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Dr. Johanna Cludius, Nelly Unger, Dr. Viktoria Noka, Dr. Katja Schumacher
Oeko-Institut e.V., Berlin

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buergerservice@uba.de
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Oeko-Institut e.V.
Merzhauser Str. 173
79100 Freiburg
Berlin Office
Borkumstraße 2
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Abstract: Energy and transport vulnerability of households in the context of emissions trading: An analysis for 10 EU Member States

Energy and transport poverty and vulnerability are a central building block in the debate around many energy and climate policy issues and have gained firm hold in EU directives, regulations and documents. National governments need to establish indicators for both energy and transport poverty and vulnerability, to fulfil reporting requirements to the EU and to develop and target suitable policies and measures. In this report, we focus specifically on those indicators and results relevant to the new EU emissions trading system covering buildings and road transport (ETS 2) and the Social Climate Fund (SCF). The goal of this study is to show the scope of options available to the Member States by identifying "vulnerability structures" related to home heating and transport.

We look at a selection of ten Member States from different regions of the EU and study vulnerability structures within and across these Member States by applying 17 indicators for both energy and transport poverty and vulnerability. We find a high degree of heterogeneity in vulnerability patterns within and between Member States, highlighting the different focal points of each indicator. For vulnerability related to heating, indicators that rely on expenditures of households generally show higher shares of vulnerable households than self-reported indicators. For vulnerability in the transport sector, no clear pattern emerges when comparing results across European regions – we rather find country-specific effects. Indicators without an income threshold likely overestimate the share of vulnerable households especially in high-income Member States. While we are able to estimate a whole range of vulnerability indicators for the ten countries, important data gaps and data quality issues exist. Additional data on the energy performance of a building, as well as the access to essential services would be very valuable in this regard.

Based on the results on vulnerability patterns across the EU, we evaluate the means available to support vulnerable households through the SCF. The amount of funding that will be available per vulnerable household is directly related to the indicator chosen to identify those households. The funding per household will be higher if the targeting is very concise and the group of recipients is small. The funding per vulnerable household can be increased if additional, national resources are made available to support vulnerable households. This is particularly important for most Northern and Western European countries that receive only a small share of the SCF funding.

Kurzbeschreibung: Energie- und Mobilitätsarmut von Haushalten im Kontext des Emissionshandels: Eine Analyse für 10 EU-Mitgliedstaaten

Energie- und Mobilitätsarmut sind integraler Bestandteil der Debatte vieler energie- und klimapolitischer Themen und haben sich in zentralen EU-Richtlinien, Verordnungen und Dokumenten fest etabliert. EU-Mitgliedstaaten müssen Indikatoren für Energie- und Mobilitätsarmut und Benachteiligung in diesen Bereichen festlegen, um die Berichtspflichten gegenüber der EU zu erfüllen und um geeignete Politiken und Maßnahmen für diese Gruppen zu entwickeln. In diesem Bericht konzentrieren wir uns speziell auf Indikatoren und Erkenntnisse, die für den neuen EU-Emissionshandel für Heiz- und Kraftstoffe (ETS 2) und den Klima-Sozialfonds (KSF) relevant sind.

Wir betrachten zehn Mitgliedstaaten aus verschiedenen Regionen der EU und untersuchen Benachteiligungsstrukturen, indem wir 17 Indikatoren für Energie- und Mobilitätsarmut anwenden. Benachteiligungsmuster variieren stark innerhalb und zwischen den Mitgliedstaaten, was verdeutlicht, dass die einzelnen Indikatoren jeweils unterschiedliche Aspekte der Benachteiligung stärker in den Vordergrund stellen. Bei der Benachteiligung im Zusammenhang mit Heizen weisen Indikatoren, die sich auf die Ausgaben der Haushalte für Heizenergie stützen, einen höheren Anteil an benachteiligten Haushalten aus als Indikatoren, die auf Selbstauskünften beruhen. Bei der Benachteiligung in Bezug auf Mobilität ergibt sich beim Vergleich der Ergebnisse zwischen den europäischen Regionen kein klares Muster. Es sind eher länderspezifische Effekte festzustellen. Indikatoren ohne Einkommensschwelle überschätzen wahrscheinlich den Anteil der benachteiligten Haushalte, insbesondere in Mitgliedstaaten mit hohem Einkommen.

Um die Möglichkeiten zur Messung von Fortschritten und zur Identifizierung benachteiligter Haushalte weiter zu verbessern, sollten zusätzliche Daten erhoben und veröffentlicht werden. In Bezug auf das Heizen betrifft dies zum Beispiel die Energieeffizienz von Gebäuden. In Bezug auf Mobilität wären Daten zu Erreichbarkeit wichtiger Dienstleistungen des täglichen Bedarfs mit unterschiedlichen Verkehrsmitteln sehr wertvoll.

Auf Grundlage der Ergebnisse zu den Benachteiligungsmustern in der EU bewerten wir die verfügbaren Mittel zur Unterstützung benachteiligter Haushalte durch den KSF. Die Höhe der Mittel, die pro benachteiligtem Haushalt zur Verfügung stehen, hängt direkt mit dem Indikator zusammen, der zur Identifizierung dieser Haushalte gewählt wurde. Die Mittel pro Haushalt sind höher, wenn die Zielgruppen sehr genau eingegrenzt werden und die Gruppe der Empfangenden klein ist. Die Mittel pro benachteiligtem Haushalt können erhöht werden, wenn zusätzliche nationale Mittel zur Unterstützung dieser Haushalte bereitgestellt werden. Dies ist besonders wichtig für die meisten nord- und westeuropäischen Länder, die nur einen geringen Anteil der Mittel aus dem KSF erhalten.

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List of abbreviations

AROP	At risk of poverty
CEE	Central and Eastern Europe
EED	Energy Efficiency Directive
EPAH	Energy Poverty Advisory Hub
EPBD	Energy Performance of Buildings Directive
EPOV	EU Energy Poverty Observatory
ETS	Emissions Trading System
EU-SILC	EU Survey on Income and Living Conditions
EVS	Einkommens- und Verbrauchsstichprobe (National Income and Expenditure Survey in Germany)
FCO	Forced Car Ownership
HBS	Household Budget Survey
HCPI	Harmonised Consumer Price Indices
LIHC	Low Income High Cost
SCF	Social Climate Fund
SCP	Social Climate Plan

1 Introduction

Energy and transport poverty of households and their vulnerability to rising prices and/or the introduction of climate policies have become central issues in EU policy making (Noka and Cludius 2021). The concepts are included and defined in a range of EU legislative documents, including the Energy Efficiency Directive (EED; EC 2023b), the Energy Performance of Buildings Directive (EPBD; to be adopted early 2024), the Emissions Trading (ETS) Directive (EU 2023b) and the Social Climate Fund Regulation (EU 2023a). Another important reference is the Energy Poverty Recommendation updated in 2023 (EC 2023a).

The Emissions Trading Directive establishes an ETS 2 that puts a price on carbon emissions in the road transport and buildings sectors, starting in 2027.[1] In order to address potential negative impacts, a Social Climate Fund (SCF) will start operating in 2026, which will fund measures targeted at those vulnerable to the introduction of the ETS 2. Article 2 of the Regulation on the Social Climate Fund (EU 2023a) contains definitions for energy and transport poverty as well as for "vulnerable households, vulnerable micro-enterprises and vulnerable transport users":

- **Energy poverty** means a household's lack of access to essential energy services that underpin a decent standard of living and health, including adequate warmth, cooling, lighting, and energy to power appliances, in the relevant national context, existing social policy and other relevant policies.
- **Transport poverty** means individuals' and households' inability or difficulty to meet the costs of private or public transport, or their lack of or limited access to transport needed for their access to essential socioeconomic services and activities, taking into account the national and spatial context.

The concept of vulnerable groups contained in the SCF is broader and emphasizes that the groups are not only affected by energy or transport poverty and low income but are also likely to be burdened by the price effects of ETS 2 and lack the means to invest in climate-friendly technologies or switch to alternatives.

- **Vulnerable households** means households in energy poverty or households, including low income and lower middle-income ones, that are significantly affected by the price impacts of the inclusion of greenhouse gas emissions from buildings within the scope of Directive 2003/87/EC and lack the means to renovate the building they occupy.
- **Vulnerable transport users** means individuals and households in transport poverty, but also individuals and households, including low income and lower middle-income ones, that are significantly affected by the price impacts of the inclusion of greenhouse gas emissions from road transport within the scope of Directive 2003/87/EC and lack the means to purchase zero- and low-emission vehicles or to switch to alternative sustainable modes of transport, including public transport.

In order to access funds from the SCF, Member States have to write up Social Climate Plans (SCPs) detailing their strategies to identify and support vulnerable groups. The same is true in relation to reporting under the EED. As Section 3 will show, a whole range of indicators is available that could potentially be used to identify those most in need and it is now up to the Member States to decide which indicator framework is most suitable in their national context.

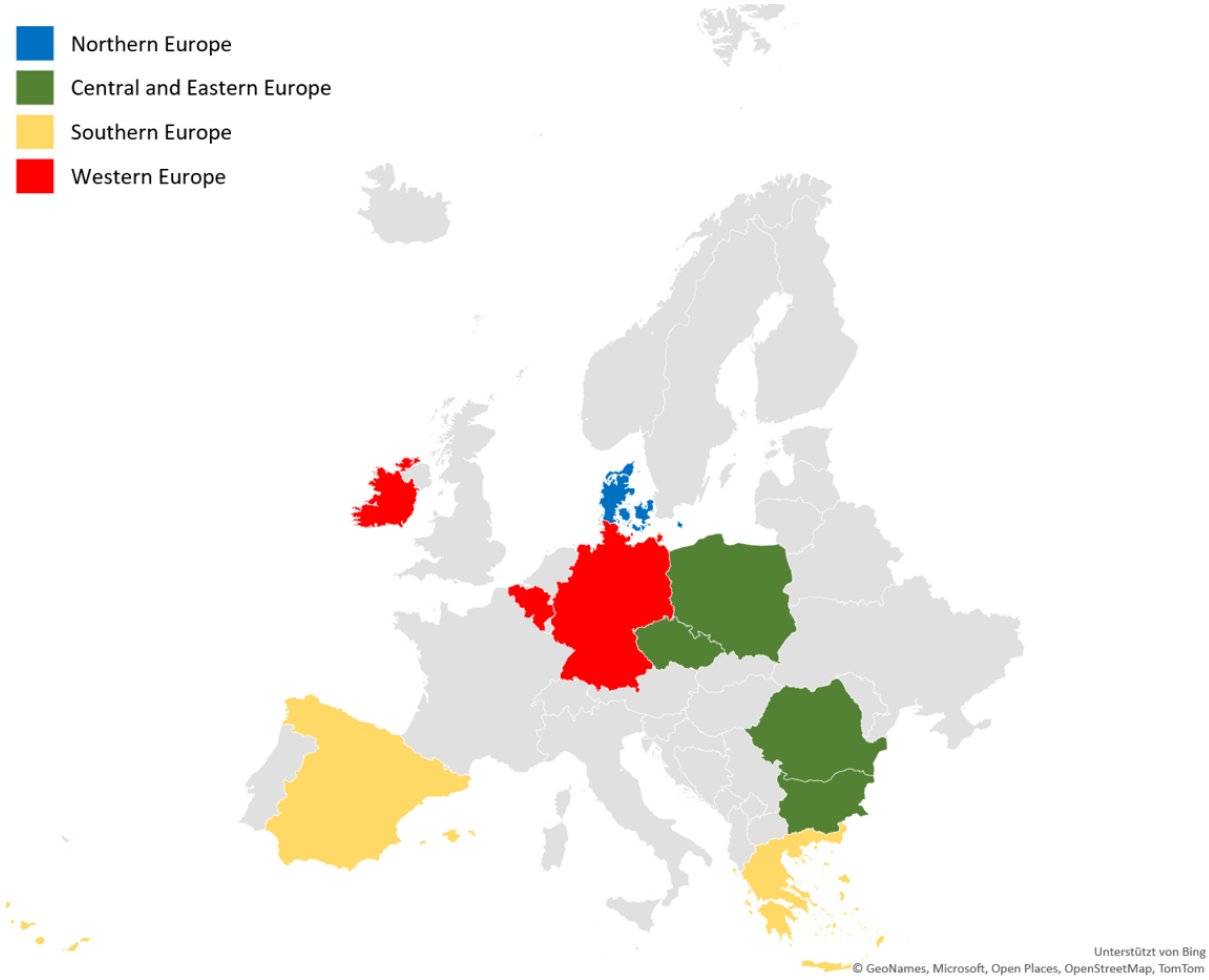
[1] In addition to the road transport and buildings sectors, the ETS-2 will also cover (small) industrial installations not covered by the ETS-1.

Member States will also have to identify which data is available at the national level to carry out these calculations, ideally comprising both data at the national and local level and potentially using EU-level data as employed in this report.

The goal of this study is to show the breadth of options available to the Member States by identifying "vulnerability structures" related to home heating and transport. We do this by comparing results for a range of different energy poverty, transport poverty and vulnerability indicators that emphasize different aspects of the challenge.

We look at a selection of ten Member States providing a large and diverse geographical coverage of the EU-27, including Belgium, Bulgaria, Czechia, Denmark, Germany, Greece, Ireland, Poland, Romania and Spain (Figure 1).

Figure 1 EU Member States selected for the study



Note: Classification according to EuroVoc[2]

The remainder of the paper is structured as follows. In Section 2, we detail our data sources and estimation method and provide statistics on expenditure for heating and transport in the ten selected Member States. In Section 3, we discuss the indicators being estimated and methodological challenges and considerations. Section 4 presents results of the vulnerability analysis covering the ten Member States. In Section 5, these results are applied to the case of the ETS 2 and SCF and used to determine the available funds to support each vulnerable household

[2] https://op.europa.eu/en/web/eu-vocabularies/concept-scheme/-/resource?uri=http://eurovoc.europa.eu/100277

according to different indicators. We compare the available funds to typical investment costs for climate protection measures in the building sector, e.g. home insulation. In Section 6, we conclude.

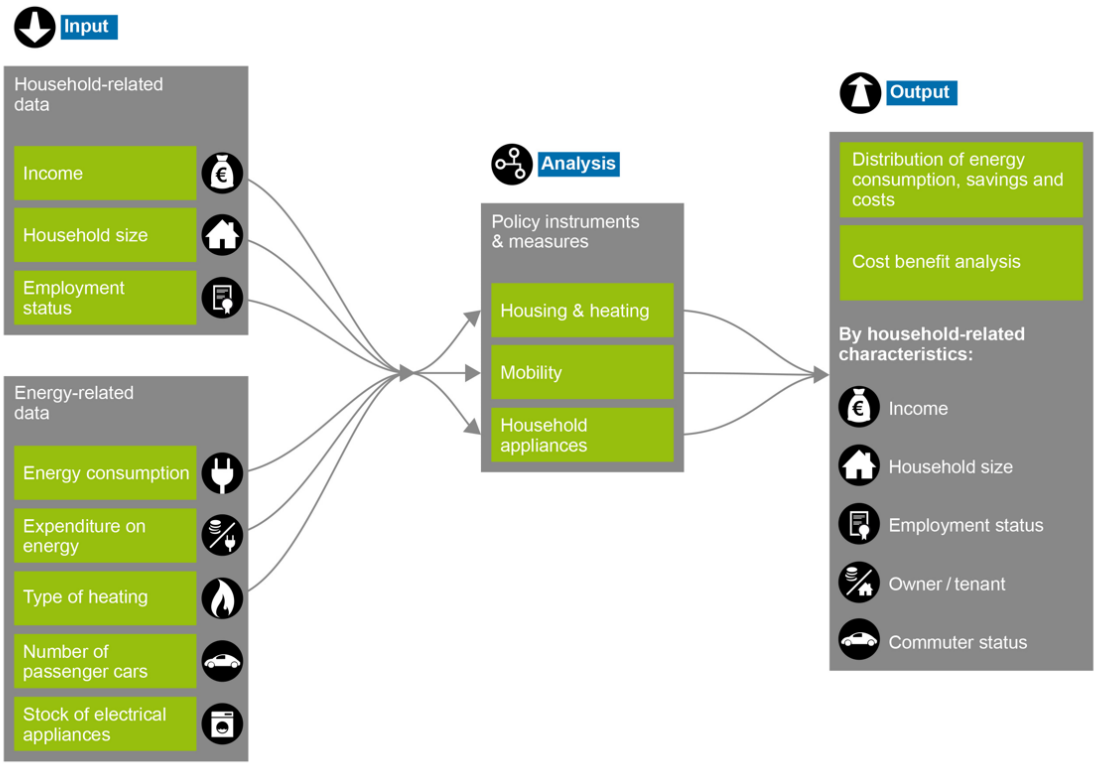
2 Data sources, estimation method and descriptive statistics

2.1 Data sources and estimation method

We use our SEEK-EU microsimulation model (Figure 2) to generate descriptive statistics for the ten selected Member States and to determine the size and characteristics of vulnerable groups according to a range of indicators. The model is based on microdata from Eurostat's Household Budget Survey (HBS) and the EU Survey on Income and Living Conditions (EU-SILC).

The HBS reports household spending and is used at a national level to calculate weights for the Consumer Price Index. It is conducted by the national statistical office of each EU country. Since Member States decide on the objectives, methodology and frequency of the survey, it may vary between countries. Eurostat collects and publishes data every five years. The EU-SILC survey provides data on household income, direct taxes and social contributions as well as further variables on social exclusion and living conditions. It is designed by Eurostat and has been conducted every year since 2004. It provides cross-sectional data as well as longitudinal data, observed periodically over a 4-year period.

Figure 2 The SEEK-EU Microsimulation Model



Source: Oeko-Institut

We use data from the HBS 2015[3] and inflate the recorded expenditures to 2022/2023 levels using the average monthly Eurostat Harmonised Consumer Price Indices (HCPI) between January 2022 and September 2023.[4] By doing so, we take into account that vulnerabilities likely

[3] The HBS 2020 only became available on 6th December 2023.

[4] https://ec.europa.eu/eurostat/web/hicp/database

increase if prices rise. At the same time, we have to assume that consumption patterns for energy and transport are still similar to what was observed in 2015. We believe that especially for those households that are vulnerable, this is likely to hold, since they often lack the means to transition away from fossil fuels (cf. Section 1).

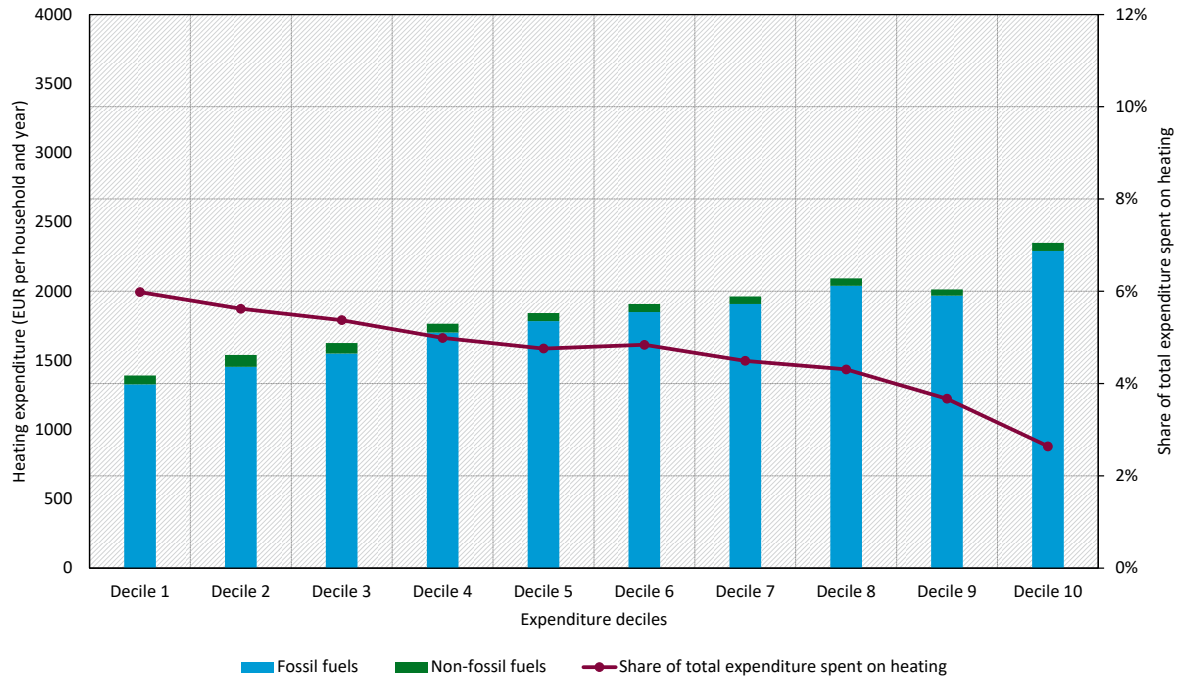
For Germany, we use data from the 2018 national Income and Expenditure Survey (EVS). The HBS published by Eurostat cannot be used for Germany, because it lacks data on several expenditure categories, including electricity, petrol and transport services. This national data is also inflated to 2022/2023 using Eurostat HCPI values.

Information on income is not available for all countries in the HBS. This is why we use expenditure as a proxy for a household's available budget[5] in our model and divide households into ten expenditure deciles. These deciles sort households according to their total expenditure from lowest to highest and take into account the composition of the household by assigning weights to each household member according to the new OECD scale.[6]

2.2 Statistics on heating and transport expenditure

When looking at the expenditure for heating and transport by expenditure deciles in the ten selected Member States, we find that they differ in a multitude of ways. Please see Annex A for the full set of results in terms of descriptive statistics. In this Section, we discuss the statistics of Belgium and Poland. These two countries show relatively large differences in relation to heating and transport expenditure and are therefore suitable to illustrate different ends of the spectrum.

Figure 3 Belgium: Heating expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).

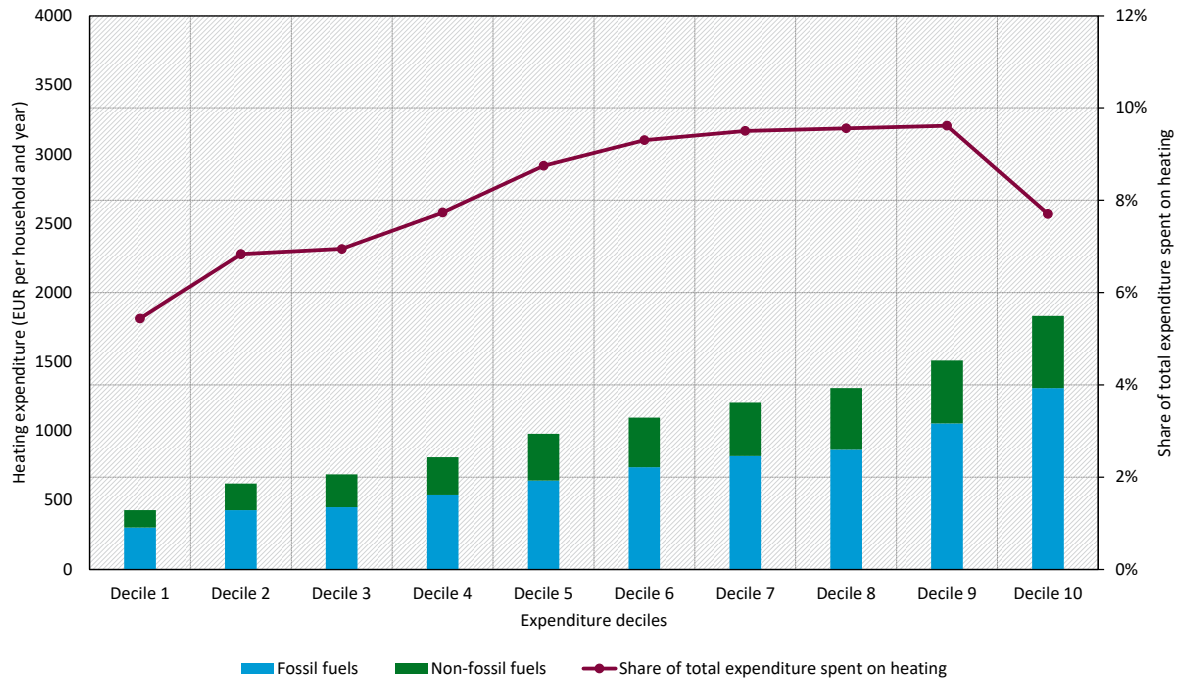
Notes: Fossil fuels include natural gas, heating oil and coal. Non-fossil fuels include biomass and district heating.

[5] For a discussion on consumption as a suitable proxy for long-term resources see e.g. (2017).

[6] The new OECD scale assigns a weight of 1 to the first household member, a weight of 0.5 to each other adult member and a weight of 0.3 to each child in the household. This reflects the "economies of scale" in a household, i.e. all household members share one kitchen and living room, one car, household appliances, and so on.

First, the absolute level of expenditures for heating and transport differs. While households in Belgium spend an average of 1,900 Euros on heating (Figure 3) and 1,700 Euros on transport per year (Figure 5), households in Poland spend an average 1,000 Euros (Figure 4) and 700 Euros (Figure 6) respectively. In both countries, expenditures for heating and transport rise with total expenditures. This is a general result for all selected Member States (Annex A) and is related to the fact that in general floor space and kilometres driven rise with income.

Figure 4 **Poland: Heating expenditure (absolute and relative to total expenditure) per household by expenditure decile**



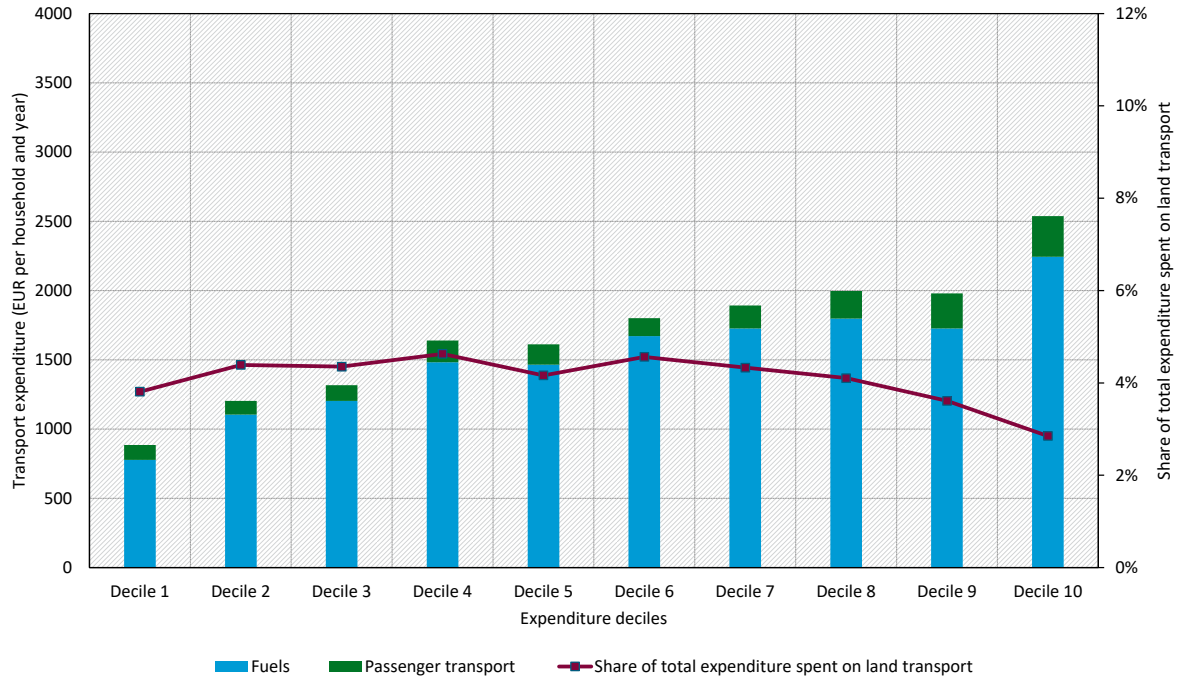
Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).

Notes: Fossil fuels include natural gas, heating oil and coal. Non-fossil fuels include biomass and district heating.

Second, the distribution of the expenditures across different energy carriers depends on the heating and mobility system of the country. In transport, the main expenditure items are petrol and diesel (aggregated to fuels in this report) in all countries observed. In most of the countries observed, these two items account for more than 85 % of the expenditure in transport, for higher incomes, often more than 90 %. The only exceptions are Bulgaria and Romania. In Bulgaria up to the seventh decile fuels account for less than 80 % of expenditure on transport. In Romania fuels account for less than 50 % in the first two deciles and the share increases with income up to 83 %. (Annex A). At least for Romania, however, comparing the data to national sources reveals that the HBS is incomplete for expenditures on petrol and diesel (cf. Eden et al. 2023).[7]

7 The HBS data is not 100% comparable between countries as the implementation of the HBS is the responsibility of the Member States and the data is not fully harmonised between countries. More information on the data quality of the HBS can be found in Section 3.2.

Figure 5 Belgium: Transport expenditure (absolute and relative to total expenditure) per household by expenditure decile



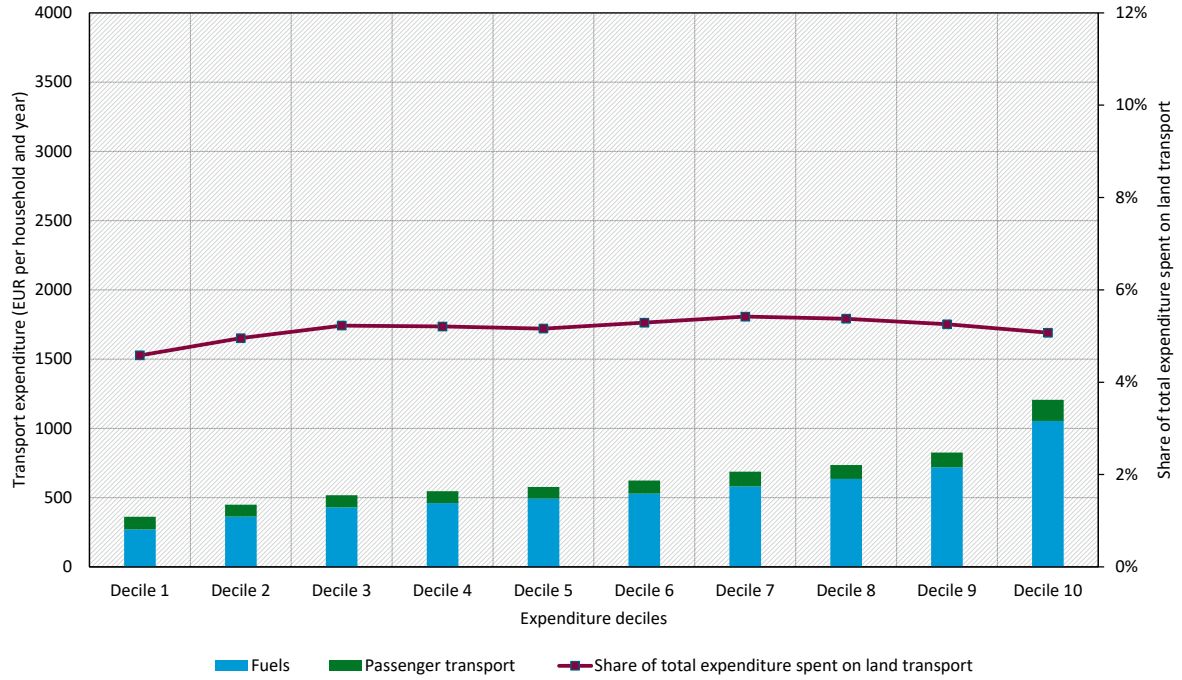
Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).

Notes: Fuels include expenditure on diesel and petrol. Passenger transport includes expenditure on passenger transport by train, underground, tram, bus, coach, taxi and hired car with driver.

Third, the statistics also reveal what share of their overall expenditure budget households spend on heating and transport. This is shown on the right-hand side axes of the figures. Although absolute amounts of Euros spent on heating (left axis) are much higher on average per household in Belgium than in Poland, households in Poland on average spend 8 % of their total budget compared to only 5 % in Belgium (compare right axis of Figure 3 and Figure 4). While the share of the overall budget spent on heating decreases with income in Belgium, it rises with income in Poland. This suggests that – in Belgium – the increase in income is more important than the increase in heating energy consumption (which in turn is likely driven by larger living space). In Poland, the dynamic seems to be reversed, which may be an indication of material deprivation in lower income deciles. In most countries observed, the share of total expenditure spent on heating decreases with income (Annex A). Poland and Romania are the exceptions.

Similarly for transport, although absolute expenditures are higher in Belgium, the average Belgian household spends 4 % of their expenditure budget on transport (Figure), while it is 5 % for the average Polish household (Figure 6). In Poland, the distribution of the budget share spent on transport is fairly flat across incomes. In Belgium, an inversed U-shape can be observed with low and high incomes spending relatively less than middle incomes. For all ten observed countries, we see a range of different distribution patterns when it comes to transport expenditure (see also Annex A). They are flat across incomes for Czechia, Denmark, Greece, Poland and Spain, an inverted U-shape for Belgium, Germany and Ireland, and a rising share of total expenditure spent on transport with income for Bulgaria and Romania.

Figure 6 **Poland: Transport expenditure (absolute and relative to total expenditure) per household by expenditure decile**



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).

Notes: Fuels include expenditure on diesel and petrol. Passenger transport includes expenditure on passenger transport by train, underground, tram, bus, coach, taxi and hired car with driver.

These differences in expenditures for heating and transport have to be taken into account when interpreting the results on the vulnerability related to heating and transport for the selected countries.

3 Vulnerability indicators and methodological considerations

3.1 Estimated vulnerability indicators

Vulnerability has multiple dimensions (Thomson et al. 2017) that are captured by different indicators (Oeko-Institut and FOES 2024). Indicators should therefore be chosen according to the purpose of the analysis. There is no "perfect" indicator that captures all dimensions, and the policy debate needs appropriate indicators to identify and monitor the number and characteristics of vulnerable households.

All indicators that are estimated in this study can be used to address the question of the resources needed to support vulnerable groups, which we tackle in Section 5. However, not all indicators are suitable for the development and implementation of policies and policy instruments. Direct income support is often feasible with only a few indicators. We take this into account by including a "policy indicator" of being at risk of poverty (AROP) into our analysis.

The search for suitable energy poverty indicators – traditionally related to both heating and electricity use in the household – has been going on for decades (Boardman 1991; Isherwood and Hancock 1979). At the EU level, a set of indicators has been established by the EU Energy Poverty Observatory (EPOV) and further developed by the Energy Poverty Advisory Hub (EPAH).[8] As shown below, these indicators encompass both expenditure-based and self-reported ones. As our analysis focusses specially on the ETS 2 and the SCF, we estimate indicators relating to home heating and exclude electricity from the analysis.[9]

Indicators for transport poverty and vulnerability in the transport sector have recently come into focus, not least because of the ETS 2 and SCF. Oeko-Institut; WiseEuropa; Center for the Study of Democracy; Cambridge Econometrics; University of Manchester; Ecoserveis (2024 forthcoming) propose to define transport poverty along the three A's of Availability, Accessibility and Affordability, along with a cross-cutting category of Acceptability. In their report, they detail relevant indicators that match these categories using Eurostat data from the HBS and EU-SILC that we also apply in this report. These findings are in line with Mejía Dorantes and Murauskaite-Bull (2022).

Based on the EU-SILC and the EU HBS datasets we construct expenditure-based and self-reported indicators for the heating and the transport sector, as well as a policy indicator based on household income. Table 1 details the estimated indicators.

Table 1 Definitions of estimated vulnerability indicators for heating and transport

Indicator	Definition	Sector	Year
Expenditure-based indicators (HBS data)			
2M	Share of energy / transport in total expenditures is more than twice the national median	Heating & transport	HBS 2015 data (inflated to 2022/23)

[8] https://energy-poverty.ec.europa.eu/index_en

[9] The generation of electricity is covered by the ETS-1. This also applies to most district heating. We do, however, include district heating in the analysis under the assumption that it is a good proxy for those heating energy carriers that cannot be included due to data issues (coal and heating oil), see also below.

Indicator	Definition	Sector	Year
2M x AROP	Share of energy / transport in total expenditures is more than twice the national median AND household is at risk of poverty, i.e. total expenditures are less than 60 % of the national median	Heating & transport	HBS 2015 data (inflated to 2022/23)
M/2	(Equivalized[10]) expenditures on energy / transport are less than half the national median	Heating	HBS 2015 data (inflated to 2022/23)
M/2 x AROP	(Equivalized) expenditures on energy / transport are less than half the national median AND household is at risk of poverty, i.e. total expenditures are less than 60 % of the national median	Heating	HBS 2015 data (inflated to 2022/23)
LIHC	Household is at risk of poverty, i.e. expenditures are less than 60 % of the national median AFTER paying for energy / transport AND share of energy / transport in total expenditures is larger than national median	Heating & transport	HBS 2015 data (inflated to 2022/23)
Self-reported indicators (EU-SILC data)			
Keep home warm	Households answers „cannot keep home adequately warm“ in EU-SILC	Heating	EU-SILC 2022 data
Keep home warm x AROP	Households answers „cannot keep home adequately warm“ in EU-SILC AND household is at risk of poverty, i.e. total expenditures are less than 60 % of the national median	Heating	EU-SILC 2022 data
Arrears	Household is „in arrears on paying utility bills“ according to EU-SILC	Heating	EU-SILC 2022 data
Arrears x AROP	Household is „in arrears on paying utility bills“ according to EU-SILC AND household is at risk of poverty, i.e. total expenditures are less than 60 % of the national median	Heating	EU-SILC 2022 data
Forced Car Ownership	Household lives in Forced Car Ownership (FCO), according to Mattioli et al. (2017) indicator. The indicator identifies households that ‘own at least a car and are materially deprived’ (Mattioli 2017, p.150). It is assumed that the household is foregoing essential goods to finance car use because there is no suitable alternative to meet its daily mobility needs.	Transport	EU-SILC 2019 data
Accessibility	Access to public transport „with (great) difficulty“ according to SILC 2012 ad-hoc module	Transport	EU-SILC 2012 ad-hoc module

[10] Equivalized expenditures or incomes takes into account the composition of a household using the OECD scale. Equivalized expenditures or incomes are constructed by dividing household expenditures by a factor that is the sum of individual factors assigned to each household member: 1 for the first person in the household, 0.5 for the second and each subsequent person aged 14 years or older and 0.3 for each person under the age of 14.

Indicator	Definition	Sector	Year
Accessibility x AROP	Access to public transport „with (great) difficulty“ according to SILC 2012 ad-hoc module AND household is at risk of poverty, i.e. the (equalized) disposable income is less than 60 % of the national median	Transport	EU-SILC 2012 ad-hoc module
Availability	Public transport not available: Household answers „No - ticket too expensive “, „No - station too far away“, „No - access too difficult“ in SILC 2014 ad-hoc module	Transport	EU-SILC 2014 ad-hoc module
Availability x AROP	Public transport not available: Household answers „No - ticket too expensive“, „No - station too far away“, „No - access too difficult“ in SILC 2014 ad-hoc module AND household is at risk of poverty, i.e. the (equalized) disposable income is less than 60 % of the national median	Transport	EU-SILC 2014 ad-hoc module
Policy indicator (EU-SILC data)			
AROP	Household is at risk of poverty, i.e. the (equalized) disposable income is less than 60 % of the national median	No specific sector	EU-SILC 2022 data

In the category of expenditure-based indicators based on HBS data, we construct the 2M indicator for both heating and transport, identifying households with particularly high heating or transport expenditure in comparison to their total budget. We construct the M/2 indicator to identify hidden energy poverty for the heating sector, assuming that unusually low energy expenditure is an indication that households are heating less than they need to because of limited financial resources. For the transport sector, the M/2 indicator is as well suited as it is likely to identify households with very low transport expenditure as transport poor, even though this may be due to a high proportion of active mobility (walking, cycling) or cheap public transport, e.g. tickets for the elderly or subsidised work tickets. Both the 2M and M/2 indicators are taken from the set of indicators recommended by the EPOV and EPAH for use in measuring energy poverty in relation to energy expenditure at the national level. For both the 2M and M/2 indicators, we examine changes in the share of vulnerable households by restricting the potentially vulnerable households to those at risk of poverty.[11] In addition, we construct the Low Income High Cost (LIHC) indicator, which first emerged in the UK energy poverty debate. It takes into account high heating or transport costs as well as low income and therefore we do not combine this indicator with the restriction of being at risk of poverty. Compared with the 2M and M/2 indicator, the LIHC indicator is more sensitive to changes in energy prices because it is not only constructed on the basis of the national expenditure median but also takes into account the disposable income after paying for energy and transport bills.

Based on the EU-SILC dataset, we examine self-reported indicators in both sectors. For the heating sector, we rely on the EPAH indicators, which focus on the ability to keep the home adequately warm and arrears on utility bills. For the transport sector, we examine information

[11] We use the threshold ‘at risk of poverty’, because it is an EU-wide accepted and used definition of a poverty threshold. The income distribution can vary widely between countries, so there is no universal income threshold for all Member States to define middle-income groups. However, the restriction to AROP likely is too restrictive in relation to the SCF definitions, as lower middle-income and potentially middle-income households should still be able to qualify as vulnerable. Therefore, the restriction to AROP serves as an illustration more so than a recommendation of how to approach the indicators.

on access to public transport and the availability of public transport. In addition, we consider forced car ownership as defined by Mattioli et al. (2017). For the indicators 'keeping the home warm', 'arrears', 'accessibility' and 'availability', we again examine changes in the share of vulnerable households by restricting the potentially vulnerable households to those at risk of poverty.

Finally, we compare our results to an indicator focusing on households at risk of poverty, defined as households with a disposable income below 60 % of the national median. This indicator may be a suitable "policy indicator", because – contrary to many of the other indicators – it is relatively easy for the authorities to check whether households fall into this category, based on, for example, tax return or social transfer data.

For Germany, Schumacher et al. (2024) propose a number of combined indicators for identifying vulnerability related to heating that also take into account the energy performance of the building. While this would be desirable also in the context of this analysis, the EU-level data we use cannot be used to investigate this important dimension (see also Section 6 where we discuss some of the data gaps that exist).

3.2 Methodological considerations

Due to limited data availability, we use different years of data for the estimated indicators. All expenditure-based indicators are based on HBS 2015 data (national household budget survey data for Germany: EVS 2018), for which every separate product category has been inflated to 2022/2023 values using Eurostat HCPI values until 09/2023 (average HCPI from 01/2022 - 09/2023). Where HCPI values were not available for a particular product category, we used the HCPI value from the aggregate product category for the product.[12] For the self-reported indicators, the latest available EU-SILC data are used, i.e. 2022 for the heating indicators and various years for the transport indicators.

The HBS data does not provide information on the main energy source used by a household for heating, this can only be inferred from household expenditure. Household budget surveys are usually conducted over a recording period of 1-3 months and Eurostat HBS data is mapped to an agreed reference year, but not annualized (EC 2022). Therefore, if households have irregular expenditure, e.g. buy oil, coal or biomass only once a year, we observe zero or very high expenditure for these households in the HBS data. Also, the data does not provide any information on the regularity of the purchase and therefore the expenditure cannot be broken down by month of use. As a solution for the expenditure-based indicators related to heating, we calculate the share of vulnerable households using only households that heat with gas and district heating and assume that the share of vulnerable households is the same in the total population. In order for this method to yield valid results, we have to assume that households that use gas and district heating are more or less representative for the whole population. We believe that this assumption is more likely to hold if a large share of the population heats with gas or district heating and therefore calculate expenditure-based indicators only for countries where this share is at least 40 % of total heating expenditure. We also ensure that there is a relevant share of expenditure on gas and district heating across income deciles.

Due to data limitations in the 2015 HBS, we exclude or flag some data in our analysis. For example, the data for Romania do not capture part of the high proportion of biomass for heating that is obtained free of charge (Eden et al. 2023). Romania is therefore excluded from the calculation of the expenditure-based heating indicators. For transport expenditure, we find

[12] For example, we use the HCPI value for the aggregate product category passenger transport by railway, when the HCPI value for passenger transport by underground and tram is not available.

missing data for transport services in some countries. The expenditure-based indicators for transport are driven by fuel expenditure and excluding expenditure on transport services does not change the results much. We therefore retain countries with missing expenditure on transport services but flag them in the analysis (Denmark, Spain). Romania is excluded from the calculation of the expenditure-based transport indicators due to an implausibly high share of households with zero transport expenditure (Eden et al. 2023).

Table 2 provides information on the quality of the HBS data and the data restrictions related to our analysis for all ten countries. There are no issues with the use of EU-SILC data and we can estimate SILC indicators for all countries in the sample.

Table 2 Data availability and data caveats for the selected Member States in the 2015 HBS

Region	Member State	Vulnerability analysis heating	Vulnerability analysis transport
Northern Europe	Denmark	OK: >80 % of total heating expenditure from gas and district heating	Caveat for expenditure-based indicators (relatively high share of households with zero transport expenditure, no information on bus, coach, train, tram, underground expenditure) --> flagged for expenditure-based indicators High non-response rate in EU-SILC 2014 availability question
Western Europe	Belgium	OK: >50 % of total heating expenditure from gas and district heating	OK
	Germany	OK using national data: >50 % of total heating expenditure from gas and district heating	OK using national data
	Ireland	>40 % of total heating expenditure from gas and district heating --> flagged for expenditure-based indicators	OK
Central and Eastern Europe	Bulgaria	Expenditure-based indicators impossible: <40 % of total heating expenditure from gas and district heating	OK
	Czechia	OK: >90 % of total heating expenditure from gas and district heating	OK
	Poland	>50 % of total heating expenditure from gas and district heating, but smaller share in low-income households where a lot of coal is being used --> flagged for expenditure-based indicators	OK
	Romania	>60 % of total heating expenditure from gas and district heating, but smaller share in low-income households where a lot of biomass is being used, some of which not recorded in HBS as acquired for free --> flagged for expenditure-based indicators	Expenditure-based indicators impossible (very high share of households with zero transport expenditure)

Region	Member State	Vulnerability analysis heating	Vulnerability analysis transport
Southern Europe	Greece	Expenditure-based indicators impossible: <30 % of total heating expenditure from gas and district heating (high share of heating oil and biomass)	OK
	Spain	OK: >60 % of total heating expenditure from gas and district heating	Caveat for expenditure-based indicators (no information on tram, underground, hired car with driver expenditure) --> flagged for expenditure-based indicators

All of the expenditure-based indicators estimated use median values in the estimation to define a threshold. These median values represent national medians (Gouveia et al. 2022). The reason for using national medians is to reflect country-specific circumstances in heating or transport expenditure, e.g. the overall composition of expenditure of a typical household, climatic or infrastructure differences. Differences between the national medians are quite large. In our country sample, Czechia has the highest median value for spending on heat with 8.9 % compared to Spain with the lowest value at 1.2 %. For transport, the highest median value is found in Greece at 5.1 % and the lowest value in Romania at 0.7 % (with the caveat mentioned above).

Compared to the dashboard of national indicators hosted by EPAH,[13] we have therefore further developed the methodology of estimating expenditure-based indicators by taking into account irregularities in heating expenditure and inflating expenditures to the current year. While our results are roughly in line with those published by EPAH, differences are explained by these factors. In addition, we estimate additional indicators, e.g. those that include income thresholds and indicators related to transport poverty, which are not included in the EPAH dashboard. Results on self-reported indicators in heating are in line with those displayed on the EPAH dashboard.

[13] https://energy-poverty.ec.europa.eu/observing-energy-poverty/national-indicators_en

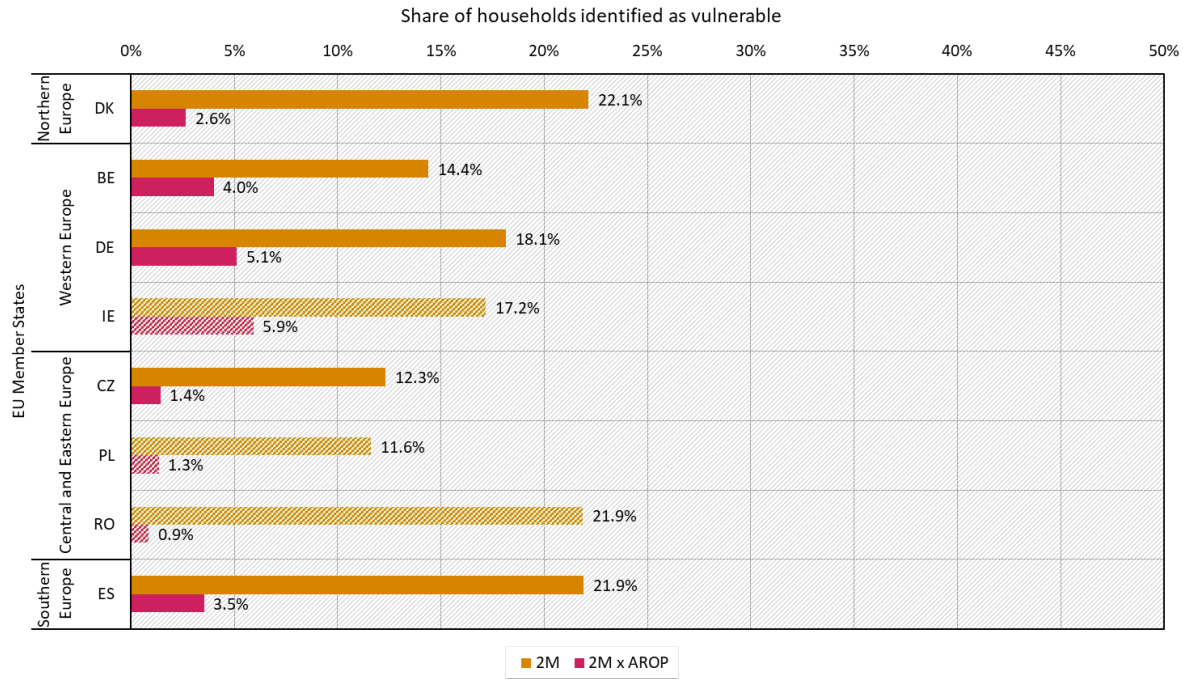
4 Vulnerability landscape across the EU according to different indicators

4.1 Vulnerability indicators for heating

This section presents results for energy poverty and vulnerability indicators for heating in the different regions and Member States of the EU. While the self-reported indicators are presented for ten countries, a reduced set of eight countries is used for the expenditure-based indicators due to data limitations. The expenditure-based indicators for Ireland, Poland and Romania have to be treated with caution due to missing information in the HBS data (cf. Section 3).

Looking at households with particularly high heating expenditures compared to total expenditure, Figure 7 presents the results for the 2M indicator. Households with expenditures relative to their total budget that are more than double the national median are identified as vulnerable. With a share of around 12 %, Poland and Czechia have the lowest share of vulnerable households according to this indicator, while Denmark has the highest share of vulnerable households (22 %). When including an income threshold for those at risk of poverty into the indicator (2M x AROP), the share of vulnerable households decreases significantly. The reduction in the share of vulnerable households is particularly large in Romania and Denmark, with a reduction of around 20 percentage points.

Figure 7 Share of vulnerable households related to heating according to the 2M and 2M x AROP indicators

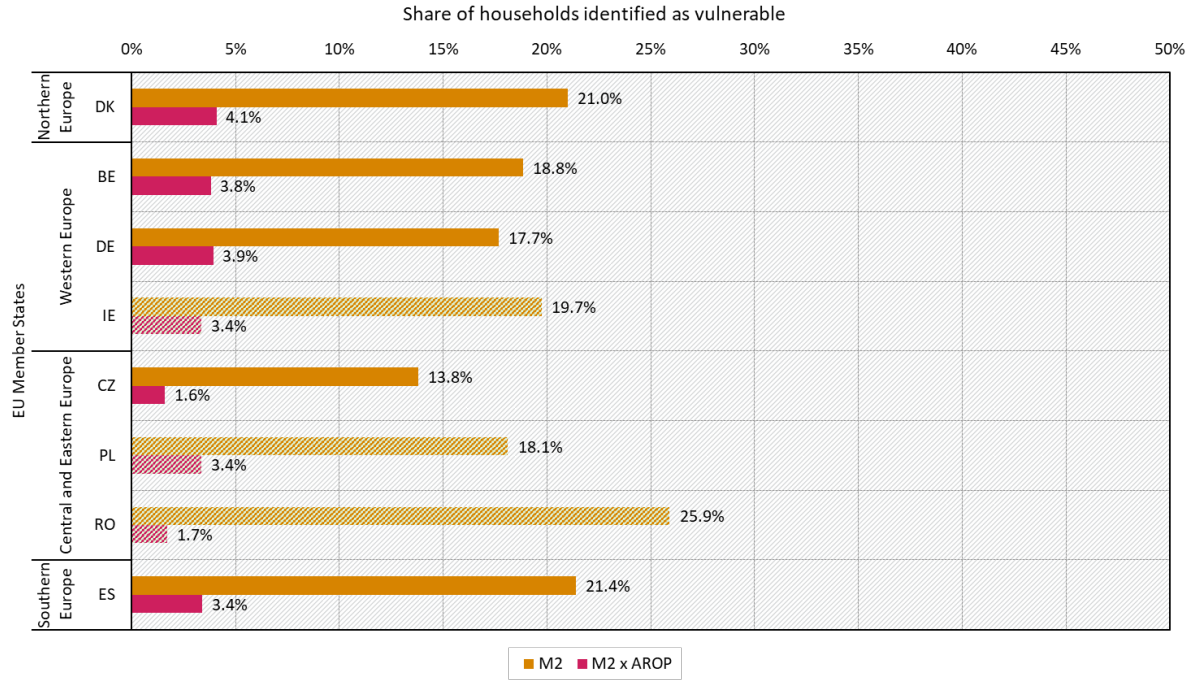


Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23). Ireland, Poland and Romania are flagged due to data limitations. Results for Germany based on SEEK-DE micromodel based on EVS 2018 data (inflated to 2022/23).
Notes: IE, PL, and RO have to be treated with caution due to missing information in the HBS data. These countries' bars are shaded. According to Eurostat rules, CZ & DK should be flagged for the indicator '2M x AROP' due to a low number of observations (20-49 observations).

Identifying households in hidden energy poverty using the M/2 indicator in Figure 8, there are no clear differences between EU regions, but there are differences between countries with

shares ranging from 14 % in Czechia to 26 % in Romania. Again, when this indicator is combined with being at risk of poverty, the share of vulnerable households decreases significantly for all ten countries observed.

Figure 8 Share of vulnerable households related to heating according to the M/2 and M/2 x AROP indicators

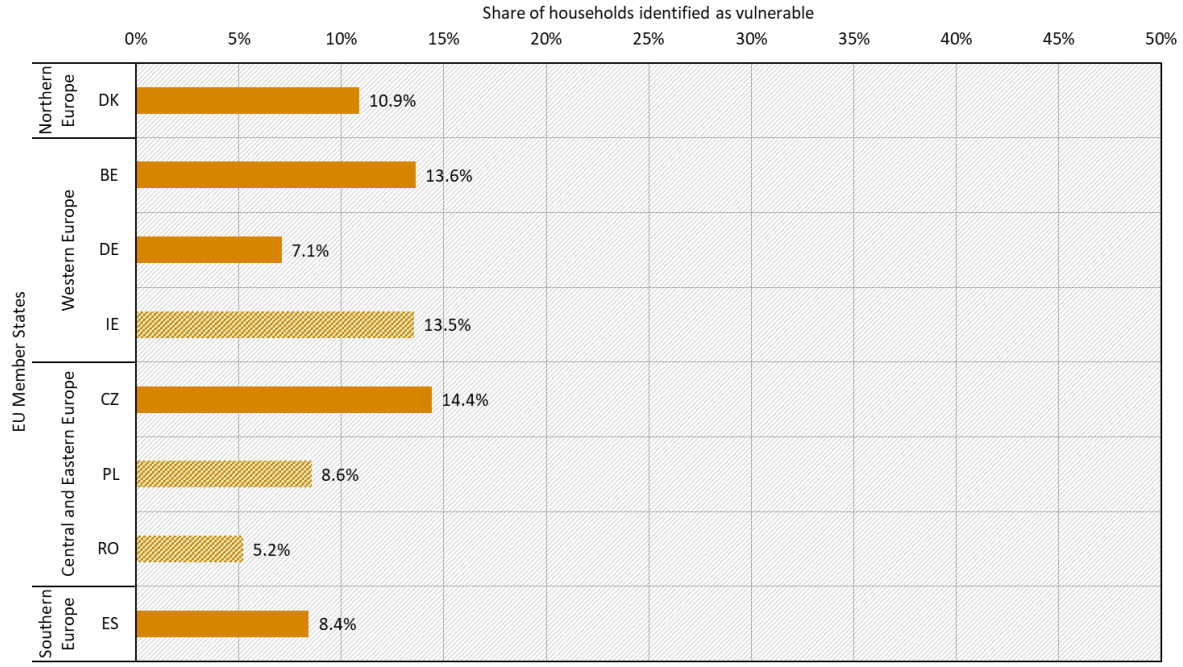


Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23). Ireland, Poland and Romania are flagged due to data limitations. Results for Germany based on SEEK-DE micromodel based on EVS 2018 data (inflated to 2022/23).
Notes: IE, PL, and RO have to be treated with caution due to missing information in the HBS data. These countries' bars are shaded. According to Eurostat rules, CZ should be flagged for the indicator 'M/2 x AROP' due to a low number of observations (20-49 observations).

Using the LIHC indicator in Figure 9, the lowest proportions of vulnerable households are found in Romania and Germany, with 5 % and 7 % of vulnerable households respectively. Belgium, Czechia and Ireland display the highest values at 14 %. The LIHC indicator lies between the 2M indicator and its combination with being at risk of poverty (2M x AROP), which seems reasonable as the LIHC considers both high expenditure and low income.

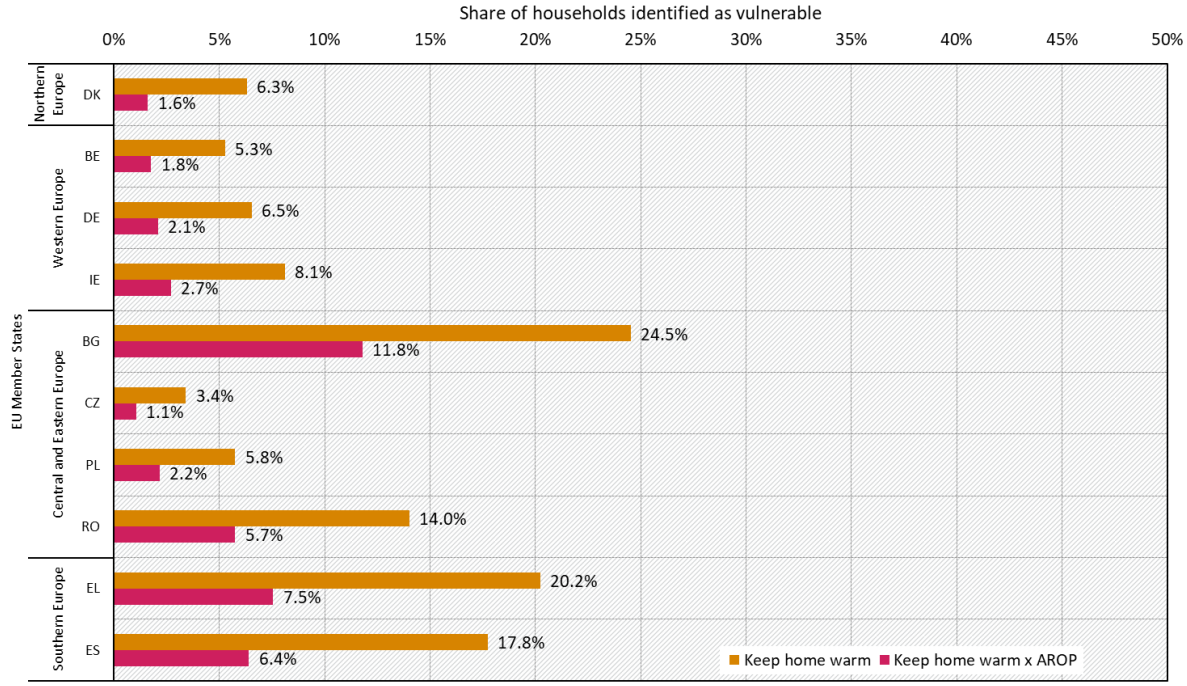
We find that the countries of Southern Europe have higher shares of households (18 % in Spain and 20 % in Greece) that report not being able to keep their home warm compared to most countries in Northern, Western and Central and Eastern Europe (Figure 10). Bulgaria is an exception and has the highest share of vulnerable households at 25 %. Restricting potentially vulnerable households to those at risk of poverty reduces the shares by more than 50 % in every country. We use the AROP threshold as an illustration of how results change if an income threshold is introduced. AROP is a concept that can easily be applied to all Member States surveyed. It is, however, likely too restrictive in the sense of the SCF as low and lower-middle-income households should also be able to qualify as vulnerable. Working out relevant national income thresholds is an area for further research.

Figure 9 Share of vulnerable households related to heating according to the LIHC indicator



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23). Ireland, Poland and Romania are flagged due to data limitations. Results for Germany based on SEEK-DE micromodel based on EVS 2018 data (inflated to 2022/23).
Notes: IE, PL, and RO have to be treated with caution due to missing information in the HBS data. These countries' bars are shaded.

Figure 10 Share of vulnerable households related to heating according to the Keep home warm and Keep home warm x AROP indicators

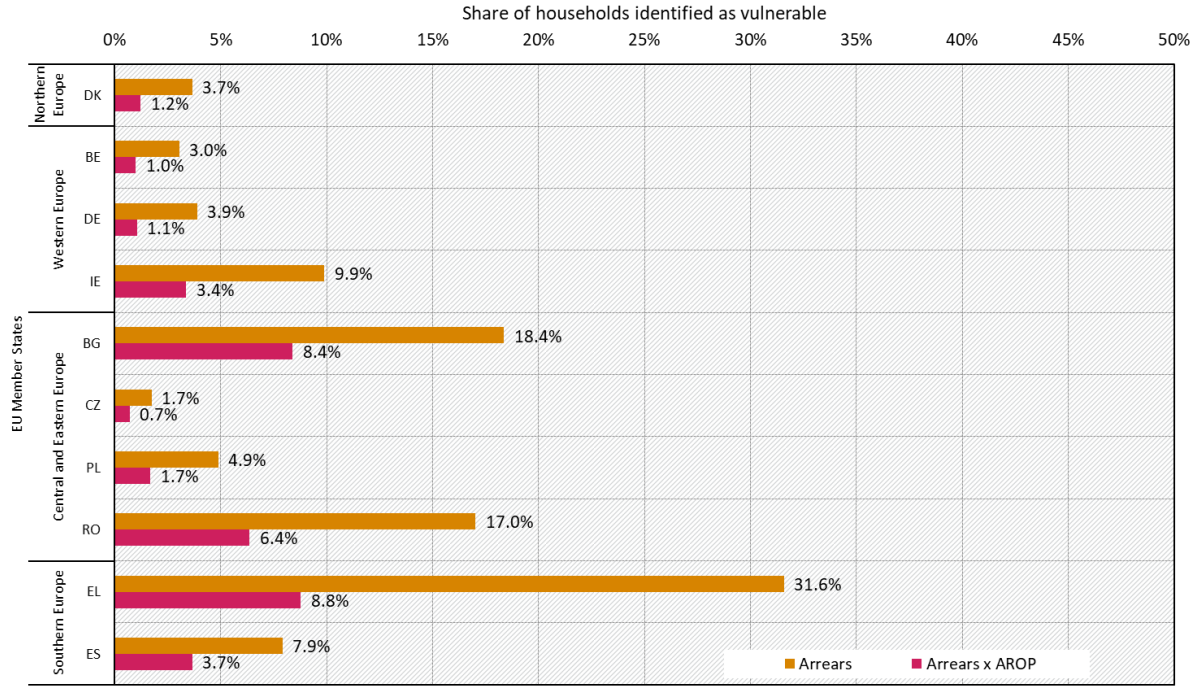


Source: SEEK-EU micromodel based on EU-SILC 2022 data.

When it comes to reporting arrears on utility bills, there is no clear pattern across European regions (Figure 11). The shares vary widely between 1 % (Czechia) and 32 % (Greece). Again,

restricting potentially vulnerable households to those at risk of poverty reduces the shares by more than 50 % in every country. This illustrates that also households that are not classified as being at risk of poverty are in arrears on their utility bills.

Figure 11 Share of vulnerable households related to heating according to the Arrears and Arrears x AROP indicators



Source: SEEK-EU micromodel based on EU-SILC 2022 data.

Notes: According to Eurostat rules, DK should be flagged for the indicator 'Arrears x AROP' due to a low number of observations (20-49 observations).

Comparing all the estimated indicators for heating, the share of vulnerable households varies widely across indicators and countries. Estimated shares of vulnerable households range from 1 % to 32 %. Within this range, the expenditure-based indicators of 2M and M/2 usually show higher shares of vulnerable households than the self-reported indicators in the calculations presented.

For Southern and some Central and Eastern European countries, however, self-reported indicators do show high shares of vulnerable households. This holds, in particular for the 'keeping the home warm' indicator for Bulgaria and the 'arrears on utility bills' indicator for Greece.

When both expenditure-based and self-reported indicators are combined with being at risk of poverty, the shares of vulnerable households decrease significantly. On the one hand, this shows that energy poverty and vulnerability in heating are not only related to income but to a whole range of important factors. This is supported by the fact that the decrease of the indicator results when combined with being at risk of poverty is not perfectly correlated with the share of the AROP population in each country. In general, the decrease differs between indicators, with higher percentage decreases observed for the expenditure-based indicators (80 % - 96%) compared to the self-reported indicators (59 % - 63 %), but not so much between countries. On the other hand, indicators without an income threshold likely overestimate the share of households needing support by including households in higher income deciles. This holds

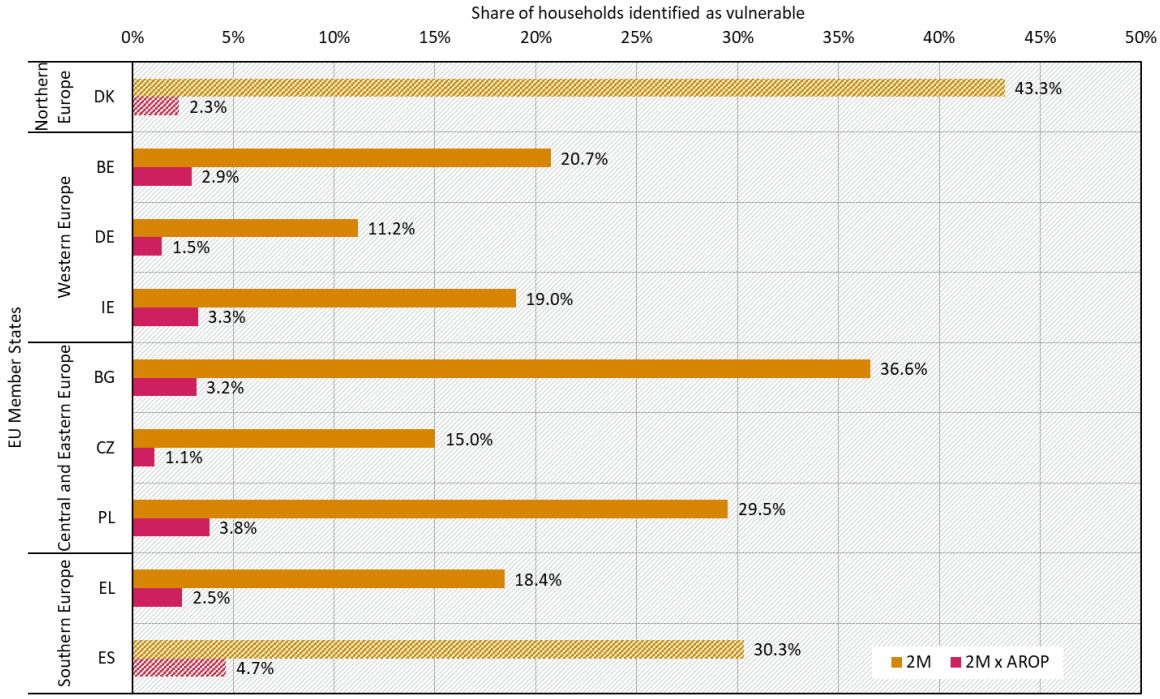
especially in high income countries. As noted above, in the context of the SCF, AROP is a too restrictive threshold and nationally appropriate income thresholds need to be elaborated.

4.2 Vulnerability indicators for transport

In this section, transport poverty and vulnerability indicators are presented. No expenditure-based indicators could be estimated for Romania due to data limitations. Also, the expenditure-based indicators for Denmark and Spain must be treated with caution due to missing information in the HBS data (cf. Section 3).

Using the 2M indicator, we find very high shares of vulnerable households in the transport sector compared to the heating sector (Figure 12). Denmark has the highest share at 43 %, but this figure should be treated with caution as we observe a very high share of households with zero transport expenditure and therefore a very low median share of transport expenditure in total expenditure. A high proportion of households with zero transport expenditure can have several causes, such as a high proportion of active mobility or households that reduce their daily mobility due to financial constraints. When restricting the potentially vulnerable households to those at risk of poverty, we observe large changes with reductions in the share of vulnerable households of up to 40 percentage points.

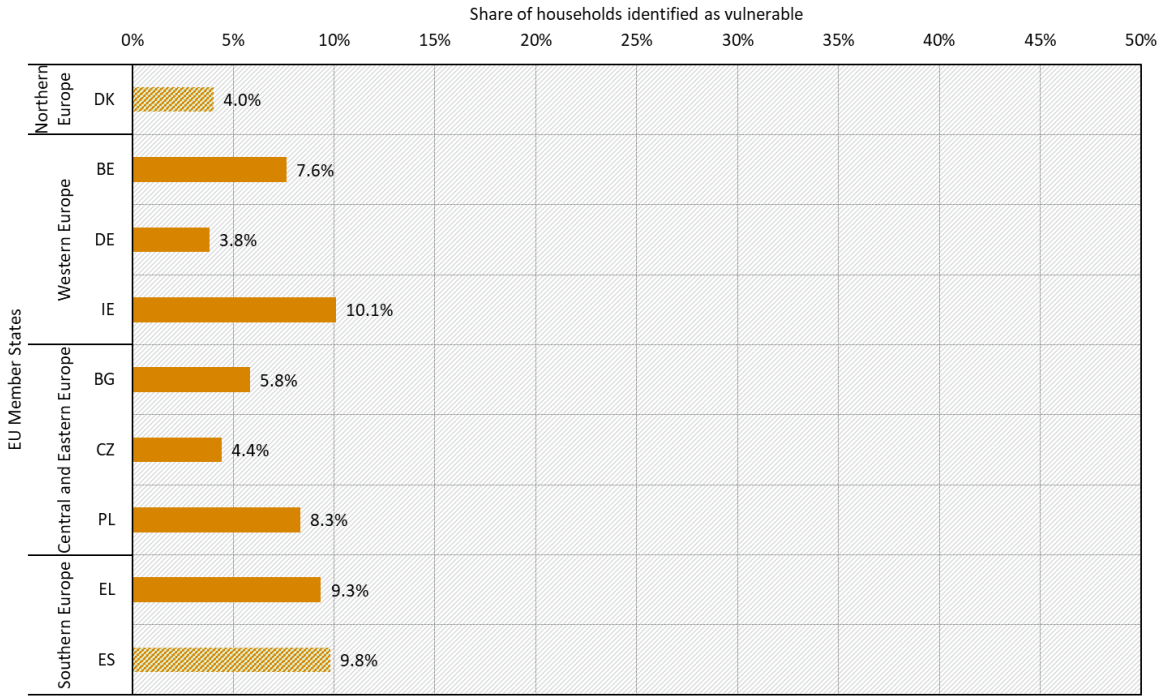
Figure 12 Share of vulnerable households related to transport according to the 2M and 2M x AROP indicators



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23). Romania is flagged due to data limitations. Results for Germany based on SEEK-DE micromodel based on EVS 2018 data (inflated to 2022/23).
Notes: DK and ES have to be treated with caution due to missing information in the HBS data. These countries' bars are shaded. According to Eurostat rules, CZ and DK should be flagged for the indicator '2M x AROP' due to a low number of observations (20-49 observations).

Using the LIHC indicator, the lowest proportion of vulnerable households is found in Germany and Denmark, where around 4 % of households are identified as vulnerable (Figure 13). Again, the LIHC indicator lies between the 2M indicator and its combination with being at risk of poverty.

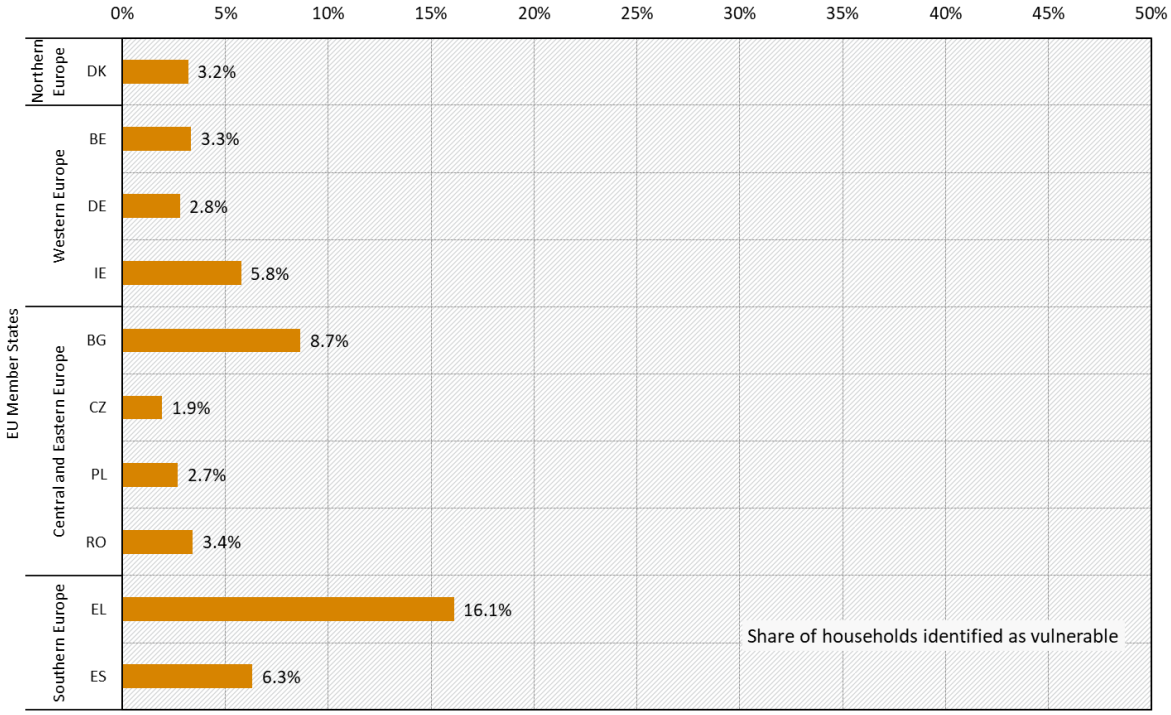
Figure 13 Share of vulnerable households related to transport according to the LIHC indicator



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23). Romania is flagged due to data limitations. Results for Germany based on SEEK-DE micromodel based on EVS 2018 data (inflated to 2022/23).
Notes: DK and ES have to be treated with caution due to missing information in the HBS data. These countries' bars are shaded.

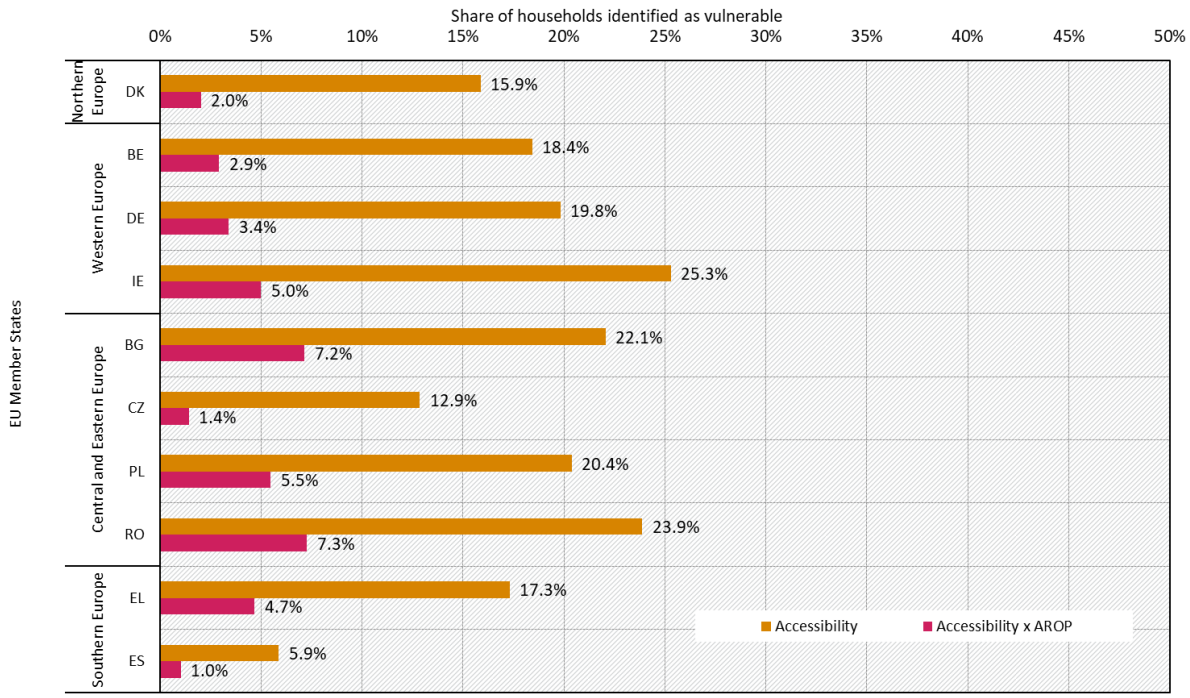
For the Forced Car Ownership (FCO) indicator in Figure 14, the accessibility indicator in Figure 15 and the availability indicator in Figure 16, there are no clear differences between EU regions. The share of households with FCO varies from 2 % in Czechia to 16 % in Greece (Figure 14). The share of households with poor public transport accessibility varies from 6 % in Spain to 25 % in Ireland (Figure 15). The share of individuals with poor public transport availability varies from 1 % in Czechia to 11 % in Germany (Figure 16). Again, the share of vulnerable households using the accessibility indicator and the share of vulnerable individuals using the availability indicator are greatly reduced when the indicators are combined with being at risk of poverty.

Figure 14 Share of vulnerable households related to transport according to the Forced Car Ownership (FCO) indicator



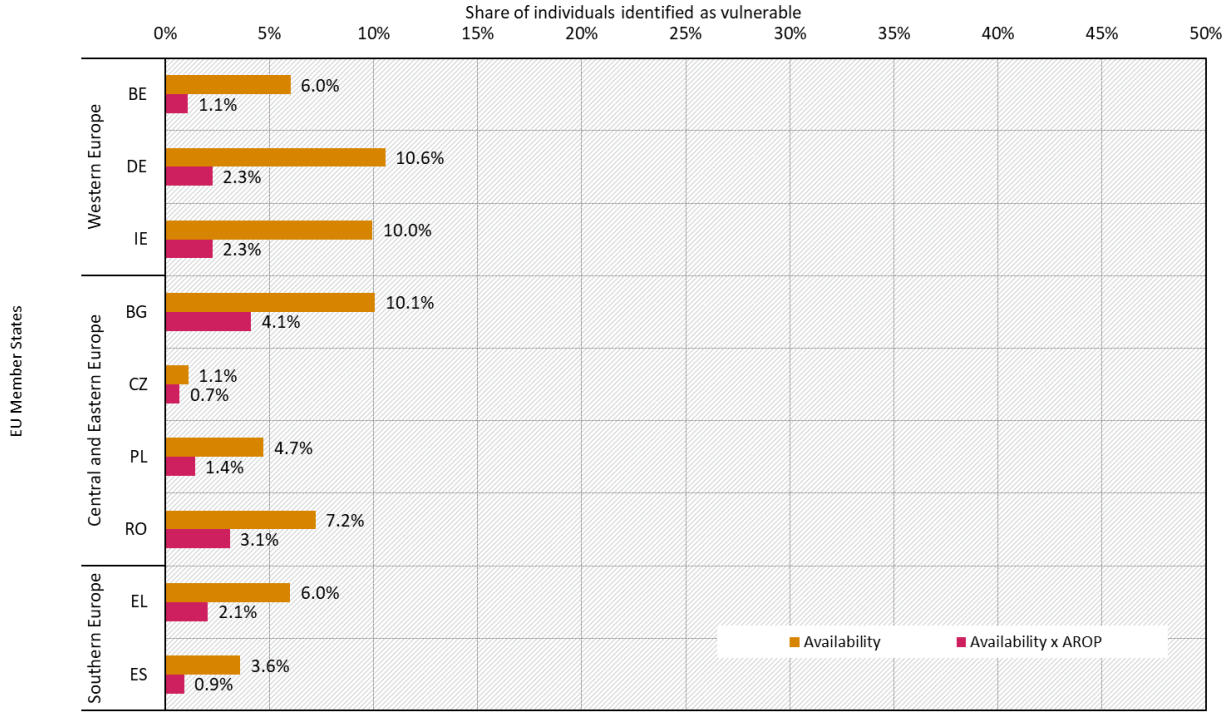
Source: SEEK-EU micromodel based on EU-SILC 2019 data.

Figure 15 Share of vulnerable households related to transport according to the Accessibility and Accessibility x AROP indicators



Source: SEEK-EU micromodel based on EU-SILC 2012 data.

Figure 16 Share of vulnerable individuals related to transport according to the Availability and Availability x AROP indicators



Source: SEEK-EU micromodel based on EU-SILC 2014 data.

Notes: According to Eurostat rules, DK is excluded due to a high non-response rate (> 50%).

Comparing all the estimated indicators in the transport sector, the share of vulnerable households varies considerably between indicators and countries, with values ranging from 1 % to 43 %. Comparisons between indicators have to be made with caution due to the different years of data that are being used.

No clear patterns emerge between EU regions. In general, the 2M indicator returns the highest share of vulnerable households. Exceptions are Germany, Ireland and Romania where the 'access to public transport with difficulty' indicator returns the highest share.[14] Again, when indicators are combined with being at risk of poverty, the shares of vulnerable households decrease significantly. As in the case of heating, the decrease in the indicator results when combined with being at risk of poverty is not perfectly correlated with the share of the AROP population in each country. The decrease differs between indicators, with on average higher percentage decreases observed for the expenditure-based indicator (83 % - 95 %) compared to the self-reported indicators (38 % - 87 %). Compared to the indicators for the heating sector, the variance between countries is higher for the decreases in the self-reported indicators when combined with being at risk of poverty, but there is no clear pattern across EU regions. Again, this shows that vulnerability in transport is not only related to income but to a whole range of important factors.

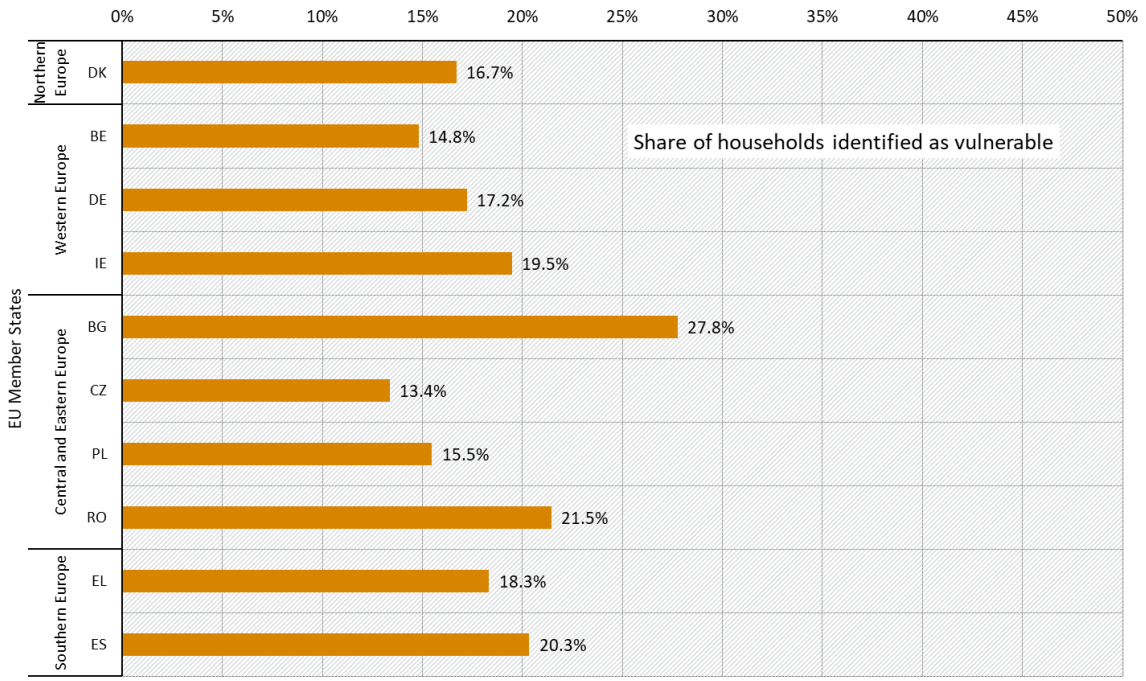
4.3 Policy indicator

When targeting policy measures at vulnerable households, it is important that households can prove they are in the vulnerable group and authorities can confirm this, e.g. through income tax statements or social security benefits documentation. A "policy indicator" is therefore likely to

[14] Note that for Romania this is the case as the 2M indicator could not be estimated due to data issues related to expenditures for fuels.

be based on information on household income. One possible policy indicator AROP (= total household expenditure is less than 60 % of the national median) in Figure 17 shows a share of vulnerable households ranging from 13 % in the Czech Republic to almost 30 % in Bulgaria. There is no clear pattern across EU regions. Households identified by the AROP indicator are concentrated in the first and second expenditure deciles, for Bulgaria extending into the third decile.

Figure 17 Share of vulnerable households according to the AROP indicator



Source: SEEK-EU micromodel based on EU-SILC 2022 data.

Identifying vulnerable households purely based on their income, reduces the issues of energy and transport poverty and vulnerability to a general poverty issue, as this indicator is not able to take into account many of the other important drivers of vulnerability in transport and heating. In order to properly target those most in need, governments should therefore expand their ability to identify households based on other important drivers of vulnerability, e.g. the energy performance of the building a household lives in or a household's access to essential services, including to public transport.

5 SCF and ETS 2 funding available to support vulnerable households

5.1 SCF funding and national ETS 2 auctioning revenues

There is no free allocation of allowances under the ETS 2 (EU 2023b). The revenue from the auctioning of a total cap of 5.3 billion allowances in 2027-2032 is distributed across two channels:

- The Social Climate Fund, which has a maximum budget of EUR 65 billion for the period 2026 to 2032 (EU Regulation 2023/955).
- The remaining revenue accrues to Member States in the form of national auction revenues.

At a carbon price of an average 45 EUR/t CO_2 (taken from the Commission's Impact Assessment of the ETS 2), the size of the Social Climate Fund is equal to about 25 % of total auctioning revenues. Since its budget is fixed, its share in the overall auctioning revenues is much smaller if CO_2 prices rise significantly above 45 EUR/t CO_2. Recent modelling (Kellner et al. 2023; Rickels et al. 2023) indicates that prices in the ETS 2 could be much higher at 200 to 400 EUR/t CO_2 in 2030 if there are no other policy measures in place that lead to emission reduction in those sectors. The breadth of price predictions is large and mainly depends on assumptions about the impact of other policy instruments and measures in buildings and road transport.

Support from the Social Climate Fund is not distributed equally to all Member States but based on a progressive formula. As illustrated in Annex A.9 it distributes larger amounts to those Member States where a higher number of households is likely to experience severe impacts from the ETS 2 (Eden et al. 2023).

Table 3 shows the total amounts available from the SCF and from national auction revenues for the period 2026/27-2032 for the ten selected Member States. At high CO_2 prices national auction revenues become much larger than money from the SCF for all Member States. At a price of 45 EUR/tCO_2, funds from the SCF are on par with or higher than national auction revenues for Bulgaria, Poland, Romania and Greece.

Table 3 SCF funding and national ETS 2 auctioning revenues (2027-2032)

Region	Member State	SCF Funding (Million EUR)	ETS 2 revenues (Million EUR)		
			45 EUR/tCO_2	100 EUR/tCO_2	200 EUR/tCO_2
Northern Europe	Denmark	325	2 120	5 600	11 929
Western Europe	Belgium	1 660	6 824	18 027	38 396
	Germany	5 318	42 176	111 420	237 319
	Ireland	663	2 730	7 213	15 364
Central and Eastern Europe	Bulgaria	2 499	1 613	4 260	9 073
	Czechia	1 562	4 504	11 899	25 343
	Poland	11 439	14 416	38 084	81 117

			ETS 2 revenues (Million EUR)		
	Romania	6 013	4 441	11 733	24 991
Southern Europe	Greece	3 587	2 878	7 604	16 196
	Spain	6 838	14 702	38 840	82 727

Source: Own elaboration based on Graichen and Ludig (2024)

While there is a strict requirement for funds from the SCF to be used towards supporting vulnerable households, Member States could further use additional funds from national auction revenues to this end. In the following, we estimate three scenarios related to the funding available for vulnerable households in the Member States observed:

- Funds from the SCF plus the required co-funding from Member States equal to 25 % of the funding received through the SCF[15]
- Funds from the SCF plus the required co-funding from Member States plus an additional 10 % of national auctioning revenues at a CO_2 price of 100 Euro/t
- Funds from the SCF plus the required co-funding from Member States plus an additional 25 % of national auctioning revenues at a CO_2 price of 100 Euro/t

5.2 Funding available per vulnerable household in the selected Member States

Based on the three scenarios of available funds described above, we estimate how much funding is available per vulnerable household in the period 2026–2032. As shown in Section 4, the number of households identified as vulnerable differs significantly based on the indicator chosen. Therefore, we apply four scenarios to estimate the expected fund per vulnerable household in each country:

- Using the minimum amount of vulnerable households in each country, i.e. applying the indicator that returns the lowest number in a country-specific context
- Using the maximum amount of vulnerable households in each country, i.e. applying the indicator that returns the highest number in a country-specific context
- Using the average amount of vulnerable households by averaging results for all indicators estimated above
- Using the AROP indicator as one possible "policy indicator" that is easy to measure at the household-level as it is based on household income.

As results on the amount of vulnerable households differ significantly by indicator, the difference between the estimated minimum and maximum value is very large in each of the Member States observed (Figure 18).[16] The difference between the minimum and maximum

[15] Note that, in this way, we allocate all of the SCF money to households. In reality, a share of the money will also go to micro-enterprises. This share will be different in each country. Also note that we use the amount of vulnerable households estimated in Section 4. These numbers are the same across all price scenarios and are not adjusted for price changes. Finally, the amount of vulnerable households is based on vulnerability indicators for the whole population, whereas for purposes of setting up a national Social Climate Plan, Member States will need to identify which households are vulnerable to ETS-2 introduction, possibly excluding those heating with renewables or district heat.

[16] Note that we include the „availability of public transport" indicator into this analysis although it is estimated as a share of the overall population rather than the share of households. We assume that these two shares are similar.

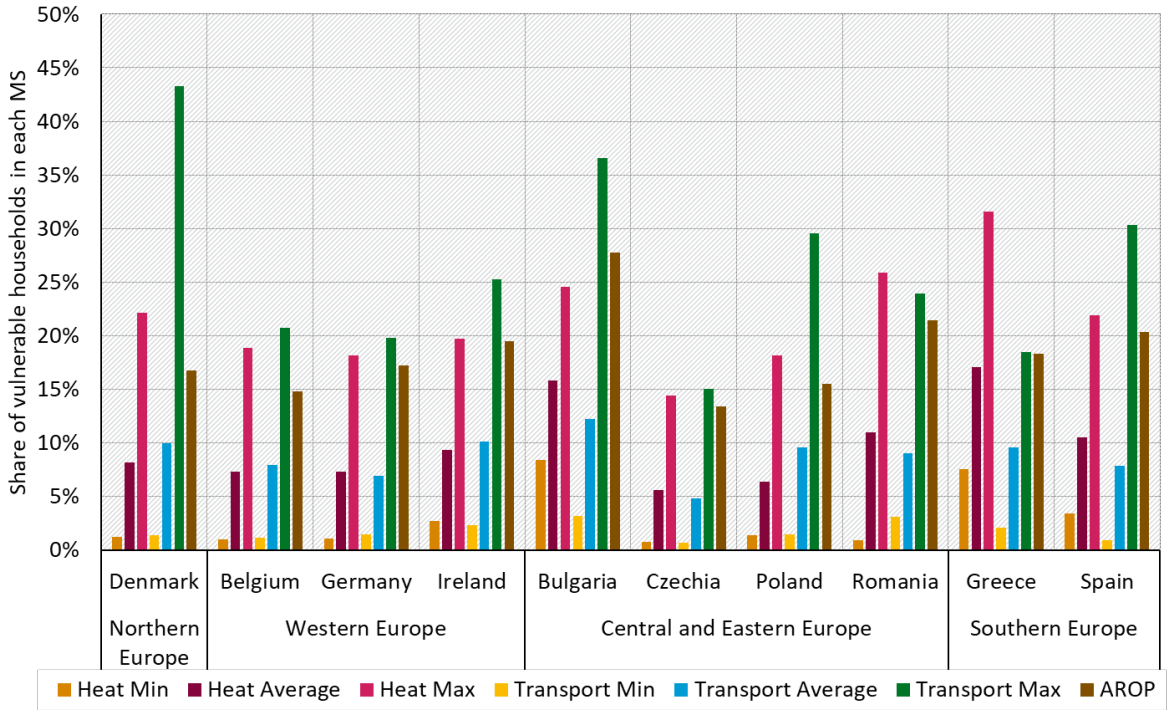
amounts of vulnerable households identified within a Member State is generally larger than the difference in the minimum or maximum values between Member States. The choice of indicator is therefore of central importance and the main influencing factor for the extent to which vulnerability is defined and identified.

With the exception of Greece, maximum values of vulnerable households are larger in the transport sector than in the heating sector. Minimum values are often similar between the heat and transport sectors, exceptions are Bulgaria, Greece and Spain. Note, however, that for Bulgaria and Greece – due to data issues – indicators that are typically smaller such as the 2M x AROP and M/2 x AROP could not be calculated (Table 2).

As noted in Section 4.1, for heat, in general, the expenditure-based indicators of 2M and M/2 show higher shares of vulnerable households than the self-reported indicators. For Bulgaria and Greece, self-reported indicators return the highest share. The minimum values are always those indicators that are combined with the income threshold of AROP, in most cases the 'arrears on utility bills' x AROP indicator.

As noted in Section 4.2, for transport, in many countries the 2M indicator returns the highest share of vulnerable households. Exceptions are Germany, Ireland and Romania where the 'difficult access to public transport' indicator returns the highest share. Note that for Romania this is the case as the 2M indicator could not be estimated due to data issues related to expenditures for fuels. The minimum values are always returned by indicators that include the AROP income threshold. For most countries, it is the combined 'no availability of public transport' x AROP indicator, for Bulgaria and Germany, it is the 2M x AROP indicator.

Figure 18 Minimum, average and maximum share of vulnerable households according to estimated indicators



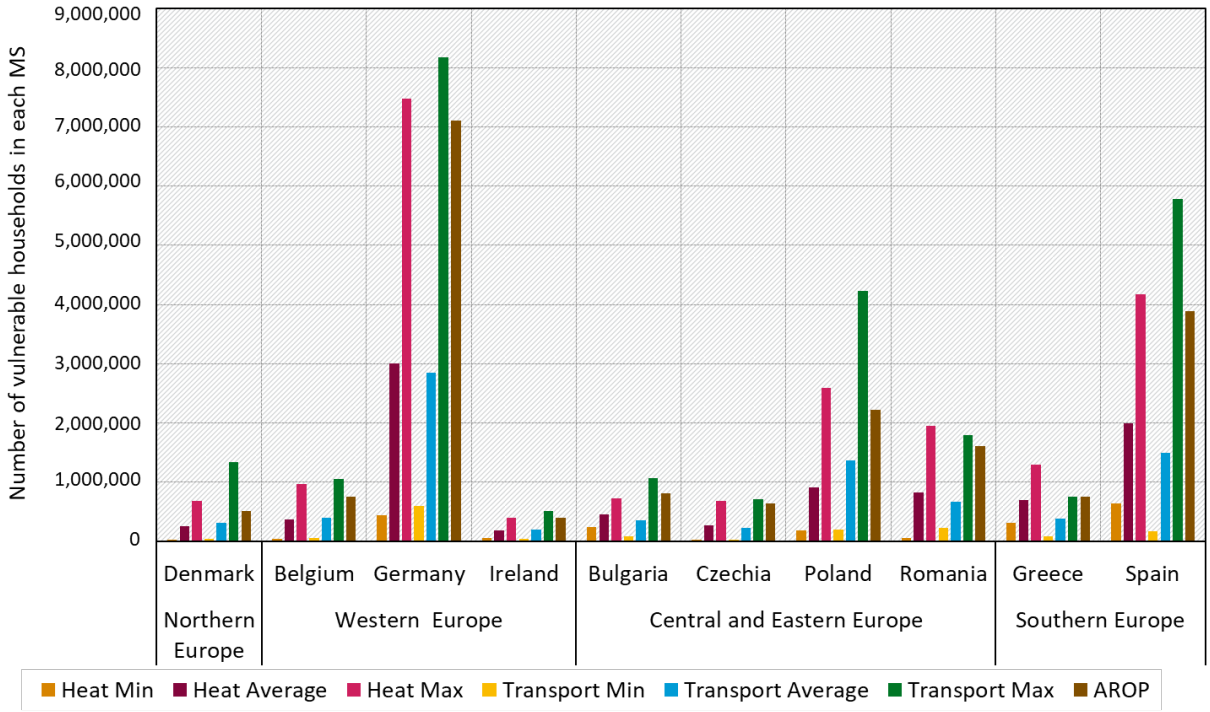
Source: Oeko-Institut

Applying the AROP indicator as one possible policy indicator, returns values that are significantly larger than average values in all of the countries. In the heating sector, they are similar to the maximum amounts estimated (with Greece being an exception).

The observed stark differences drive home the fact that it is very important for Member States to think about their priorities in defining and identifying vulnerable households, designing measures and distributing funds.

Figure 19 translates the estimated shares into expected numbers of vulnerable households per Member State. Following the differences in the shares, the number of vulnerable households per Member State varies greatly depending on whether the minimum, maximum or average numbers are used. The total number of vulnerable households depends on the overall population of the Member State, which is estimated based on Eurostat information on the size of the population in 2022.

Figure 19 Minimum, maximum and average number of vulnerable households according to estimated indicators



Source: Oeko-Institut based on Figure 18 and Eurostat household composition statistics 2022 [lfst_hhnhtych].

In splitting the available funds between the heating and transport sectors, we assume that the same amount of money is available for each vulnerable household in each sector. We therefore split the overall available funds between sectors according to the amount of vulnerable households in each sector. For example, if 1 million households are deemed vulnerable in the heating sector and 2 million households in transport, then 1/3 of the overall funds goes to the heating sector and 2/3 of the overall funds to transport. In reality, the concrete organisation of the measures in each Member State will be decided at political level.

Table 4 shows the available funds per vulnerable household in the heating and transport sectors each if only money from the SCF and the required national co-financing is used. As the SCF is a mechanism that distributes more funds to Member States that likely have a larger share of vulnerable households, the funding per household is generally larger in CEE countries and Greece.

If only the minimum number of vulnerable households is applied in each country (mostly less than 2 % of all households), there is considerable funding per household in this scenario ranging from an estimated 5 414 Euro per vulnerable household in Denmark to 38 353 Euro per

vulnerable household in Poland. If, however, the funds have to be used for a much bigger pool of vulnerable households, e.g. those identified using the indicator with the highest value or the AROP indicator, funds per household become rather small for the 2026-2032 period and equal 213 to 2 326 Euro per vulnerable household and 417 to 3 434 Euro per vulnerable household respectively.

Table 4 Available funds total and per vulnerable households from the SCF and national co-financing 2026-2032

Region	Member State	Available funds (M Euro)	Available funds per vulnerable household in each heating and transport (Euro)			
			Target group: Minimum no. of vuln. households	Target group: Maximum no. of vuln. households	Target group: Average no. of vuln. households	Target group: Households at risk of poverty
Northern Europe	Denmark	433	5 414	213	768	417
Western Europe	Belgium	2 213	20 673	1 092	2 842	1 459
	Germany	7 091	6 807	453	1 211	499
	Ireland	885	8 674	958	2 225	1 108
Central and Eastern Europe	Bulgaria	3 333	9 782	1 853	4 047	2 039
	Czechia	2 082	31 084	1 483	4 185	1 632
	Poland	15 252	38 353	2 231	6 671	3 434
	Romania	8 017	26 808	2 135	5 328	2 477
Southern Europe	Greece	4 782	12 122	2 326	4 377	3 175
	Spain	9 117	11 109	915	2 610	1 174

Source: Oeko-Institut

Table 5 shows the available funds per vulnerable household under the condition that in addition to money from the SCF and national co-financing, 10 % from national auction proceeds at a price of 100 Euro/tCO_2 are used. Adding national funds to the SCF money to support vulnerable households is particularly important for those countries that are not identified by the SCF as particularly vulnerable. For Denmark and Germany, for example, adding 10 % from national auctioning proceeds, more than doubles the amount available for vulnerable households. Even at a broader indicator such as AROP, funds available for a vulnerable household in heating and transport each are now at least equal to 1 000 Euro in each country observed. Especially for those countries not identified as vulnerable, it is therefore important to add national resources to the support of vulnerable households in order to secure relevant funding. The difference in available funds is smaller for those countries that are identified as especially vulnerable by the SCF, such as Bulgaria, Greece, Poland and Romania.

Table 5 Available funds total 2026-2032 and per vulnerable household from the SCF and national co-financing plus 10 % of national auction proceeds at price of 100 Euro/tCO_2

Region	Member State	Available funds (M Euro)	Available funds per vulnerable household in each heating and transport (Euro)			
			Target group: Minimum no. of vuln. households	Target group: Maximum no. of vuln. households	Target group: Average no. of vuln. households	Target group: Households at risk of poverty
Northern Europe	Denmark	993	12 410	488	1 761	955
Western Europe	Belgium	4 016	37 513	1 981	5 158	2 647
	Germany	18 233	17 502	1 165	3 114	1 284
	Ireland	1 606	15 746	1 739	4 040	2 012
Central and Eastern Europe	Bulgaria	3 759	11 033	2 090	4 564	2 299
	Czechia	3 272	48 848	2 331	6 576	2 565
	Poland	19 060	47 929	2 788	8 336	4 291
	Romania	9 190	30 731	2 447	6 108	2 840
Southern Europe	Greece	5 543	14 050	2 696	5 073	3 680
	Spain	13 001	15 841	1 304	3 721	1 674

Source: Oeko-Institut

In our final simulation where 25 % of national auction revenue at a price of 100 Euro/tCO_2 is used in addition to SCF funding and co-financing (Table 6), the support for vulnerable households becomes considerable at the minimum number of vulnerable households identified, reaching more than 60 000 Euros per vulnerable household in each heating and transport in Belgium, Czechia and Poland. This shows that if the support is very specific (i.e. targeting the most vulnerable 1-2 % of the population), larger scale investments per vulnerable household in the 2026–2032 period are possible.

Table 6 Available funds total 2026-2032 and per vulnerable household from the SCF and national co-financing and 25 % of national auction proceeds at price of 100 Euro/tCO_2

Region	Member State	Available funds (M Euro)	Available funds per vulnerable household in each heating and transport (Euro)			
			Target group: Minimum no. of vuln. households	Target group: Maximum no. of vuln. households	Target group: Average no. of vuln. households	Target group: Households at risk of poverty
Northern Europe	Denmark	1 833	22 905	901	3 251	1 763

Region	Member State	Available funds (M Euro)	Available funds per vulnerable household in each heating and transport (Euro)			
			Target group: Minimum no. of vuln. households	Target group: Maximum no. of vuln. households	Target group: Average no. of vuln. households	Target group: Households at risk of poverty
Western Europe	Belgium	6 720	62 773	3 314	8 630	4 430
	Germany	34 946	33 545	2 233	5 968	2 461
	Ireland	2 688	26 356	2 911	6 762	3 367
Central and Eastern Europe	Bulgaria	4 398	12 908	2 446	5 340	2 690
	Czechia	5 057	75 492	3 602	10 163	3 964
	Poland	24 773	62 294	3 623	10 835	5 578
	Romania	10 950	36 616	2 916	7 278	3 384
Southern Europe	Greece	6 683	16 941	3 250	6 117	4 437
	Spain	18 827	22 940	1 889	5 389	2 424

Source: Oeko-Institut

In order to put the estimated available funds per vulnerable household into perspective, Table 7 shows typical investment cost of measures in home insulation and renewable heat in a single-family home for Germany, Greece, Romania and Spain. We take Greece as an example, where the available funds per vulnerable household in heating according to our last scenario (SCF + co-financing + 25 % national auctioning proceeds) are equal to about 6 000 Euro at the average amount of vulnerable households. These estimated 6 000 Euro are in line with the costs of replacing old windows or installing solar thermal in a single-family home and only somewhat smaller than the cost of installing solar PV. As support for installing a heat pump or insulating the exterior roof, however, they would only cover a fraction of the cost.

Table 7 Typical investment costs of measures in home insulation and renewable heat in a single-family home[17]

Region	MS	Installation heat pump	Insulation exterior roof	Replacing old windows	Installation solar PV	Installation solar thermal
WE	Germany	20 000	35 494 - 50 319	22 028	8 500	2 697
CEE	Romania	8 800	11 116 - 15 432	6 475	8 992	6 224
SE	Greece	16 392	21 608 - 29 542	5 018	8 905	6 009
SE	Spain	12 000	13 866 - 19 530	8 731	9 991	3 750

Source: Hesse et al. (2023) Annex IV

[17] The study does not elaborate on the size of the single-family building for which the reference investment cost values are given.

6 Conclusion and outlook

In this report, we have painted a picture of the vulnerability landscape in the EU by looking at ten out of 27 Member States and estimating the share of vulnerable households according to a range of indicators in the heating and transport sectors. While discussing energy and transport poverty and determining the size and characteristics of the vulnerable population is highly relevant for a whole range of EU energy and climate policy initiatives, we focus in particular on the ETS 2 starting from 2027 and the Social Climate Fund (SCF) that is set up to support vulnerable households and micro-enterprises in the transition to climate neutrality. In order to access money from the SCF, Member States have to draw up Social Climate Plans (SCPs) until mid-2025. In these plans, definitions, indicators and estimations for the number of vulnerable households in both the heating and transport sectors need to be included.

Against this backdrop, we simulate the number of vulnerable households according to nine different indicators for heating and eight indicators for road transport as well as one "policy indicator". These indicators are based on those currently discussed in the literature and policy sphere. We show that the number of households identified as vulnerable differs widely depending on the specific indicators applied. For vulnerability related to heating, the expenditure-based indicators 2M and M/2 generally show higher shares (up to 26 %) of vulnerable households than the self-reported indicators (1 %-32 %). In Southern and Central and Eastern Europe, however, the share of households identified as vulnerable using self-reported indicators is also high.

No clear patterns emerge across European regions for the ten countries we observe in relation to transport poverty and vulnerability. We rather find country-specific effects for the individual indicators. Between indicators, we observe a large range of 1 % to 43 % households identified as vulnerable according to the different indicators in the different countries. In general, the 2M indicator returns the highest share of vulnerable households. Exceptions are Germany, Ireland and Romania where the 'access to public transport with difficulty' indicator returns the highest share.

When an income threshold of being at risk of poverty is included into the indicators, the share of vulnerable households decreases by a large margin. This holds for both heating and transport and for both expenditure-based and self-reported indicators. Differences are particularly high for the expenditure-based indicators.

The fact that households identified as energy and transport poor extend into middle- and high-income deciles shows that energy and transport poverty are issues that go beyond material deprivation and the traditional perception of poverty. At the same time, the SCF Regulation very clearly defines that only low- and lower-middle-income households need to be supported in the context of the ETS 2, as it can be expected that higher-income households have the means to bear additional carbon cost and invest into climate-friendly measures out of their own account.

Indicators without an income threshold therefore likely overestimate the share of vulnerable households by including households in higher income deciles. This holds in particular for high-income countries. In our analysis, we apply the AROP criterion as one possibility for an income threshold, one that is rather restrictive. Since the income distribution in the EU is extremely uneven (cf. Figure 6 in Braungardt et al. 2022), it is important to think about nationally appropriate income thresholds. These may be more restrictive in higher- than in lower-income countries.

We estimate the AROP indicator as one possible "policy indicator" that could be used to distribute income support. However, this indicator only takes income up to a certain threshold

into account and neglects other important factors. If heating and/or mobility costs are very high due to structural characteristics, lower middle- and middle-income households can also be exposed to energy and transport vulnerability. Especially in the context of the SCF, suitable national income thresholds need to be elaborated that are likely higher than the AROP threshold which is very restrictive. When targeting policy measures at vulnerable households, governments should ideally include drivers of vulnerability beyond income into their targeting strategy. This requires collecting additional information on, for example the access to essential services via the transport system or the energy-performance of buildings in order to identify those households that would benefit the most from relevant measures.

In general, collecting and making available additional data that can be helpful in identifying vulnerability in the heating and transport sectors is key. Related to transport in particular, the data available at the EU-level but also at the national level in most Member States does not allow to construct indicators that are concise in showing the availability of transport options and the accessibility of essential services. The UK government's journey time statistics provide data on the journey times to key services, such as employment, health care, town centres, education and food stores at the level of postcodes and can be considered best-practice in making this information available.[18]

The amount of funding that will be available per vulnerable household in heating and transport is directly related to the indicator chosen to identify those households. The funding per household will be higher if the targeting is very concise and the group of recipients is small. On the other hand, a narrow definition of vulnerability increases the risk that vulnerable people outside the chosen definition will receive no support. The funding per vulnerable household can also be increased if additional, national resources are available to support vulnerable households in the context of the ETS 2.

We show that especially for those countries that are not identified as particularly vulnerable according to the Social Climate Fund, it will be important to make additional, national resources available to support vulnerable households in the context of the ETS 2. This applies to most Northern and Western European countries. However, also in countries that do receive a higher share from the SCF due to their vulnerability, making additional funds available to vulnerable households (e.g. from national auction proceeds) allows supporting more households or more impactful measures. Another important point in this regard is that the size of the SCF budget should increase with higher CO_2 prices such that more funds are available to support vulnerable groups. As the legislation stands, the size of the SCF is unresponsive to rising CO_2 prices.

Even if additional funding is made available, it is important that the overall limited funds reach those most in need, especially if more expensive investments – for example into heat pumps and building insulation – are to be financed. It is therefore crucial to develop suitable national strategies to define, identify and target those households that benefit most from support related to the SCF and ETS 2.

[18] https://www.gov.uk/government/collections/journey-time-statistics

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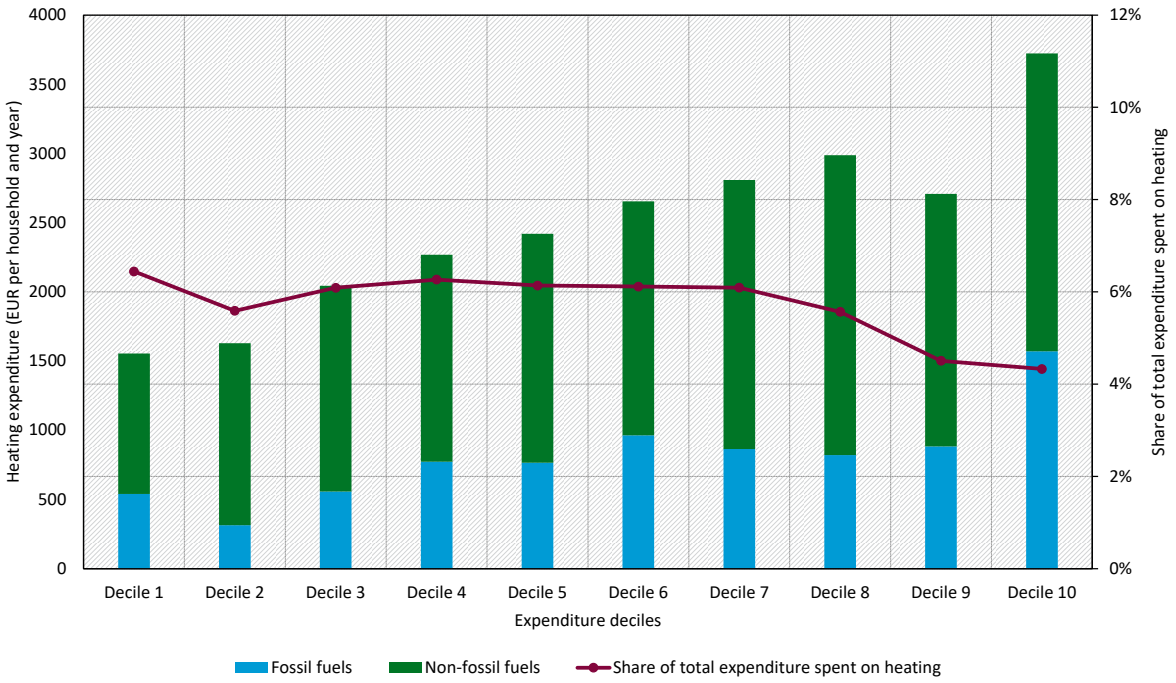
A Heating and transport expenditure by expenditure decile for the ten selected Member States

A.1 Denmark

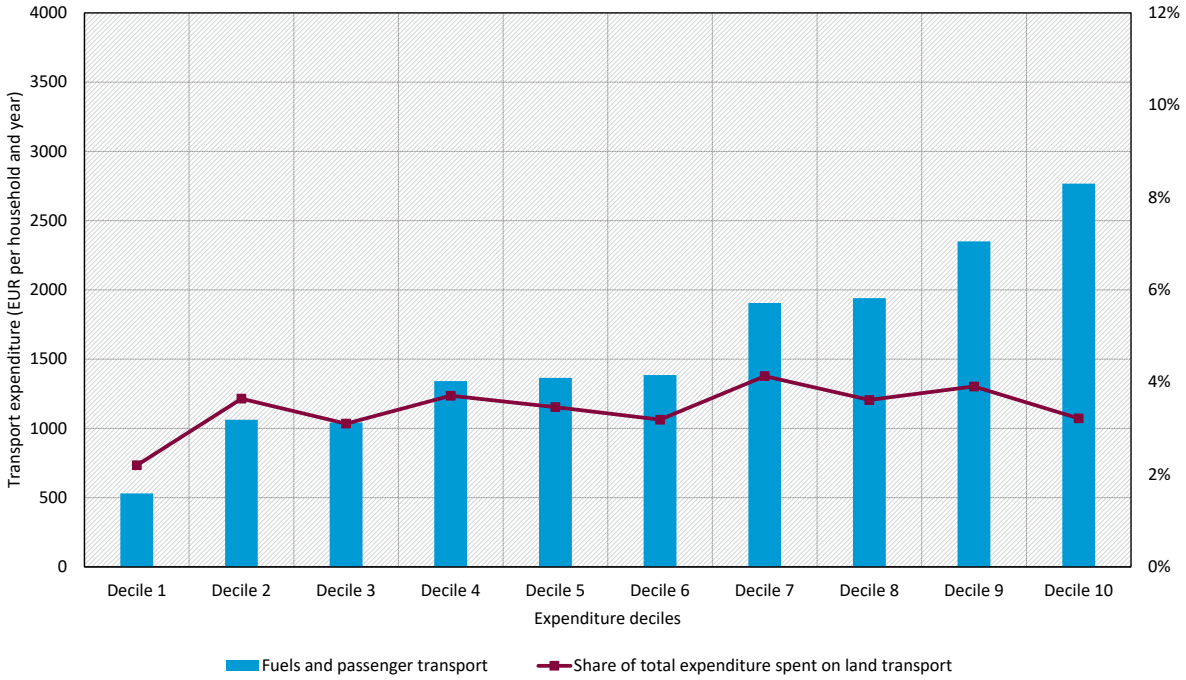
Figure 20 Denmark: Heating expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).

Notes: Fossil fuels include natural gas, heating oil and coal. Non-fossil fuels include biomass and district heating. According to Eurostat rules, deciles 1 & 2 for the category 'Fossil fuels' should be flagged due to a low number of observations (20-49 observations).

Figure 21 Denmark: Transport expenditure (absolute and relative to total expenditure) per household by expenditure decile

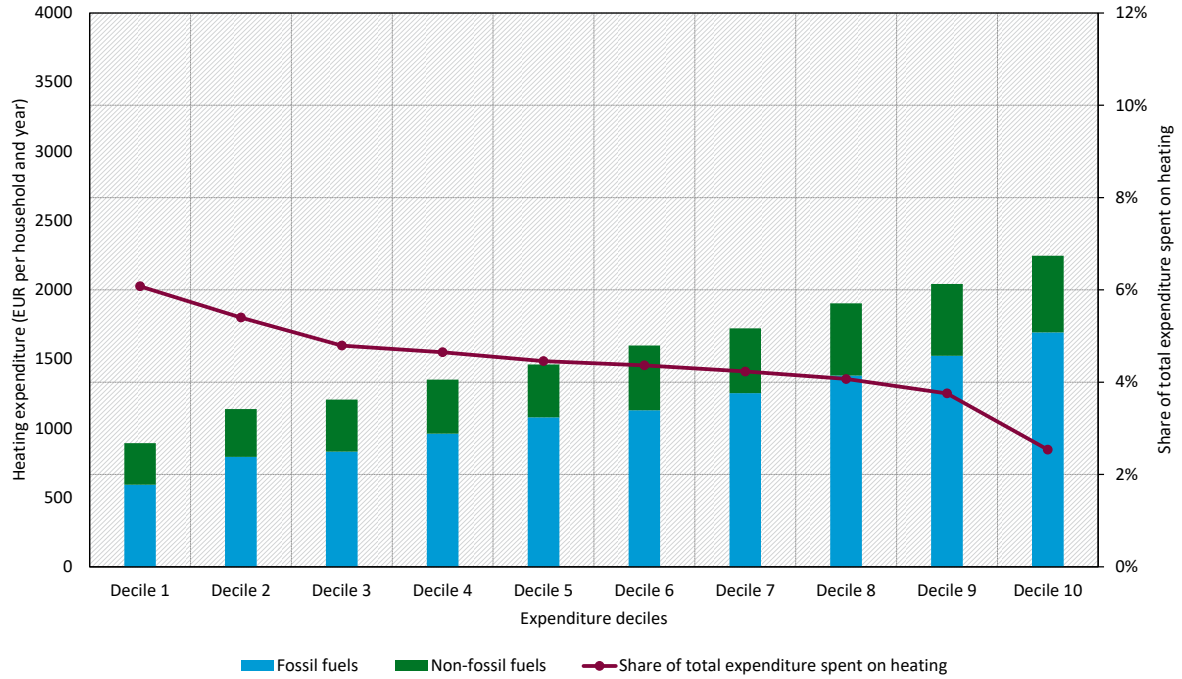


Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).

Notes: Fuels include expenditure on diesel and petrol. Passenger transport includes expenditure on passenger transport by train, underground, tram, bus, coach, taxi and hired car with driver. Too few observations for passenger transport for Denmark, which is why categories were aggregated.

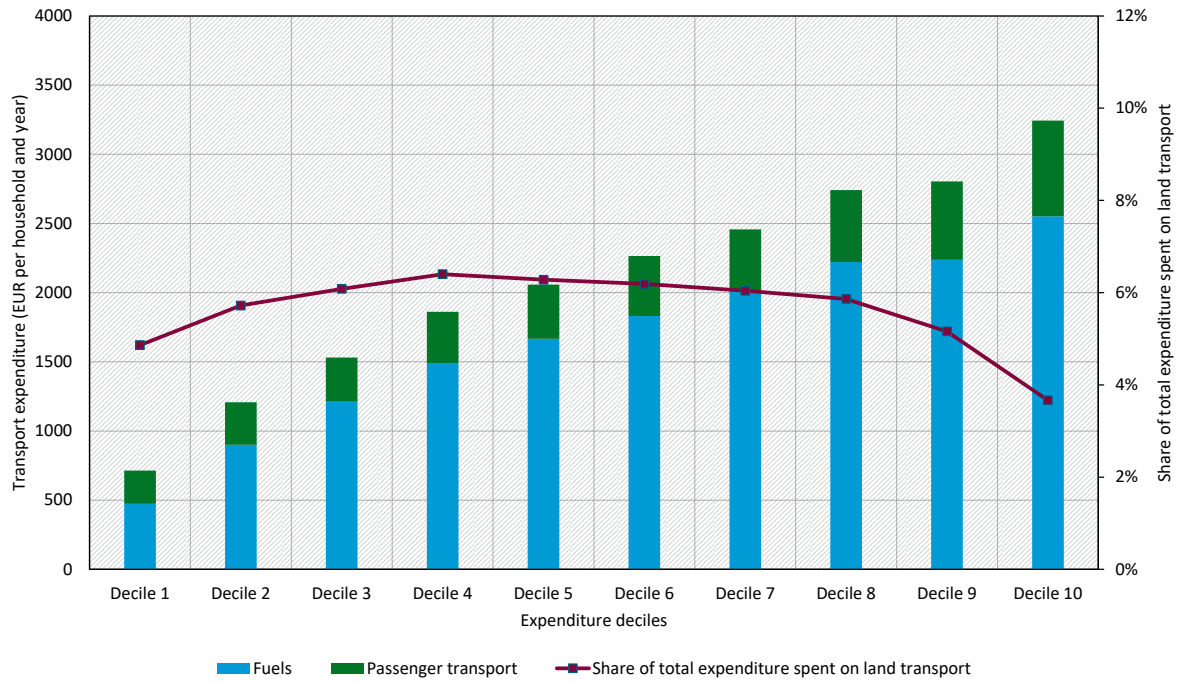
A.2 Germany

Figure 22 Germany: Heating expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-DE micromodel based on EVS 2018 data (inflated to 2022/23).
Notes: Fossil fuels include natural gas, heating oil and coal. Non-fossil fuels include biomass, electric and district heating.

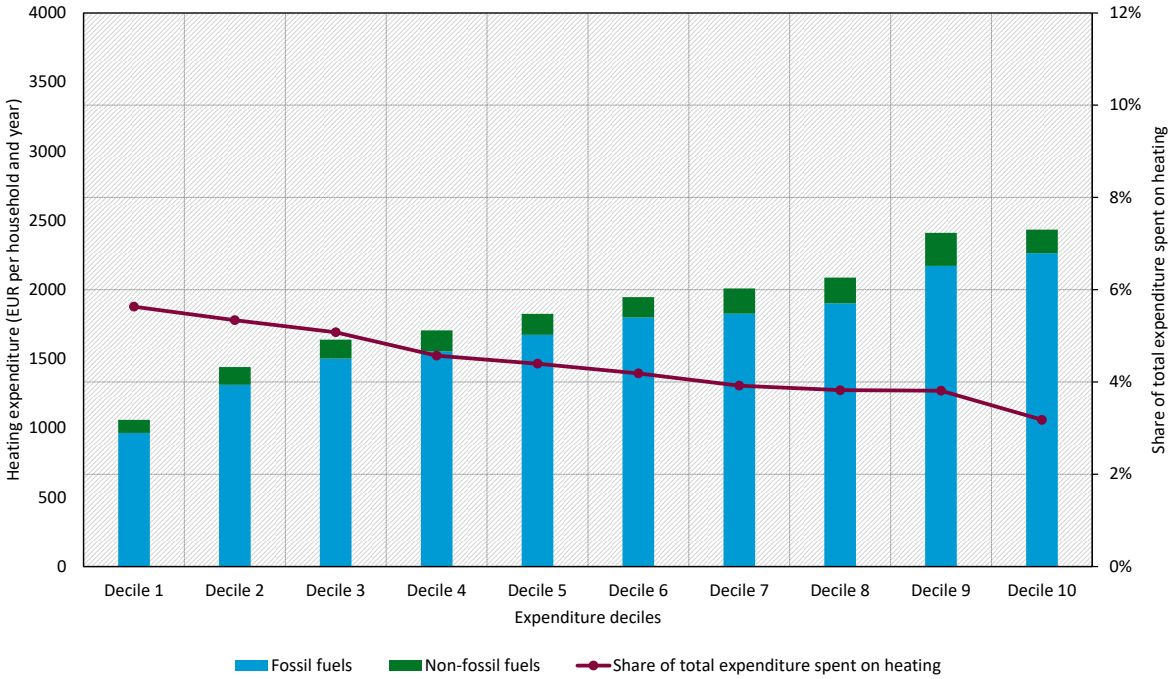
Figure 23 Germany: Transport expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-DE micromodel based on EVS 2018 data (inflated to 2022/23).
Notes: Fuels include expenditure on diesel and petrol. Passenger transport includes expenditure on passenger transport by train, underground, tram, bus, coach, taxi and hired car with driver.

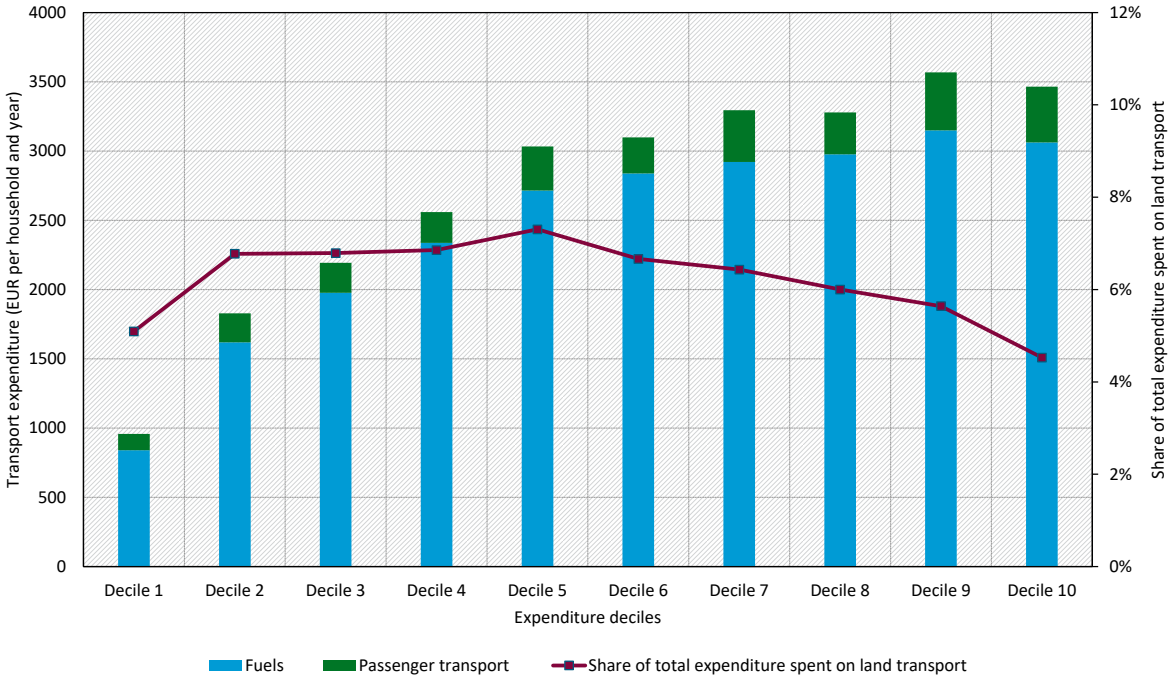
A.3 Ireland

Figure 24 Ireland: Heating expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).
Notes: Fossil fuels include natural gas, heating oil and coal. Non-fossil fuels include biomass and district heating.

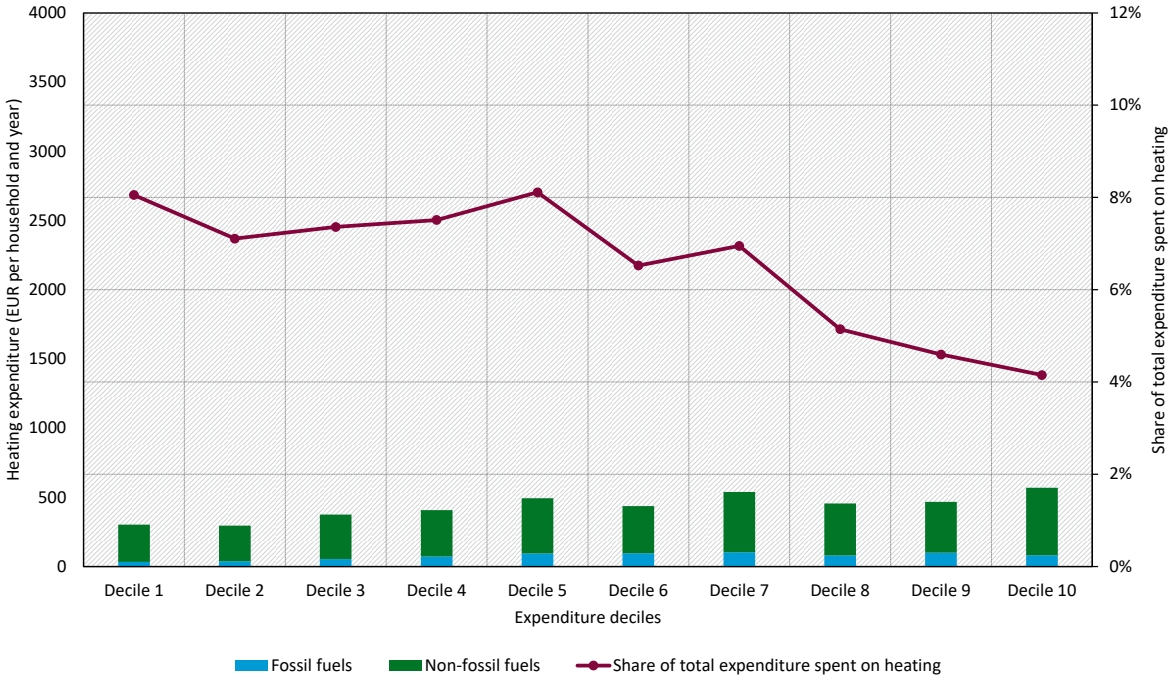
Figure 25 Ireland: Transport expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).
Notes: Fuels include expenditure on diesel and petrol. Passenger transport includes expenditure on passenger transport by train, underground, tram, bus, coach, taxi and hired car with driver.

A.4 Bulgaria

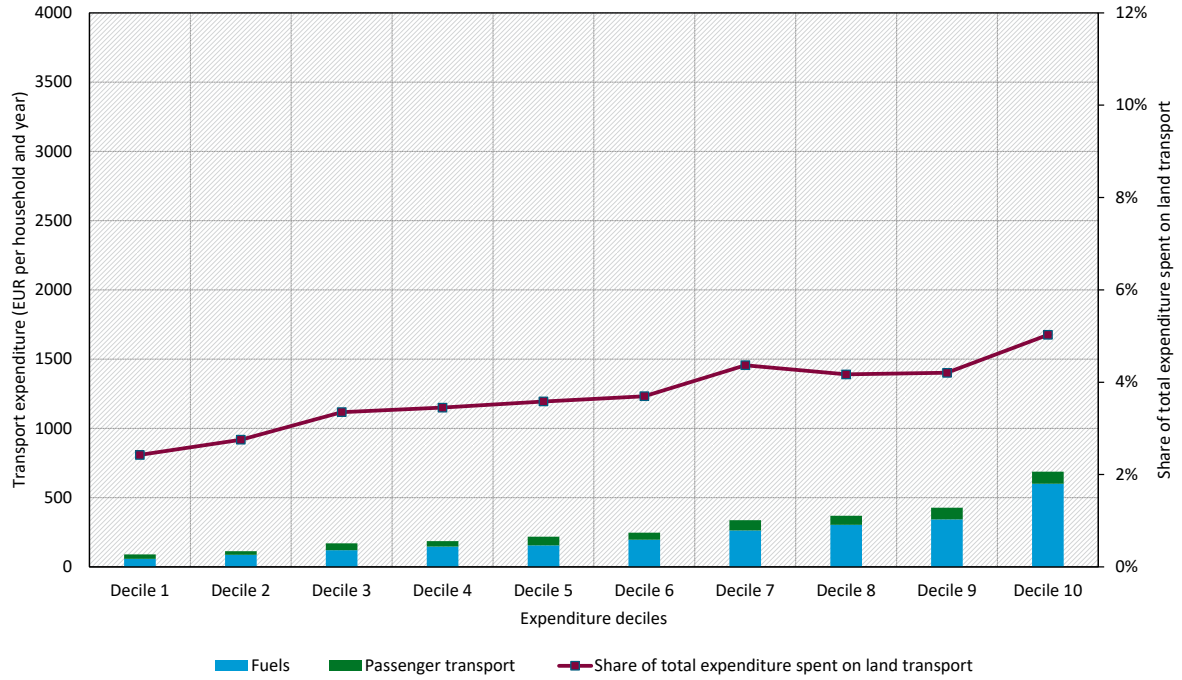
Figure 26 Bulgaria: Heating expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).

Notes: Fossil fuels include natural gas, heating oil and coal. Non-fossil fuels include biomass and district heating. According to Eurostat rules, decile 1 for the category 'Fossil fuels' should be flagged due to a low number of observations (20-49 observations).

Figure 27 Bulgaria: Transport expenditure (absolute and relative to total expenditure) per household by expenditure decile

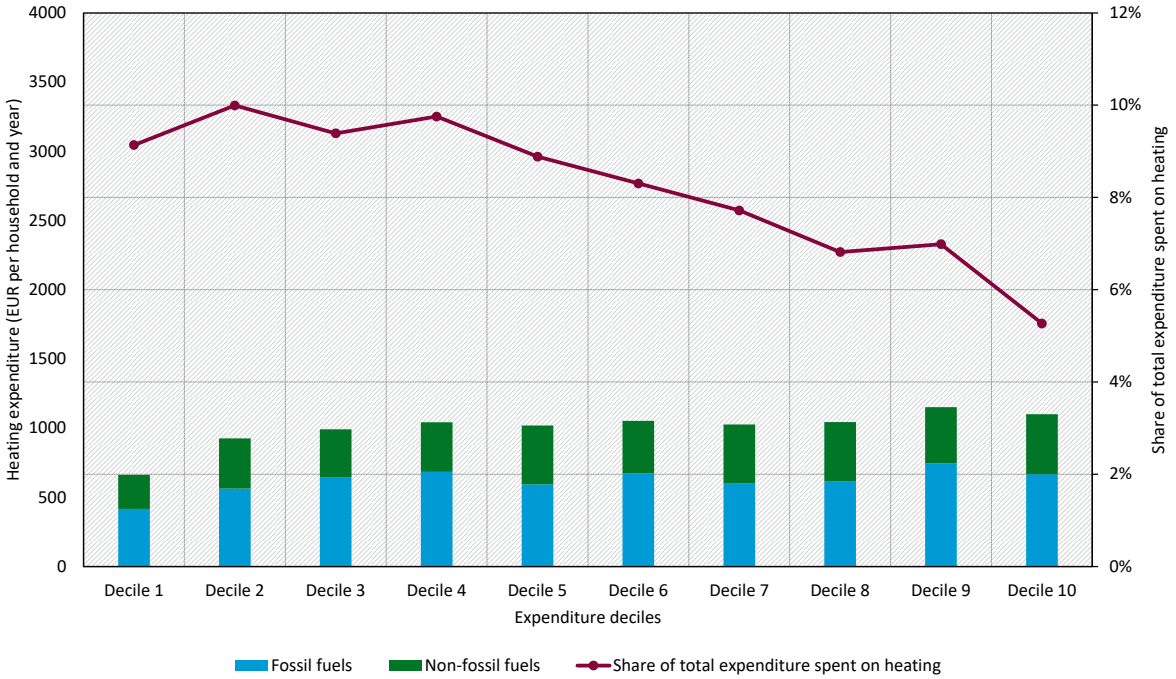


Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).

Notes: Fuels include expenditure on diesel and petrol. Passenger transport includes expenditure on passenger transport by train, underground, tram, bus, coach, taxi and hired car with driver. According to Eurostat rules, decile 1 for the category 'Fuels' should be flagged due to a low number of observations (20-49 observations).

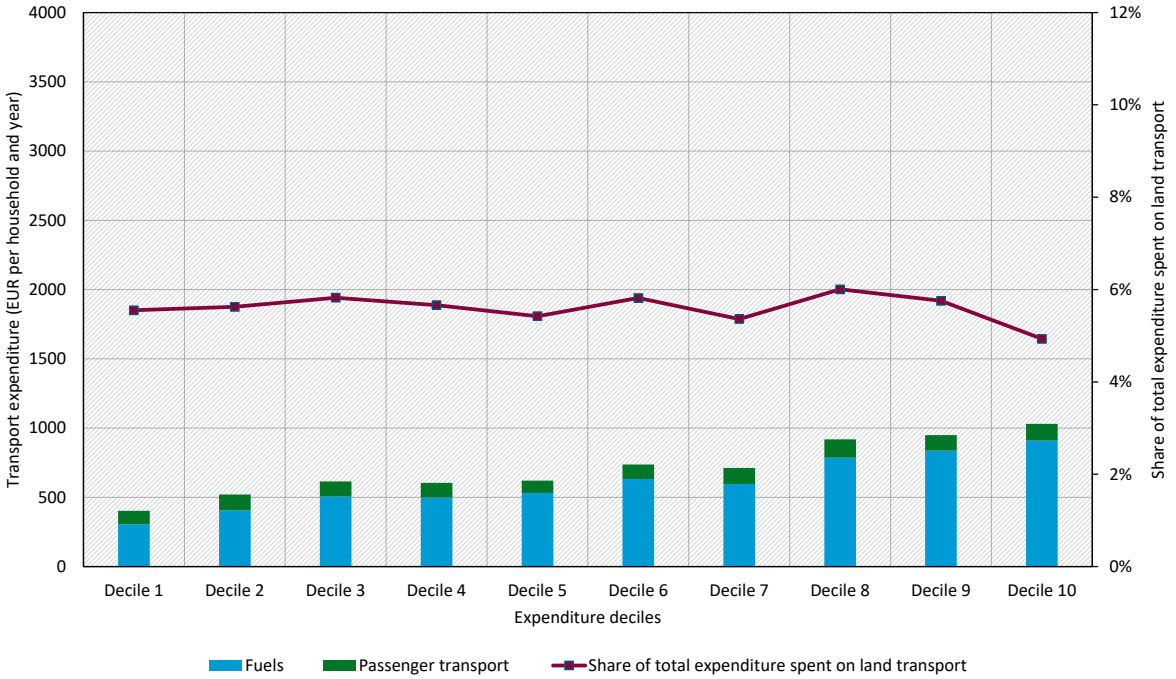
A.5 Czechia

Figure 28 Czechia: Heating expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).
Notes: Fossil fuels include natural gas, heating oil and coal. Non-fossil fuels include biomass and district heating.

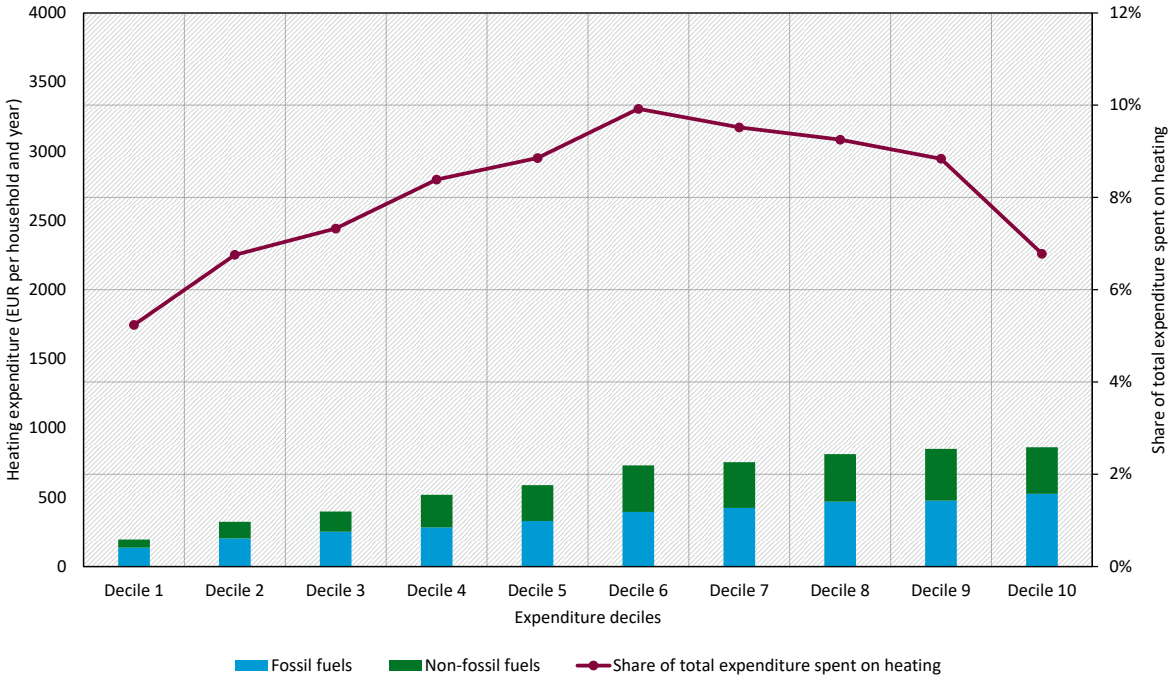
Figure 29 Czechia: Transport expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).
Notes: Fuels include expenditure on diesel and petrol. Passenger transport includes expenditure on passenger transport by train, underground, tram, bus, coach, taxi and hired car with driver.

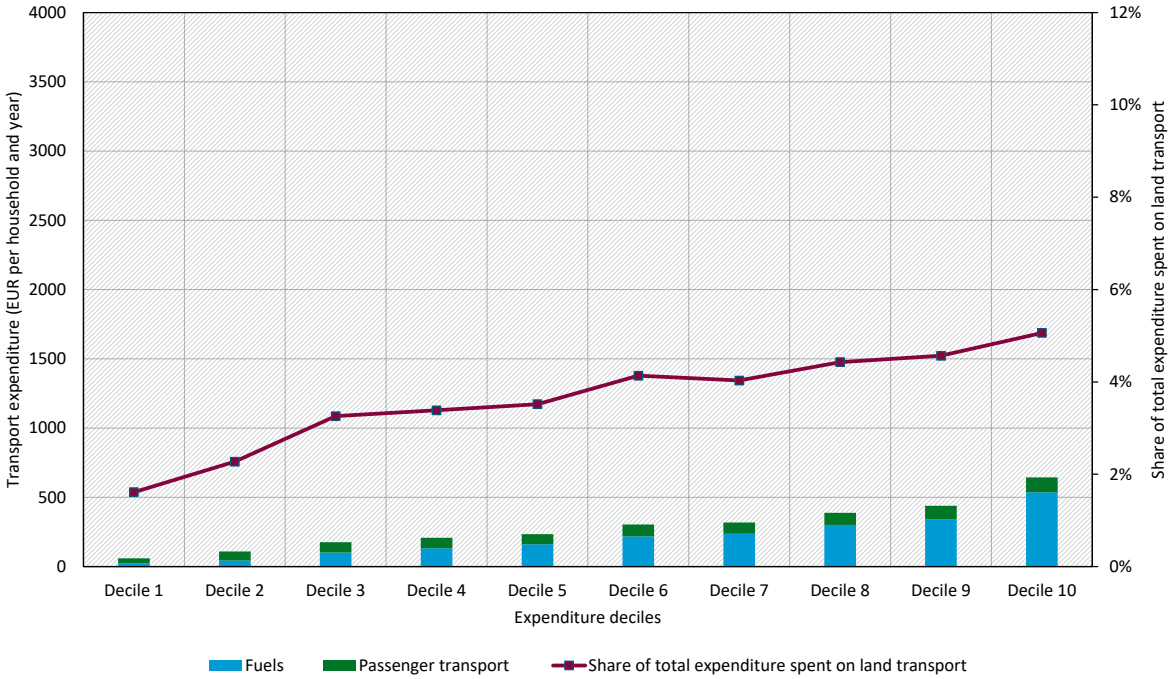
A.6 Romania

Figure 30 Romania: Heating expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).
Notes: Fossil fuels include natural gas, heating oil and coal. Non-fossil fuels include biomass and district heating.

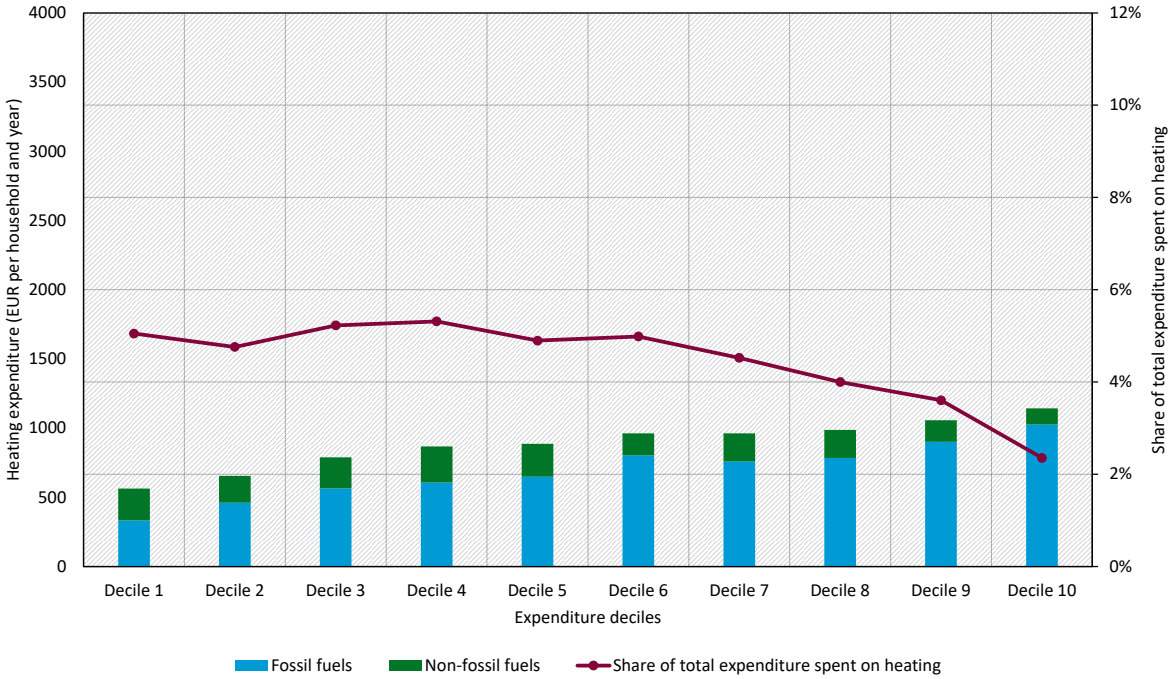
Figure 31 Romania: Transport expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).
Notes: Fuels include expenditure on diesel and petrol. Passenger transport includes expenditure on passenger transport by train, underground, tram, bus, coach, taxi and hired car with driver.

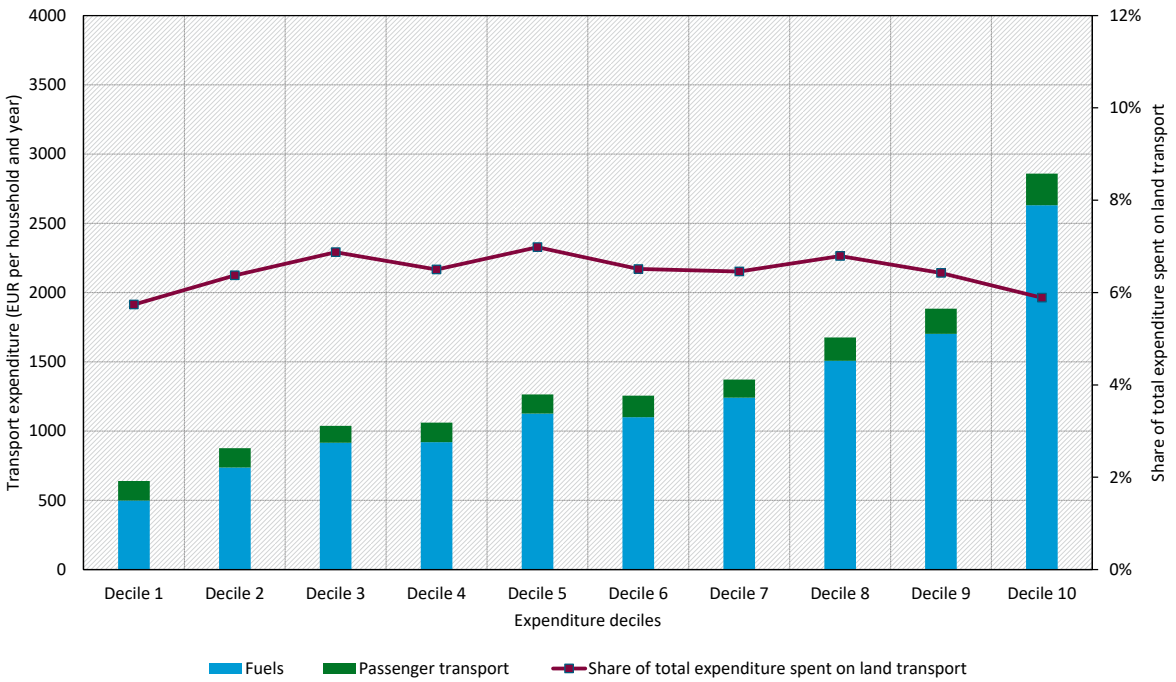
A.7 Greece

Figure 32 Greece: Heating expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).
Notes: Fossil fuels include natural gas, heating oil and coal. Non-fossil fuels include biomass and district heating.

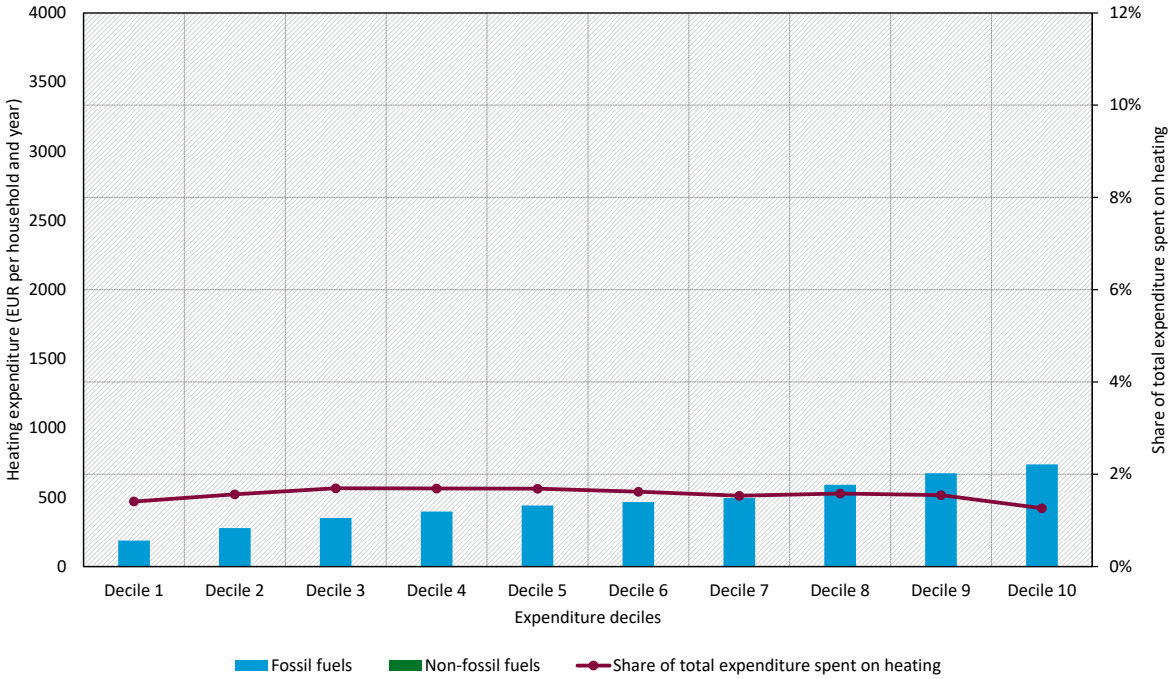
Figure 33 Greece: Transport expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).
Notes: Fuels include expenditure on diesel and petrol. Passenger transport includes expenditure on passenger transport by train, underground, tram, bus, coach, taxi and hired car with driver.

A.8 Spain

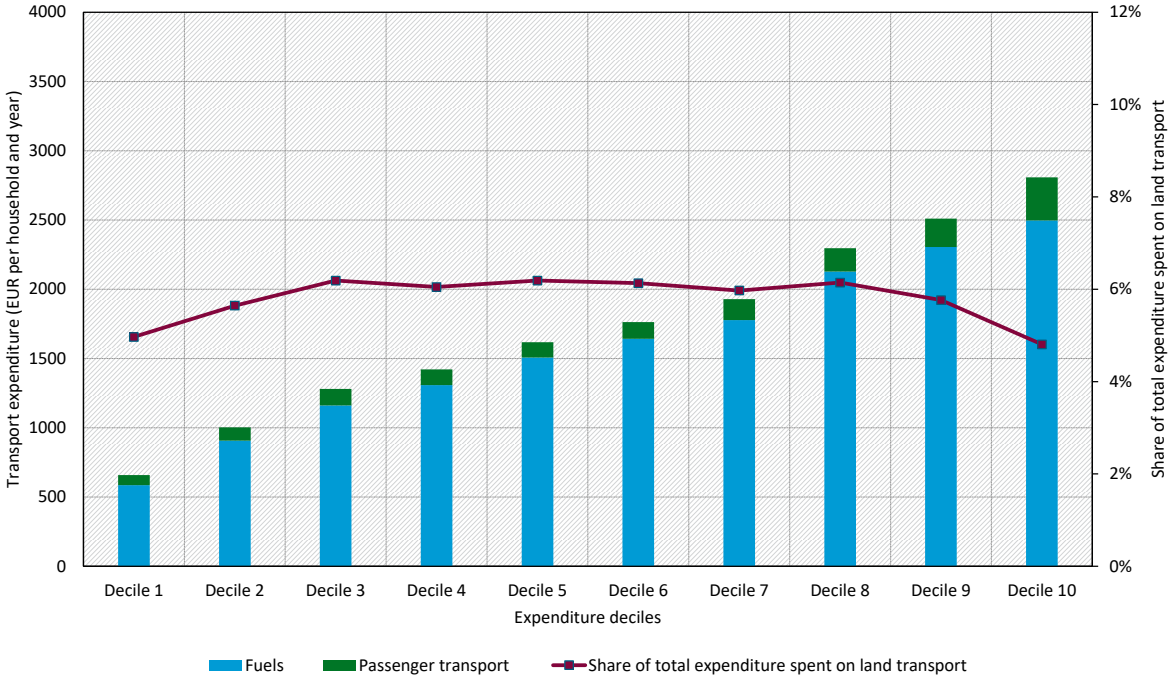
Figure 34 Spain: Heating expenditure (absolute and relative to total expenditure) per household by expenditure decile



Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).

Notes: Fossil fuels include natural gas, heating oil and coal. Non-fossil fuels include biomass and district heating but are not reported in the HBS for Spain.

Figure 35 Spain: Transport expenditure (absolute and relative to total expenditure) per household by expenditure decile

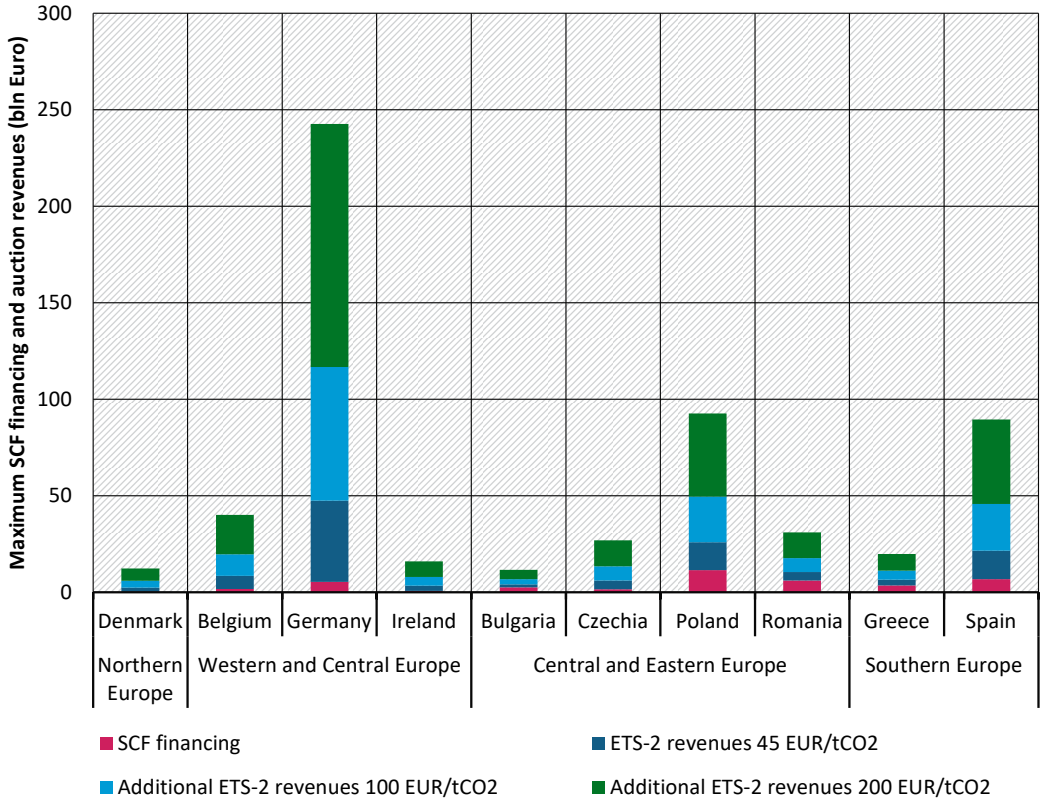


Source: SEEK-EU micromodel based on HBS 2015 data (inflated to 2022/23).

Notes: Fuels include expenditure on diesel and petrol. Passenger transport includes expenditure on passenger transport by train, underground, tram, bus, coach, taxi and hired car with driver.

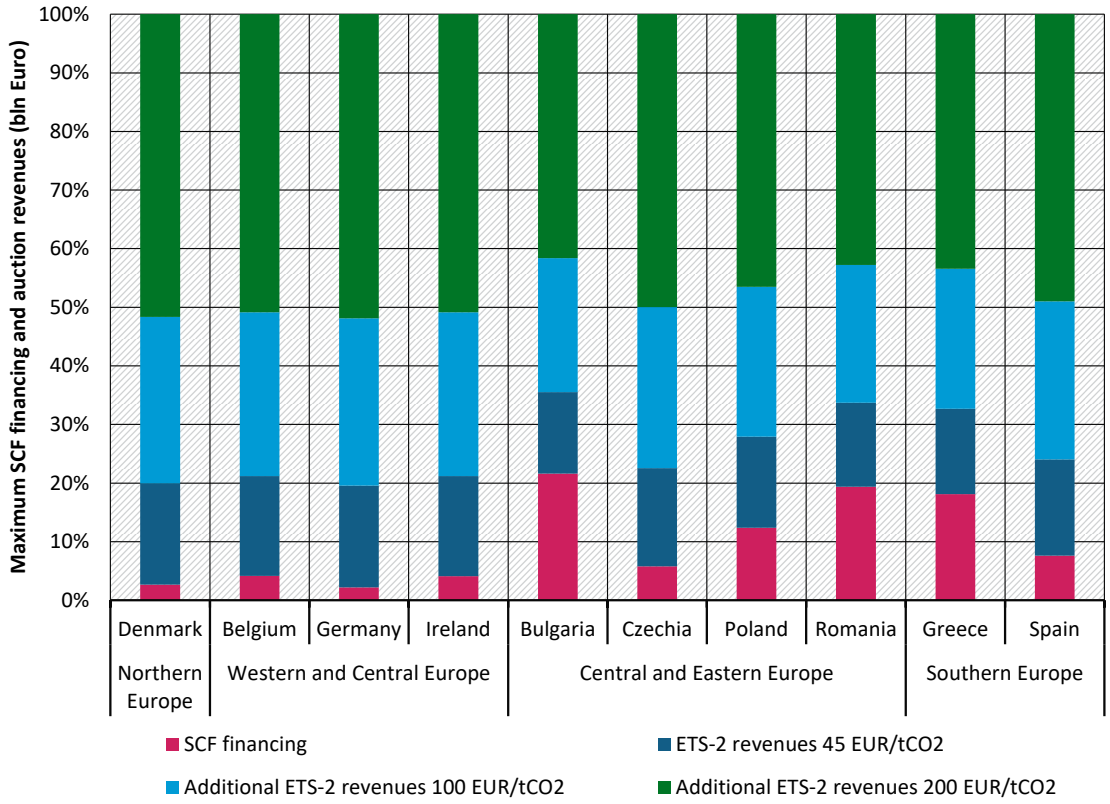
A.9 SCF funding and auction revenues per Member State

Figure 36 Maximum funding through the SCF in the 2026-2032 period and ETS 2 auction revenues at different CO_2 prices 2027-2032 (absolute values)



Source: Own elaboration based on Graichen and Ludig (2024)

Figure 37 Maximum funding through the SCF in the 2026-2032 period and ETS 2 auction revenues at different CO_2 prices 2027-2032 (relative values)



Source: Own elaboration based on Graichen and Ludig (2024)