	80.8	8.72	210.96
DE242	Bayreuth, Kreisfreie Stadt	87.8	8.72	211.81
DE243	Coburg, Kreisfreie Stadt	82.9	8.63	208.02
DE244	Hof, Kreisfreie Stadt	89.4	9.90	240.76
DE245	Bamberg, Landkreis	63.8	22.13	529.76
DE246	Bayreuth, Landkreis	65.0	19.76	475.12
DE247	Coburg, Landkreis	75.7	15.38	369.70
DE248	Forchheim	69.0	19.24	462.84
FRK25	Loire	60.9	29.91	254.15
FRK26	Rhône	53.1	28.71	244.97
FRK27	Savoie	38.1	30.21	255.63
FRK28	Haute-Savoie	48.8	34.10	288.65
FRL01	Alpes-de-Haute-Pro-vence	29.2	37.13	313.30
FRL02	Hautes-Alpes	34.3	33.94	286.58
FRL03	Alpes-Maritimes	43.2	29.00	246.34
FRL04	Bouches-du-Rhône	39.5	35.87	305.15
FRL05	Var	26.4	37.28	315.91
FRL06	Vaucluse	36.1	37.65	318.57
FRM01	Corse-du-Sud	16.1	33.82	288.17
FRM02	Haute-Corse	13.5	36.33	308.32
HR021	Bjelovarsko-bilogorska županija	23.1	202.80	572.78
HR022	Virovitičko-podravska županija	22.9	202.45	572.08
HR023	Požeško-slavonska županija	23.5	195.51	552.95
HR024	Brodsko-posavska županija	23.3	199.70	563.70
HR025	Osječko-baranjska županija	21.3	197.55	557.94
HR026	Vukovarsko-srijemska županija	22.8	197.75	558.67
HR027	Karlovačka županija	23.2	191.40	539.93
HR028	Sisačko-moslavačka županija	22.8	196.85	555.86
HR031	Primorsko-goranska županija	36.7	194.95	548.79
HR032	Ličko-senjska županija	18.3	167.92	472.33
HR033	Zadarska županija	24.9	202.04	567.86
HR034	Šibensko-kninska župan-ija	25.3	196.64	551.82
HR035	Splitsko-dalmatinska županija	26.8	216.60	607.91
HR036	Istarska županija	34.8	211.01	593.10
HR037	Dubrovačko-neretvan-ska županija	30.7	221.24	619.96
HR050	Grad Zagreb	13.9	203.99	575.80
HR061	Međimurska županija	25.6	219.23	620.68
HR062	Varaždinska županija	25.1	221.24	626.08
HR063	Koprivničko-križevačka županija	24.9	216.76	613.77
HR064	Krapinsko-zagorska županija	25.3	221.86	628.59
HR065	Zagrebačka županija	26.6	223.50	631.99
HU110	Budapest	65.3	131.93	375.55
HU120	Pest	78.8	125.88	358.67
HU211	Fejér	60.0	123.82	352.79
HU212	Komárom-Esztergom	50.6	115.97	329.90
HU213	Veszprém	59.3	110.34	313.50
HU221	Győr-Moson-Sopron	63.1	121.07	344.55
HU222	Vas	58.9	108.89	309.41
HU223	Zala	74.6	103.92	294.64
HU231	Baranya	49.9	105.57	299.54
HU232	Somogy	61.2	102.32	290.26
HU233	Tolna	57.5	105.13	298.46
HU311	Borsod-Abaúj-Zemplén	57.2	101.56	288.34
HU312	Heves	76.0	100.25	284.36

NUTS3	Region	Fossil heat-ers (%)	Avg. additional heating costs (€) ETS2 60 EUR/t	ETS2 180 EUR/t
DE249	Hof, Landkreis	78.7	14.00	339.59
DE24A	Kronach	74.7	16.15	392.72
DE24B	Kulmbach	69.6	14.56	350.35
DE24C	Lichtenfels	68.8	16.52	398.26
DE24D	Wunsiedel i. Fichtelge-birge	75.6	12.75	307.76
DE251	Ansbach, Kreisfreie Stadt	88.2	10.47	254.13
DE252	Erlangen, Kreisfreie Stadt	65.6	11.30	275.84
DE253	Fürth, Kreisfreie Stadt	85.0	8.78	211.99
DE254	Nürnberg, Kreisfreie Stadt	67.6	9.15	221.67
DE255	Schwabach, Kreisfreie Stadt	85.3	11.58	281.86
DE256	Ansbach, Landkreis	62.2	20.08	481.43
DE257	Erlangen-Höchstadt	63.0	23.25	553.85
DE258	Fürth, Landkreis	68.2	19.05	457.45
DE259	Nürnberger Land	71.9	17.33	416.24
DE25A	Neustadt a. d. Aisch-Bad Windsheim	64.8	19.54	469.12
DE25B	Roth	72.3	18.03	433.70
DE25C	Weißenburg-Gunzen-hausen	61.6	18.84	450.50
DE261	Aschaffenburg, Kreis-freie Stadt	90.8	9.32	224.80
DE262	Schweinfurt, Kreisfreie Stadt	69.2	8.81	212.58
DE263	Würzburg, Kreisfreie Stadt	82.2	8.39	202.45
DE264	Aschaffenburg, Land-kreis	66.7	21.38	509.81
DE265	Bad Kissingen	62.7	20.23	481.83
DE266	Rhön-Grabfeld	58.9	22.28	531.55
DE267	Haßberge	58.7	23.45	559.00
DE268	Kitzingen	71.3	16.87	403.42
DE269	Miltenberg	72.1	18.54	444.42
DE26A	Main-Spessart	68.0	18.40	440.88
DE26B	Schweinfurt, Landkreis	71.5	19.22	463.40
DE26C	Würzburg, Landkreis	65.5	21.23	507.30
DE271	Augsburg, Kreisfreie Stadt	75.4	9.09	220.25
DE272	Kaufbeuren, Kreisfreie Stadt	94.9	8.40	202.17
DE273	Kempten (Allgäu), Kreis-freie Stadt	66.4	9.14	221.76
DE274	Memmingen, Kreisfreie Stadt	57.9	23.64	560.56
DE275	Aichach-Friedberg	60.5	23.45	560.60
DE276	Augsburg, Landkreis	66.8	20.09	479.39
DE277	Dillingen a.d. Donau	61.8	21.76	520.68
DE278	Günzburg	70.5	20.26	489.41
DE279	Neu-Ulm	72.6	15.12	367.72
DE27A	Lindau (Bodensee)	66.0	17.18	407.51
DE27B	Ostallgäu	64.5	20.26	483.65
DE27C	Unterallgäu	58.7	23.77	566.57
DE27D	Donau-Ries	66.7	18.58	447.68
DE27E	Oberallgäu	65.2	17.08	410.88
DE300	Berlin	57.2	8.06	194.02
DE401	Brandenburg an der Ha-vel, Kreisfreie Stadt	62.5	7.62	181.84
DE402	Cottbus, Kreisfreie Stadt	35.3	8.39	201.42
DE403	Frankfurt (Oder), Kreis-freie Stadt	38.0	7.36	176.06

NUTS3	Region	Fossil heat-ers (%)	Avg. additional heating costs (€) ETS2 60 EUR/t	ETS2 180 EUR/t
HU313	Nógrád	61.5	97.36	276.21
HU321	Hajdú-Bihar	64.6	107.17	304.38
HU322	Jász-Nagykun-Szolnok	75.1	103.79	294.46
HU323	Szabolcs-Szatmár-Bereg	63.7	107.01	304.41
HU331	Bács-Kiskun	66.4	105.83	300.40
HU332	Békés	80.9	103.81	294.54
HU333	Csongrád-Csanád	66.8	107.08	303.86
IE041	Border	84.9	-11.56	372.85
IE042	West	80.8	-12.79	409.40
IE051	Mid-West	80.3	-10.25	331.99
IE052	South-East	79.6	-10.53	341.07
IE053	South-West	79.8	-9.66	314.21
IE061	Dublin	77.0	-5.48	180.00
IE062	Mid-East	79.8	-8.55	278.29
IE063	Midland	77.5	-12.98	413.34
ITC11	Torino	83.5	46.43	137.22
ITC12	Vercelli	75.8	52.51	154.76
ITC13	Biella	77.3	57.59	169.47
ITC14	Verbano-Cusio-Ossola	80.1	43.57	128.55
ITC15	Novara	81.0	56.49	166.71
ITC16	Cuneo	80.3	51.68	152.66
ITC17	Asti	75.5	57.72	169.81
ITC18	Alessandria	76.0	58.14	171.15
ITC20	Valle d'Aosta/Vallée d'Aoste	84.4	28.29	84.05
ITC31	Imperia	81.9	58.31	171.23
ITC32	Savona	80.1	63.79	187.41
ITC33	Genova	85.6	53.56	157.95
ITC34	La Spezia	83.3	61.39	180.74
ITC41	Varese	79.7	56.27	166.09
ITC42	Como	79.7	56.31	166.17
ITC43	Lecco	83.1	56.17	165.96
ITC44	Sondrio	78.2	28.68	85.09
ITC46	Bergamo	86.6	54.80	162.01
ITC47	Brescia	86.4	53.44	158.03
ITC48	Pavia	77.6	58.47	172.21
ITC49	Lodi	79.4	62.18	183.03
ITC4A	Cremona	83.7	61.38	181.34
ITC4B	Mantova	80.5	62.68	185.04
ITC4C	Milano	83.3	57.01	168.40
ITC4D	Monza e della Brianza	83.6	59.42	175.48
ITF11	L'Aquila	71.1	56.03	164.69
ITF12	Teramo	72.0	62.89	184.76
ITF13	Pescara	75.6	64.08	188.29
ITF14	Chieti	70.0	64.57	189.65
ITF21	Isernia	74.3	55.81	164.22
ITF22	Campobasso	76.1	59.83	175.92
ITF31	Caserta	78.2	61.43	180.53

			Avg. additional heating costs (€)					Avg. additional heating costs (€)	
NUTS3	Region	Fossil heat-ers (%)	ETS2 60 EUR/t	ETS2 180 EUR/t	NUTS3	Region	Fossil heat-ers (%)	ETS2 60 EUR/t	ETS2 180 EUR/t
DE404	Potsdam, Kreisfreie Stadt	35.9	7.70	184.37	ITF32	Benevento	74.7	58.57	172.16
DE405	Barnim	66.0	9.37	224.56	ITF33	Napoli	83.1	63.54	186.70
DE406	Dahme-Spreewald	78.4	9.34	223.82	ITF34	Avellino	76.3	59.20	174.08
DE407	Elbe-Elster	72.2	13.19	319.45	ITF35	Salerno	79.3	63.52	186.61
DE408	Havelland	76.6	10.33	248.68	ITF43	Taranto	81.0	63.37	186.28
DE409	Märkisch-Oderland	70.0	9.91	237.38	ITF44	Brindisi	78.5	64.53	189.67
DE40A	Oberhavel	62.9	10.20	245.29	ITF45	Lecce	77.3	64.95	190.91
DE40B	Oberspreewald-Lausitz	57.1	11.02	265.40	ITF46	Foggia	79.4	62.15	182.64
DE40C	Oder-Spree	74.8	8.89	213.07	ITF47	Bari	82.3	63.44	186.54
DE40D	Ostprignitz-Ruppin	62.7	11.14	269.40	ITF48	Barletta-Andria-Trani	80.5	61.59	181.13
DE40E	Potsdam-Mittelmark	73.3	10.97	264.54	ITF51	Potenza	75.5	58.83	172.80
DE40F	Prignitz	73.4	10.39	250.24	ITF52	Matera	79.3	62.33	183.16
DE40G	Spree-Neiße	67.0	11.45	275.49	ITF61	Cosenza	76.5	58.94	173.23
DE40H	Teltow-Fläming	74.8	10.04	240.78	ITF62	Crotone	77.3	62.97	184.92
DE40I	Uckermark	55.5	11.35	274.00	ITF63	Catanzaro	77.4	60.60	178.11
DE501	Bremen, Kreisfreie Stadt	79.0	8.82	212.80	ITF64	Vibo Valentia	74.3	61.53	180.74
DE502	Bremerhaven, Kreisfreie Stadt	77.5	8.26	199.16	ITF65	Reggio Calabria	77.0	61.24	179.96
DE600	Hamburg	62.4	8.63	208.33	ITG11	Trapani	75.0	65.36	192.04
DE711	Darmstadt, Kreisfreie Stadt	78.7	9.36	225.73	ITG12	Palermo	75.5	62.66	184.17
DE712	Frankfurt am Main, Kreisfreie Stadt	82.1	8.67	208.82	ITG13	Messina	73.8	60.19	176.86
DE713	Offenbach am Main, Kreisfreie Stadt	65.7	8.75	210.68	ITG14	Agrigento	75.9	64.63	189.90
DE714	Wiesbaden, Kreisfreie Stadt	86.2	8.84	213.35	ITG15	Caltanissetta	74.8	63.81	187.48
DE715	Bergstraße	76.9	16.75	404.56	ITG16	Enna	74.4	62.34	183.22
DE716	Darmstadt-Dieburg	71.7	18.99	454.51	ITG17	Catania	75.8	62.60	184.01
DE717	Groß-Gerau	78.2	14.86	357.17	ITG18	Ragusa	75.2	64.01	188.10
DE718	Hochtaunuskreis	63.3	23.28	555.50	ITG19	Siracusa	75.2	64.90	190.75
DE719	Main-Kinzig-Kreis	67.9	18.70	446.52	ITG2D	Sassari	71.7	62.99	185.10
DE71A	Main-Taunus-Kreis	63.1	23.21	553.04	ITG2E	Nuoro	67.9	61.97	182.15
DE71B	Odenwaldkreis	73.6	19.39	469.01	ITG2F	Cagliari	74.1	70.51	207.19
DE71C	Offenbach, Landkreis	62.1	20.17	477.66	ITG2G	Oristano	66.3	64.14	188.54
DE71D	Rheingau-Taunus-Kreis	67.8	20.62	490.88	ITG2H	Sud Sardegna	67.6	64.69	190.11
DE71E	Wetteraukreis	69.5	20.09	480.38	ITH10	Bolzano-Bozen	83.4	21.88	65.16
DE721	Gießen, Landkreis	67.0	13.83	331.71	ITH20	Trento	85.5	38.75	114.84
DE722	Lahn-Dill-Kreis	72.2	17.91	428.80	ITH31	Verona	84.1	58.04	171.24
DE723	Limburg-Weilburg	70.8	17.42	414.80	ITH32	Vicenza	87.1	55.26	163.23
DE724	Marburg-Biedenkopf	65.8	19.06	454.54	ITH33	Belluno	77.2	38.53	114.18
DE725	Vogelsbergkreis	69.5	18.73	451.00	ITH34	Treviso	85.1	62.35	183.94
DE731	Kassel, Kreisfreie Stadt	74.7	8.58	207.30	ITH35	Venezia	77.6	60.97	179.58
DE732	Fulda	77.5	14.68	353.69	ITH36	Padova	86.6	62.81	185.36
DE733	Hersfeld-Rotenburg	79.7	14.63	352.46	ITH37	Rovigo	74.4	62.99	185.33
DE734	Kassel, Landkreis	69.8	17.94	429.55	ITH41	Pordenone	78.4	55.36	163.47
DE735	Schwalm-Eder-Kreis	76.1	16.25	391.47	ITH42	Udine	78.1	49.49	146.27
DE736	Waldeck-Frankenberg	73.0	16.67	399.73	ITH43	Gorizia	77.2	60.54	178.16
DE737	Werra-Meißner-Kreis	82.7	12.74	308.52	ITH44	Trieste	88.5	54.61	161.01
DE803	Rostock, Kreisfreie Stadt	28.3	6.48	154.83	ITH51	Piacenza	82.6	56.12	165.73
DE804	Schwerin, Kreisfreie Stadt	37.5	7.13	170.48	ITH52	Parma	83.4	54.55	161.15
DE80J	Mecklenburgische Seenplatte	51.2	11.30	271.85	ITH53	Reggio nell'Emilia	86.1	59.02	174.41
DE80K	Landkreis Rostock	64.3	11.64	279.44	ITH54	Modena	84.0	57.75	170.64
DE80L	Vorpommern-Rügen	61.3	9.40	225.45	ITH55	Bologna	85.0	56.67	167.29
DE80M	Nordwestmecklenburg	70.0	10.86	259.63	ITH56	Ferrara	77.1	61.56	181.20
DE80N	Vorpommern-Greifswald	57.8	10.71	257.47	ITH57	Ravenna	80.8	61.07	180.11
DE80O	Ludwigslust-Parchim	72.5	11.40	273.82	ITH58	Forlì-Cesena	83.9	61.58	181.76
DE911	Braunschweig, Kreisfreie Stadt	60.7	9.14	220.75	ITH59	Rimini	79.6	61.89	182.41
DE912	Salzgitter, Kreisfreie Stadt	77.4	9.08	218.23	ITI11	Massa-Carrara	62.6	63.08	185.09

NUTS3	Region	Fossil heat-ers (%)	Avg. additional heating costs (€) ETS2 60 EUR/t	ETS2 180 EUR/t
DE913	Wolfsburg, Kreisfreie Stadt	14.3	16.23	398.60
DE914	Gifhorn	69.9	17.66	420.42
DE916	Goslar	83.4	9.63	231.31
DE917	Helmstedt	76.7	14.56	347.30
DE918	Northeim	74.0	14.81	354.71
DE91A	Peine	80.1	13.61	327.34
DE91B	Wolfenbüttel	82.7	12.90	309.02
DE91C	Göttingen	65.7	16.14	382.92
DE922	Diepholz	74.9	15.14	360.21
DE923	Hameln-Pyrmont	79.1	12.21	293.58
DE925	Hildesheim	85.5	11.16	268.52
DE926	Holzminden	77.4	13.66	328.18
DE927	Nienburg (Weser)	77.2	14.92	356.31
DE928	Schaumburg	74.4	16.23	387.55
DE929	Region Hannover	81.6	10.32	247.86
DE931	Celle	78.6	13.77	329.44
DE932	Cuxhaven	78.2	15.24	365.88
DE933	Harburg	61.4	22.86	542.11
DE934	Lüchow-Dannenberg	70.0	15.55	371.96
DE935	Lüneburg, Landkreis	68.7	14.85	353.35
DE936	Osterholz	75.5	17.28	413.12
DE937	Rotenburg (Wümme)	60.9	22.79	540.50
DE938	Heidekreis	70.0	17.50	417.22
DE939	Stade	69.3	17.32	411.98
DE93A	Uelzen	75.8	15.25	364.87
DE93B	Verden	72.3	16.83	401.23
DE941	Delmenhorst, Kreisfreie Stadt	93.9	8.24	197.65
DE942	Emden, Kreisfreie Stadt	92.9	8.29	198.60
DE943	Oldenburg (Oldenburg), Kreisfreie Stadt	94.0	7.78	186.70
DE944	Osnabrück, Kreisfreie Stadt	93.6	8.58	206.83
DE945	Wilhelmshaven, Kreis-freie Stadt	97.6	7.22	172.68
DE946	Ammerland	65.0	20.00	471.07
DE947	Aurich	82.1	11.85	281.89
DE948	Cloppenburg	62.7	22.32	527.01
DE949	Emsland	77.6	15.38	366.70
DE94A	Friesland (DE)	81.5	12.13	288.27
DE94B	Grafschaft Bentheim	76.2	14.93	354.30
DE94C	Leer	73.9	15.75	373.16
DE94D	Oldenburg, Landkreis	71.1	16.72	395.90
DE94E	Osnabrück, Landkreis	74.4	15.60	371.78
DE94F	Vechta	60.4	25.72	610.06
DE94G	Wesermarsch	80.8	12.24	290.35
DE94H	Wittmund	75.2	14.18	336.75
DEA11	Düsseldorf, Kreisfreie Stadt	80.8	8.32	200.05
DEA12	Duisburg, Kreisfreie Stadt	65.1	9.01	216.71
DEA13	Essen, Kreisfreie Stadt	72.2	8.42	202.35
DEA14	Krefeld, Kreisfreie Stadt	82.3	9.72	234.58
DEA15	Mönchengladbach, Kreisfreie Stadt	94.2	9.14	220.33
DEA16	Mülheim an der Ruhr, Kreisfreie Stadt	88.0	9.09	218.87
DEA17	Oberhausen, Kreisfreie Stadt	61.8	9.41	226.46
DEA18	Remscheid, Kreisfreie Stadt	91.8	9.16	221.20

NUTS3	Region	Fossil heat-ers (%)	Avg. additional heating costs (€) ETS2 60 EUR/t	ETS2 180 EUR/t
ITI12	Lucca	58.4	64.51	189.46
ITI13	Pistoia	63.0	64.67	189.96
ITI14	Firenze	86.4	63.03	185.70
ITI15	Prato	78.0	62.93	185.26
ITI16	Livorno	71.3	66.91	196.28
ITI17	Pisa	76.5	67.31	198.02
ITI18	Arezzo	66.6	60.07	176.59
ITI19	Siena	73.9	63.43	186.39
ITI1A	Grosseto	68.2	65.27	191.28
ITI21	Perugia	65.1	60.14	176.70
ITI22	Terni	73.8	61.22	179.78
ITI31	Pesaro e Urbino	66.5	64.22	188.84
ITI32	Ancona	69.4	64.41	189.49
ITI33	Macerata	62.1	65.22	191.47
ITI34	Ascoli Piceno	64.4	67.04	196.90
ITI35	Fermo	72.6	64.94	190.73
ITI41	Viterbo	70.9	64.10	188.03
ITI42	Rieti	69.2	56.41	165.57
ITI43	Roma	88.8	64.78	190.83
ITI44	Latina	75.1	67.06	196.94
ITI45	Frosinone	70.0	65.45	192.19
LT011	Vilniaus apskritis	4.3	23.26	68.82
LT021	Alytaus apskritis	5.4	29.95	88.01
LT022	Kauno apskritis	3.7	28.65	84.34
LT023	Klaipėdos apskritis	3.2	29.99	88.27
LT024	Marijampolės apskritis	6.3	31.73	93.20
LT025	Panevėžio apskritis	5.6	29.32	86.20
LT026	Šiaulių apskritis	5.5	30.02	88.24
LT027	Tauragės apskritis	6.4	31.43	92.34
LT028	Telšių apskritis	5.0	31.02	91.21
LT029	Utenos apskritis	5.6	29.95	87.93
LU000	Luxembourg	82.6	49.11	336.63
LV003	Kurzeme	4.0	75.66	219.11
LV005	Latgale	4.3	73.68	213.55
LV006	Rīga	4.3	74.23	214.77
LV007	Pierīga	3.9	85.85	249.02
LV008	Vidzeme	3.9	76.03	220.33
LV009	Zemgale	3.6	78.82	228.36
MT001	Malta	26.3	87.04	252.66
MT002	Gozo and Comino/Għawdex u Kemmuna	26.8	94.26	273.68
NL111	Oost-Groningen	89.4	76.35	224.00
NL112	Delfzijl en omgeving	0.0	NaN	NaN
NL113	Overig Groningen	88.0	66.71	195.65
NL124	Noord-Friesland	91.5	60.15	176.90
NL125	Zuidwest-Friesland	94.0	66.14	194.44
NL126	Zuidoost-Friesland	94.6	63.05	185.45
NL131	Noord-Drenthe	94.4	63.51	186.89
NL132	Zuidoost-Drenthe	94.6	64.72	190.40
NL133	Zuidwest-Drenthe	93.8	64.97	191.11
NL211	Noord-Overijssel	92.3	66.00	194.15
NL212	Zuidwest-Overijssel	91.2	63.55	186.92

			Avg. additional heating costs (€)	
NUTS3	Region	Fossil heaters (%)	ETS2 60 EUR/t	ETS2 180 EUR/t
DEA19	Solingen, Kreisfreie Stadt	91.7	9.34	225.20
DEA1A	Wuppertal, Kreisfreie Stadt	89.7	8.71	210.08
DEA1B	Kleve	85.0	10.97	264.49
DEA1C	Mettmann	84.6	9.85	237.66
DEA1D	Rhein-Kreis Neuss	86.9	10.76	259.84
DEA1E	Viersen	83.9	10.67	256.40
DEA1F	Wesel	69.0	11.39	275.47
DEA22	Bonn, Kreisfreie Stadt	82.8	9.70	234.41
DEA23	Köln, Kreisfreie Stadt	80.5	8.99	216.32
DEA24	Leverkusen, Kreisfreie Stadt	82.3	9.95	239.89
DEA26	Düren	86.2	11.01	266.47
DEA27	Rhein-Erft-Kreis	82.3	11.30	273.31
DEA28	Euskirchen	84.7	12.25	297.29
DEA29	Heinsberg	81.0	14.24	347.03
DEA2A	Oberbergischer Kreis	80.2	13.71	328.54
DEA2B	Rheinisch-Bergischer Kreis	85.4	11.51	276.85
DEA2C	Rhein-Sieg-Kreis	83.9	12.27	295.76
DEA2D	Städteregion Aachen	88.1	9.68	233.53
DEA31	Bottrop, Kreisfreie Stadt	63.4	10.32	248.59
DEA32	Gelsenkirchen, Kreisfreie Stadt	69.3	8.33	199.52
DEA33	Münster, Kreisfreie Stadt	78.3	9.48	229.33
DEA34	Borken	78.3	14.92	357.20
DEA35	Coesfeld	86.3	11.54	278.58
DEA36	Recklinghausen	74.3	9.69	232.54
DEA37	Steinfurt	85.6	12.80	307.45
DEA38	Warendorf	84.3	12.63	302.65
DEA41	Bielefeld, Kreisfreie Stadt	75.8	9.17	221.06
DEA42	Gütersloh	80.9	15.39	370.90
DEA43	Herford	84.8	12.16	291.84
DEA44	Höxter	75.5	16.04	385.89
DEA45	Lippe	70.9	15.95	381.79
DEA46	Minden-Lübbecke	84.1	12.10	293.09
DEA47	Paderborn	72.5	13.94	332.61
DEA51	Bochum, Kreisfreie Stadt	78.6	8.23	197.66
DEA52	Dortmund, Kreisfreie Stadt	87.1	8.15	195.82
DEA53	Hagen, Kreisfreie Stadt	88.5	8.48	204.20
DEA54	Hamm, Kreisfreie Stadt	86.3	9.55	229.93
DEA55	Herne, Kreisfreie Stadt	83.5	7.80	186.51
DEA56	Ennepe-Ruhr-Kreis	84.3	10.38	247.98
DEA57	Hochsauerlandkreis	78.3	13.04	312.21
DEA58	Märkischer Kreis	79.4	12.23	293.07
DEA59	Olpe	71.7	17.63	422.48
DEA5A	Siegen-Wittgenstein	82.1	12.27	295.99
DEA5B	Soest	85.9	11.10	267.29
DEA5C	Unna	84.2	9.70	233.51
DEB11	Koblenz, Kreisfreie Stadt	90.4	8.34	200.69
DEB12	Ahrweiler	63.7	18.90	449.44
DEB13	Altenkirchen (Westerwald)	60.2	21.94	522.53
DEB14	Bad Kreuznach	68.2	16.09	383.08
DEB15	Birkenfeld	60.1	16.45	394.54
DEB17	Mayen-Koblenz	71.5	15.96	379.72
DEB18	Neuwied	73.0	15.91	377.63
DEB1A	Rhein-Lahn-Kreis	58.1	21.06	498.73
DEB1B	Westerwaldkreis	59.0	21.95	520.46

			Avg. additional heating costs (€)	
NUTS3	Region	Fossil heaters (%)	ETS2 60 EUR/t	ETS2 180 EUR/t
NL213	Twente	88.7	64.21	188.87
NL221	Veluwe	88.9	68.28	200.88
NL224	Zuidwest-Gelderland	92.0	72.39	212.97
NL225	Achterhoek	93.2	69.37	204.10
NL226	Arnhem/Nijmegen	87.0	64.47	189.60
NL230	Flevoland	62.2	64.91	190.90
NL310	Utrecht	80.7	69.74	205.30
NL321	Kop van Noord-Holland	94.3	72.85	214.54
NL323	IJmond	95.6	72.11	212.25
NL324	Agglomeratie Haarlem	91.7	66.67	196.27
NL325	Zaanstreek	93.2	68.92	202.92
NL327	Het Gooi en Vechtstreek	88.4	81.25	236.78
NL328	Alkmaar en omgeving	72.2	127.95	364.23
NL329	Groot-Amsterdam	79.0	60.96	179.04
NL332	Agglomeratie 's-Gravenhage	85.6	61.10	179.64
NL333	Delft en Westland	88.3	67.81	199.46
NL337	Agglomeratie Leiden en Bollenstreek	85.6	66.71	196.26
NL33A	Zuidoost-Zuid-Holland	92.3	68.45	201.42
NL33B	Oost-Zuid-Holland	93.9	70.86	208.53
NL33C	Groot-Rijnmond	80.6	70.86	206.73
NL341	Zeeuwsch-Vlaanderen	94.6	68.69	201.90
NL342	Overig Zeeland	92.5	67.13	197.31
NL411	West-Noord-Brabant	85.9	68.62	201.82
NL412	Midden-Noord-Brabant	79.3	67.52	198.58
NL413	Noordoost-Noord-Brabant	78.7	104.43	299.54
NL414	Zuidoost-Noord-Brabant	89.4	68.24	200.73
NL421	Noord-Limburg	92.2	68.41	201.12
NL422	Midden-Limburg	94.5	68.50	201.39
NL423	Zuid-Limburg	92.7	62.63	184.08
PL213	Miasto Kraków	7.1	79.31	231.55
PL214	Krakowski	64.6	289.97	805.19
PL217	Tarnowski	45.6	319.95	885.85
PL218	Nowosądecki	54.8	354.11	979.35
PL219	Nowotarski	51.4	484.92	1336.18
PL21A	Oświęcimski	41.1	353.16	976.39
PL224	Częstochowski	35.2	449.88	1243.17
PL225	Bielski	44.7	397.91	1103.80
PL227	Rybnicki	28.9	481.06	1328.88
PL228	Bytomski	23.2	368.82	1020.12
PL229	Gliwicki	13.9	346.65	961.50
PL22A	Katowicki	7.8	226.42	633.11
PL22B	Sosnowiecki	20.3	360.30	998.89
PL22C	Tyski	29.8	389.88	1081.87
PL411	Pilski	31.6	421.95	1164.68
PL414	Koniński	35.9	466.81	1287.55
PL415	Miasto Poznań	9.4	134.21	382.15
PL416	Kaliski	42.9	489.32	1349.84
PL417	Leszczyński	44.1	381.90	1057.34
PL418	Poznański	44.3	288.35	803.41
PL424	Miasto Szczecin	8.5	112.85	320.47
PL426	Koszaliński	22.3	305.84	847.98
PL427	Szczecinecko-pyrzycki	24.1	390.09	1077.02
PL428	Szczeciński	23.3	309.76	858.68
PL431	Gorzowski	23.7	338.71	935.26

			Avg. additional heating costs (€)	
NUTS3	Region	Fossil heat-ers (%)	ETS2 60 EUR/t	ETS2 180 EUR/t
DEB1C	Cochem-Zell	55.3	20.51	487.83
DEB1D	Rhein-Hunsrück-Kreis	58.8	18.99	451.64
DEB21	Trier, Kreisfreie Stadt	82.0	9.47	229.64
DEB22	Bernkastel-Wittlich	59.6	20.34	484.52
DEB23	Eifelkreis Bitburg-Prüm	54.2	22.60	535.49
DEB24	Vulkaneifel	51.6	22.81	539.44
DEB25	Trier-Saarburg	56.5	24.24	575.57
DEB31	Frankenthal (Pfalz), Kreisfreie Stadt	94.0	9.53	229.15
DEB32	Kaiserslautern, Kreisfreie Stadt	79.8	8.62	207.54
DEB33	Landau in der Pfalz, Kreisfreie Stadt	85.4	9.56	229.96
DEB34	Ludwigshafen am Rhein, Kreisfreie Stadt	76.2	10.36	250.05
DEB35	Mainz, Kreisfreie Stadt	78.1	9.63	232.55
DEB36	Neustadt an der Weinstraße, Kreisfreie Stadt	89.5	9.14	219.39
DEB37	Pirmasens, Kreisfreie Stadt	91.3	8.85	213.08
DEB38	Speyer, Kreisfreie Stadt	78.9	10.34	249.24
DEB39	Worms, Kreisfreie Stadt	90.5	10.22	246.82
DEB3A	Zweibrücken, Kreisfreie Stadt	85.6	9.99	240.97
DEB3B	Alzey-Worms	67.9	19.34	459.93
DEB3C	Bad Dürkheim	71.3	18.30	434.46
DEB3D	Donnersbergkreis	62.4	19.47	463.35
DEB3E	Germersheim	62.0	23.66	558.86
DEB3F	Kaiserslautern, Landkreis	61.8	21.11	500.33
DEB3G	Kusel	58.2	20.78	495.56
DEB3H	Südliche Weinstraße	62.2	21.31	504.81
DEB3I	Rhein-Pfalz-Kreis	68.7	20.46	484.54
DEB3J	Mainz-Bingen	68.9	18.89	449.16
DEB3K	Südwestpfalz	54.3	24.36	577.65
DEC01	Regionalverband Saarbrücken	73.4	10.26	248.25
DEC02	Merzig-Wadern	80.6	15.94	387.83
DEC03	Neunkirchen	91.5	10.61	256.59
DEC04	Saarlouis	77.0	13.40	326.52
DEC05	Saarpfalz-Kreis	87.8	10.85	263.04
DEC06	St. Wendel	85.3	14.18	346.94
DED21	Dresden, Kreisfreie Stadt	48.2	7.76	185.81
DED2C	Bautzen	67.8	12.00	289.16
DED2D	Görlitz	67.8	11.03	264.00
DED2E	Meißen	69.4	10.62	255.61
DED2F	Sächsische Schweiz-Osterzgebirge	73.2	10.06	241.95
DED41	Chemnitz, Kreisfreie Stadt	51.4	7.41	177.50
DED42	Erzgebirgskreis	77.5	9.83	236.74
DED43	Mittelsachsen	77.9	10.27	247.38
DED44	Vogtlandkreis	74.9	9.30	224.26
DED45	Zwickau	73.7	9.51	228.85
DED51	Leipzig, Kreisfreie Stadt	62.7	7.00	167.41
DED52	Leipzig	78.9	9.89	238.05
DED53	Nordsachsen	76.5	10.18	245.43
DEE01	Dessau-Roßlau, Kreisfreie Stadt	49.8	8.37	200.56
DEE02	Halle (Saale), Kreisfreie Stadt	52.4	6.67	159.24
DEE03	Magdeburg, Kreisfreie Stadt	59.9	7.12	170.39
DEE04	Altmarkkreis Salzwedel	70.7	9.92	238.93
DEE05	Anhalt-Bitterfeld	70.8	10.70	258.27

			Avg. additional heating costs (€)	
NUTS3	Region	Fossil heat-ers (%)	ETS2 60 EUR/t	ETS2 180 EUR/t
PL432	Zielonogórski	33.6	318.82	881.39
PL514	Miasto Wrocław	6.4	118.13	337.48
PL515	Jeleniogórski	23.9	361.55	998.75
PL516	Legnicko-głogowski	18.7	356.43	987.56
PL517	Wałbrzyski	18.8	353.40	975.72
PL518	Wrocławski	36.1	380.33	1052.51
PL523	Nyski	31.8	410.24	1130.76
PL524	Opolski	31.5	451.18	1244.28
PL613	Bydgosko-toruński	14.3	319.21	884.26
PL616	Grudziądzki	28.0	443.26	1220.60
PL617	Inowrocławski	26.0	422.37	1163.88
PL618	Świecki	40.3	471.52	1298.94
PL619	Włocławski	31.5	436.11	1201.27
PL621	Elbląski	22.6	428.20	1180.24
PL622	Olsztyński	20.4	366.22	1011.30
PL623	Ełcki	17.1	426.35	1175.14
PL633	Trójmiejski	5.1	139.09	393.22
PL634	Gdański	34.9	342.55	948.17
PL636	Słupski	21.2	389.12	1074.03
PL637	Chojnicki	33.4	462.62	1274.56
PL638	Starogardzki	24.8	392.69	1083.83
PL711	Miasto Łódź	5.6	159.36	447.25
PL712	Łódzki	35.4	356.66	986.63
PL713	Piotrkowski	40.3	492.82	1358.94
PL714	Sieradzki	40.6	505.74	1392.27
PL715	Skierniewicki	32.7	461.51	1271.50
PL721	Kielecki	32.9	413.19	1139.57
PL722	Sandomiersko-jędrzejowski	48.5	443.58	1222.27
PL811	Bialski	39.5	442.84	1219.56
PL812	Chełmsko-zamojski	40.5	414.21	1141.63
PL814	Lubelski	24.0	335.31	927.11
PL815	Puławski	41.7	398.11	1098.20
PL821	Krośnieński	48.1	307.10	849.25
PL822	Przemyski	46.6	353.63	975.83
PL823	Rzeszowski	45.0	313.49	867.39
PL824	Tarnobrzeski	42.4	336.74	930.08
PL841	Białostocki	19.7	313.22	865.67
PL842	Łomżyński	34.8	424.17	1167.64
PL843	Suwalski	28.9	463.48	1275.04
PL911	Miasto Warszawa	9.9	304.57	855.20
PL912	Warszawski wschodni	40.0	265.07	740.92
PL913	Warszawski zachodni	38.8	165.45	470.26
PL921	Radomski	35.8	420.27	1161.84
PL922	Ciechanowski	43.8	473.31	1307.64
PL923	Płocki	30.8	569.19	1581.55
PL924	Ostrołęcki	39.6	474.78	1311.13
PL925	Siedlecki	43.1	438.36	1211.63
PL926	Żyrardowski	38.8	419.24	1160.60
PT111	Alto Minho	8.8	-8.28	118.42
PT112	Cávado	11.8	-6.34	92.25
PT119	Ave	11.4	-7.66	109.34

NUTS3	Region	Fossil heat-ers (%)	Avg. additional heating costs (€) ETS2 60 EUR/t	Avg. additional heating costs (€) ETS2 180 EUR/t
DEE06	Jerichower Land	74.1	9.94	239.62
DEE07	Börde	79.8	9.95a	239.33
DEE08	Burgenlandkreis	69.7	11.08	268.01
DEE09	Harz	78.5	9.31	224.18
DEE0A	Mansfeld-Südharz	72.4	11.43	276.42
DEE0B	Saalekreis	68.9	11.70	283.73
DEE0C	Salzlandkreis	71.5	9.64	231.77
DEE0D	Stendal	62.1	10.08	242.31
DEE0E	Wittenberg	69.7	11.27	272.79
DEF01	Flensburg, Kreisfreie Stadt	6.0	10.84	263.61
DEF02	Kiel, Kreisfreie Stadt	37.8	8.92	215.60
DEF03	Lübeck, Kreisfreie Stadt	75.2	8.82	213.25
DEF04	Neumünster, Kreisfreie Stadt	47.4	9.99	241.96
DEF05	Dithmarschen	59.0	21.27	503.40
DEF06	Herzogtum Lauenburg	52.5	23.87	564.97
DEF07	Nordfriesland	57.9	19.14	453.83
DEF08	Ostholstein	60.8	19.70	467.07
DEF09	Pinneberg	60.5	19.13	453.26
DEF0A	Plön	60.9	20.45	485.78
DEF0B	Rendsburg-Eckernförde	56.1	21.15	501.40
DEF0C	Schleswig-Flensburg	50.0	22.29	530.19
DEF0D	Segeberg	52.4	22.02	521.39
DEF0E	Steinburg	57.3	21.92	518.60
DEF0F	Stormarn	58.7	20.83	493.96
DEG01	Erfurt, Kreisfreie Stadt	56.8	7.43	178.08
DEG02	Gera, Kreisfreie Stadt	55.7	7.35	175.95
DEG03	Jena, Kreisfreie Stadt	45.5	7.32	175.22
DEG04	Suhl, Kreisfreie Stadt	53.5	8.41	201.89
DEG05	Weimar, Kreisfreie Stadt	71.7	7.04	167.98
DEG06	Eichsfeld	69.0	11.86	284.51
DEG07	Nordhausen	78.6	9.08	218.27
DEG09	Unstrut-Hainich-Kreis	75.0	10.11	243.85
DEG0A	Kyffhäuserkreis	70.1	12.26	296.20
DEG0B	Schmalkalden-Meiningen	77.5	11.76	285.07
DEG0C	Gotha	74.0	9.21	221.23
DEG0D	Sömmerda	60.4	14.36	348.12
DEG0E	Hildburghausen	73.9	12.46	301.59
DEG0F	Ilm-Kreis	70.0	8.67	207.90
DEG0G	Weimarer Land	77.7	11.40	274.70
DEG0H	Sonneberg	76.4	8.99	216.36
DEG0I	Saalfeld-Rudolstadt	69.0	10.23	246.30
DEG0J	Saale-Holzland-Kreis	63.3	12.75	306.09
DEG0K	Saale-Orla-Kreis	69.2	11.43	276.12
DEG0L	Greiz	78.7	11.43	276.00
DEG0M	Altenburger Land	66.0	10.07	242.06
DEG0N	Eisenach, Kreisfreie Stadt	29.8	18.94	443.24
DEG0P	Wartburgkreis	73.9	12.15	294.78
DK011	Byen København	4.2	-101.38	196.24
DK012	Københavns omegn	31.3	-104.78	202.09
DK013	Nordsjælland	37.8	-107.92	208.10
DK014	Bornholm	9.5	-112.67	221.01
DK021	Østsjælland	42.6	-102.46	197.66
DK022	Vest- og Sydsjælland	31.1	-99.22	192.15
DK031	Fyn	20.4	-98.09	189.88
DK032	Sydjylland	18.8	-101.02	195.59
DK041	Vestjylland	16.5	-102.57	199.39
PT11A	Área Metropolitana do Porto	14.4	-4.75	69.97
PT11B	Alto Tâmega e Barroso	8.3	-8.22	118.49
PT11C	Tâmega e Sousa	10.3	-9.42	134.85
PT11D	Douro	6.5	-8.08	115.45
PT11E	Terras de Trás-os-Montes	7.4	-7.21	103.00
PT150	Algarve	3.0	-7.60	109.44
PT16B	Oeste	7.6	-9.47	134.50
PT16D	Região de Aveiro	8.8	-9.95	140.86
PT16E	Região de Coimbra	8.1	-8.15	116.29
PT16F	Região de Leiria	7.0	-9.52	135.40
PT16G	Viseu Dão Lafões	7.7	-8.88	126.38
PT16H	Beira Baixa	7.1	-8.17	116.13
PT16I	Médio Tejo	6.8	-9.11	129.63
PT16J	Beiras e Serra da Estrela	7.0	-7.91	112.91
PT170	Área Metropolitana de Lisboa	7.5	-9.63	134.81
PT181	Alentejo Litoral	5.5	-17.02	240.94
PT184	Baixo Alentejo	4.6	-13.62	193.23
PT185	Lezíria do Tejo	5.0	-16.53	234.79
PT186	Alto Alentejo	5.1	-13.53	192.15
PT187	Alentejo Central	5.6	-16.40	235.12
PT200	Região Autónoma dos Açores	3.2	0.00	0.00
PT300	Região Autónoma da Madeira	3.0	-12.78	180.03
RO111	Bihor	31.0	37.24	107.48
RO112	Bistriţa-Năsăud	56.4	26.02	76.21
RO113	Cluj	73.2	24.77	72.78
RO114	Maramureş	58.4	27.02	79.09
RO115	Satu Mare	61.1	32.87	95.98
RO116	Sălaj	51.0	34.59	100.59
RO121	Alba	64.5	29.64	86.84
RO122	Braşov	66.9	24.69	72.49
RO123	Covasna	48.9	29.17	84.89
RO124	Harghita	31.6	26.19	76.36
RO125	Mureş	65.4	28.99	84.78
RO126	Sibiu	68.3	27.19	79.74
RO211	Bacău	59.8	108.65	297.86
RO212	Botoşani	54.2	148.86	404.29
RO213	Iaşi	65.2	87.41	241.37
RO214	Neamţ	62.5	109.36	299.78
RO215	Suceava	42.6	147.81	400.58
RO216	Vaslui	65.1	110.12	302.06
RO221	Brăila	78.6	38.75	112.56
RO222	Buzău	61.2	39.56	114.38
RO223	Constanţa	66.1	73.15	204.60
RO224	Galaţi	68.8	39.09	113.35
RO225	Tulcea	46.5	54.06	153.57
RO226	Vrancea	52.5	37.30	108.25
RO311	Argeş	64.6	34.40	100.20
RO312	Călăraşi	59.6	44.03	126.98
RO313	Dâmboviţa	69.9	38.26	111.13
RO314	Giurgiu	59.6	41.26	119.43
RO315	Ialomiţa	66.1	43.34	125.38
RO316	Prahova	67.8	35.28	102.86
RO317	Teleorman	55.5	43.55	125.33
RO321	Bucureşti	48.4	30.95	91.50
RO322	Ilfov	77.5	38.89	114.58
RO411	Dolj	55.8	168.75	457.46

			Avg. additional heating costs (€)	
NUTS3	Region	Fossil heat-ers (%)	ETS2 60 EUR/t	ETS2 180 EUR/t
DK042	Østjylland	12.8	-102.91	199.56
DK050	Nordjylland	13.0	-99.63	193.92
EE001	Põhja-Eesti	5.7	94.23	273.33
EE004	Lääne-Eesti	3.3	103.49	298.60
EE008	Lõuna-Eesti	4.0	95.51	276.27
EE009	Kesk-Eesti	3.4	93.42	270.03
EE00A	Kirde-Eesti	4.8	90.98	262.94
EL301	Βόρειος Τομέας Αθηνών	83.4	89.90	262.29
EL302	Δυτικός Τομέας Αθηνών	77.1	94.92	276.51
EL303	Κεντρικός Τομέας Αθηνών	84.9	81.68	238.00
EL304	Νότιος Τομέας Αθηνών	83.2	87.50	254.90
EL305	Ανατολική Αττική	75.0	106.43	310.48
EL306	Δυτική Αττική	75.6	108.64	317.48
EL307	Πειραιάς, Νήσοι	80.0	92.32	269.00
EL411	Λέσβος, Λήμνος	60.3	108.77	317.02
EL412	Ικαρία, Σάμος	61.6	108.98	317.53
EL413	Χίος	61.9	110.58	322.35
EL421	Κάλυμνος, Κάρπαθος – Ηρωική Νήσος Κάσος, Κως, Ρόδος	53.5	121.79	354.51
EL422	Άνδρος, Θήρα, Κέα, Μήλος, Μύκονος, Νάξος, Πάρος, Σύρος, Τήνος	44.4	124.59	363.06
EL431	Ηράκλειο	63.8	103.91	302.63
EL432	Λασίθι	54.4	110.73	322.25
EL433	Ρέθυμνο	60.2	106.11	308.86
EL434	Χανιά	63.1	103.39	301.02
EL511	Έβρος	67.4	94.56	275.58
EL512	Ξάνθη	69.7	89.53	261.19
EL513	Ροδόπη	64.1	93.52	272.60
EL514	Δράμα	66.0	89.38	260.81
EL515	Θάσος, Καβάλα	68.4	96.08	280.16
EL521	Ημαθία	74.1	98.70	287.78
EL522	Θεσσαλονίκη	84.7	85.56	249.30
EL523	Κιλκίς	71.7	97.07	283.02
EL524	Πέλλα	72.7	96.85	282.52
EL525	Πιερία	76.4	94.62	275.95
EL526	Σέρρες	72.4	92.20	268.92
EL527	Χαλκιδική	73.9	98.85	288.35
EL531	Γρεβενά, Κοζάνη	81.0	94.18	274.82
EL532	Καστοριά	78.3	91.71	267.95
EL533	Φλώρινα	79.5	91.02	265.62
EL541	Άρτα, Πρέβεζα	71.8	104.92	305.60
EL542	Θεσπρωτία	72.7	105.55	307.54
EL543	Ιωάννινα	76.3	89.15	260.01
EL611	Καρδίτσα, Τρίκαλα	72.7	96.91	282.50
EL612	Λάρισα	79.7	91.65	267.21
EL613	Μαγνησία, Σποράδες	79.1	90.50	263.87
EL621	Ζάκυνθος	61.5	119.70	348.99
EL622	Κέρκυρα	62.9	114.19	332.57
EL623	Ιθάκη, Κεφαλληνία	61.1	112.74	328.40
EL624	Λευκάδα	61.4	112.96	329.28
EL431	Ηράκλειο	63.8	103.91	302.63

			Avg. additional heating costs (€)	
NUTS3	Region	Fossil heat-ers (%)	ETS2 60 EUR/t	ETS2 180 EUR/t
RO412	Gorj	62.9	154.18	418.89
RO413	Mehedinţi	26.8	164.15	442.39
RO414	Olt	57.5	174.37	472.58
RO415	Vâlcea	47.3	167.03	452.04
RO421	Arad	52.1	33.00	96.44
RO422	Caraş-Severin	47.1	34.20	99.94
RO423	Hunedoara	76.4	30.07	87.93
RO424	Timiş	60.7	31.89	93.42
SE110	Stockholms län	0.0	-493.38	294.26
SE121	Uppsala län	0.0	-303.05	179.96
SE122	Södermanlands län	0.0	-368.79	219.03
SE123	Östergötlands län	0.0	-193.43	114.80
SE124	Örebro län	0.0	-341.51	204.14
SE125	Västmanlands län	0.0	-320.86	191.32
SE211	Jönköpings län	0.0	-220.84	131.11
SE212	Kronobergs län	0.0	-166.93	99.23
SE213	Kalmar län	0.0	-254.96	152.61
SE214	Gotlands län	0.0	-357.45	211.54
SE221	Blekinge län	0.1	-303.37	180.34
SE224	Skåne län	0.0	-317.62	188.60
SE231	Hallands län	0.1	-335.50	199.24
SE232	Västra Götalands län	0.0	-253.83	150.77
SE311	Värmlands län	0.0	-278.84	165.51
SE312	Dalarnas län	0.6	-243.57	145.26
SE313	Gävleborgs län	0.0	-243.63	144.66
SE321	Västernorrlands län	0.0	-384.15	228.49
SE322	Jämtlands län	0.0	-296.62	176.21
SE331	Västerbottens län	0.0	NaN	NaN
SE332	Norrbottens län	0.0	NaN	NaN
SI031	Pomurska	27.1	210.02	608.21
SI032	Podravska	28.1	194.10	561.89
SI033	Koroška	27.5	192.83	558.52
SI034	Savinjska	27.4	198.68	575.23
SI035	Zasavska	28.5	189.00	546.83
SI036	Posavska	26.6	208.54	603.76
SI037	Jugovzhodna Slovenija	26.5	211.23	611.67
SI038	Primorsko-notranjska	27.6	191.49	554.39
SI041	Osrednjeslovenska	29.9	195.41	565.64
SI042	Gorenjska	28.6	198.34	574.30
SI043	Goriška	27.8	199.56	577.96
SI044	Obalno-kraška	29.8	202.63	586.31
SK010	Bratislavský kraj	89.3	293.04	839.45
SK021	Trnavský kraj	71.6	231.62	663.00
SK022	Trenčiansky kraj	71.5	225.78	646.27
SK023	Nitriansky kraj	80.8	229.03	655.55
SK031	Žilinský kraj	41.8	232.73	666.18
SK032	Banskobystrický kraj	53.3	225.97	646.90
SK041	Prešovský kraj	71.6	236.77	677.71
SK042	Košický kraj	63.0	234.16	670.24

Experts' contribution

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Johanna Cludius, Senior Researcher, Energy & Climate, Öko-Institut

Elisabetta Cornago, Senior Research Fellow, EU Energy and Climate Policy, Centre for European Reform

Sorcha Edwards, Secretary General, Housing Europe

Lorenzo Faggiano, Policy Analyst, European Commission, DG CLIMA

Simon Feindt, Researcher, Climate & Energy Policy, Potsdam Institute for Climate Impact Research

Christopher Fernandes, Policy Assistant to the Director of CLIMA B, European Commission, DG CLIMA

Murielle Gagnebin, Senior Associate, EU and French Energy Policy, Agora Energiewende

Benjamin Görlach, Lead, EU Climate Economics and Finance, Agora Energiewende

Philipp Jäger, Senior Policy Fellow, European Climate and Economic Policy, Jacques Delors Centre

Sebastian Kraus, Policy Officer, German Federal Chancellery

Sandra Köster, Head, Socially Just Climate Policy, Climate Protection and Acceptance (KA4), German Federal Ministry for Economic Affairs and Climate Action

Joachim Maes, Policy Analyst, European Commission, DG REGIO

Phuc Vinh Nguyen, Head, Energy Centre, Jacques Delors Institute

Michael Pahle, Working Group Leader, Climate & Energy Policy, Potsdam Institute for Climate Impact Research

Katja Schumacher, Deputy Head of Division / Senior Researcher, Energy & Climate, Öko-Institut

Eleanor Scott, Expert on EU Carbon Markets, Carbon Market Watch

François Schmitt, Policy Officer, Carbon Markets and Clean Mobility, European Commission, DG CLIMA

Jenny Simon, Head of Division, Social Dimension of Climate and Environmental Policy, German Federal Ministry of Labor and Social Affairs

Kerstin Tews, Head of Section, Economic & Socio-Scientific Environmental Issues and Sustainable Consumption, German Federal Environment Agency (Umweltbundesamt)

Nelly Unger, Researcher, Resources & Mobility, Öko-Institut

Helga Weisz, Head, FutureLab - Social Metabolism & Impacts, Potsdam Institute for Climate Impact Research (PIK) / Professor of Industrial Ecology and Climate Change, Humboldt University

Hans Zschüttig, Policy Officer, Economic Policy Issues of Emissions Trading, Auctions, Evaluations, German Emissions Trading Authority (DEHSt), German Federal Environment Agency (Umweltbundesamt)

Address | Contact

Bertelsmann Stiftung
Carl-Bertelsmann-Straße 256
33311 Gütersloh
Germany
Phone +49 (5241) 81-0
bertelsmann-stiftung.de

Dr. Thomas Schwab
Senior Expert European Economics
Program Europe's Future
Phone +49 (30) 27 57 88-132
thomas.schwab@bertelsmann-stiftung.de
bertelsmann-stiftung.de/europes-economy

Sara Hagemann
Project Manager
Program Sustainable Social Market Economies
Phone +49 (5241) 81-81143
sara.hagemann@bertelsmann-stiftung.de
bertelsmann-stiftung.de/unsere-projekte/zukunftsstandort-deutschland