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Taxing Households Energy Consumption in the EU: the Tax Burden and its Redistributive effect

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Abstract

The taxation of energy consumption is a central topic in the current policy debate of the European Union. While raising energy taxation is part of the European Commission's strategy for achieving its 2030/50 climate targets, the ongoing dramatic increases in the price of energy products are raising calls for reducing their taxation. Therefore, a close consideration of the incidence and redistributive effects of energy taxation is crucial to design compensatory measures and to ensure support for the Green transition. In this paper, we employ the EUROMOD microsimulation model to estimate the burden and the redistributive impact of energy consumption taxation on households across Member States. In doing so, we break down the role played by differences in consumption patterns, rates of taxation and their regressivity. We find that countries where energy taxation is the highest are often not the ones where its incidence on household income is the strongest. At the same time, the highest inequality impact is not always taking place in countries with the most regressive energy taxation. We therefore stress the importance of considering, not only the level of energy consumption taxation, but also its regressivity and its incidence over household income when assessing its inequality cost.

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Authors

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Executive summary

- In this study, we use the recently developed Indirect Tax Tool (ITT) of the EU-wide tax-benefit microsimulation model EUROMOD to simulate energy consumption taxation on households in each Member State, extending EUROMOD's input dataset with imputed consumption data from Household Budget Surveys.
- Our estimates provide a harmonized EU-wide picture of the inequality cost of energy taxation (considering not only excises but also VAT) by type of energy product for all EU 27 Member States. Furthermore, we disentangle the roles played by regressivity, tax rates and consumption patterns in the overall distributional impact of energy taxation.

Policy context

- The taxation of energy consumption is a central topic in the current policy debate. On the one hand, energy taxation is a key lever for the achievement of the European Green Deal targets. On the other, the Ukraine crisis is causing dramatic increases in the price of energy products across the EU, raising calls for reducing their taxes to support households.
- Measuring the total incidence of taxation over energy consumption in terms of households' incomes and estimating its redistributive effect is a key and challenging task for the design and promotion of EU-wide green and just policies.

Main findings

- Remarkably, our results show that countries featuring the highest taxation burden often display the lowest income shares of energy consumption, and vice-versa. This implies that the overall tax burden and its redistributive impact of these taxes are ex-ante ambiguous.
- Consumption patterns widely vary across countries and products, although in general energy consumption tends to represent a larger share of household income in Eastern European countries (often above 14%), while lower shares are observed in Northern and Central European countries (down to less than 6%). Moreover, electricity and vehicle fuel (e.g., petrol and diesel) generally represent the largest household income shares.
- Implicit tax rates of the energy bundle range between 60% and 20% in the EU. Vehicle fuel and liquid fuels (e.g., heating oil) tend to attract the highest rates of taxation. At the other extreme, 'other heating products' (e.g., district heating) are usually the least taxed. The relatively high implicit tax rates combined with the large income shares of expenditures on energy products makes Portugal, Italy, and Greece the countries with the highest share of income allocated on energy taxes in the EU.
- Indirect taxes are generally regressive. Regressivity is the strongest in The Netherlands, Italy, and Germany. In these countries households in the lowest deciles suffer a burden of energy taxation which is between 2-3 times as large as one of the tenth decile. Taxation of housing energy is typically more regressive than the one of vehicles fuel.
- Taxes on energy consumption are also inequality-increasing across the board. The strongest impact is observed in Italy and Germany, followed by Greece and Latvia. While for some of these the negative redistributive impact is mainly driven by regressivity (e.g. Germany), for others it is more about the average weight of these taxes on household income (e.g. in Greece and Latvia). In Italy, the combination of extremely high levels of mean incidence and regressivity makes its energy tax system the most unequalizing one.

1 Introduction

The taxation of energy consumption is a key lever for the achievement of the European Union (EU) 2030/50 climate targets. Indeed, setting new minimum rates for energy products underpins one of the major legislative initiatives of the European Green Deal, the Revision of the Energy Taxation Directive. It is also well in line with the long-established idea in economics (Pigou, 1924) that taxation can provide the price-induced signal needed for consumers to internalise environmental costs and promote efficiency (Voulis et al 2019). Moreover, the combination of energy and carbon taxes avoid direct rebound effects (Linares and Labandeira, 2010), i.e. an increase in the demand for these products following the decrease of their cost because of (sometimes subsidized) efficiency improvements (Small and Van Dender, 2007).

At the same time, taxing energy consumption does not come without trade-offs. The existing literature (among others: Vandyck et al 2021; Maier and Ricci, 2022a; Capéau et al, 2022) suggests that increases in consumer prices, especially in the housing sector, disproportionally affect households at the bottom of the income distribution. Moreover, the ongoing global energy crisis is causing dramatic increases in the price of energy products across the EU, raising calls for reducing their taxes to support households. In addition to ethical concerns about income distribution, perceived unfairness of energy and carbon taxes may hamper their acceptance, as the yellow vest protests in France have shown (see Klenert et al. 2018, for a discussion). Therefore, a close consideration of the incidence and redistributive effects of energy taxation is crucial to design compensation measures and to ensure public support for the Green transition (Labandeira et al 2009; Drews et al, 2016).

While there is a growing body of literature analysing the redistributive implications of energy taxation (for a review, see: Pizer and Sexton, 2020), to the best of our knowledge there are no recent studies covering the whole of the EU. Besides, many works (e.g. Sterner, 2012) have focused on excise duties in isolation. However, considering the overall taxation of energy products, including VAT together with excise duties, is crucial for a number of reasons. Firstly, these taxes interact such that the effect of raising a tax rate depends on the level of the other. Secondly, we estimate VAT to represent about half of the total tax burden over energy consumption in the EU. Therefore, an analysis of energy consumption taxation based on specific excises only would provide a rather incomplete picture. Finally, in the present circumstances of spiralling energy prices, we are witnessing how policy makers use VAT along with excise duties to adjust the taxation of energy products and influence their prices.[1] In a closely related study, Thomas and Flues (2015) analyse the redistributive impact of the overall taxation burden on transport fuels, heating fuels and electricity for a selection of EU countries. They find taxes on heating fuel to be the most regressive[2] while taxes on transport fuel are the least. Our comparative analysis, which covers the whole of the EU, updates and extends their contribution.[3]

In this paper, we employ the Indirect Tax Tool extension of the EU tax-benefit microsimulation model EUROMOD (Akoğuz et al., 2020, 2022) to assess the tax burden on energy consumption in the EU and investigate its redistributive impact on households. We begin by analysing how energy consumption varies across Member States. We find that energy consumption tends to represent a larger share of household income in Eastern European countries (often above 14%), while lower shares are observed in Northern and Central European countries (down to less than 6%). Across the board, electricity and vehicle fuel feature the largest shares in the consumption mix. We then construct implicit tax rates measuring the overall taxation on energy products (i.e., excises and VAT). We show that there are significant differences across EU Member States, with the implicit tax rate on the energy bundle varying from 60% in the Netherlands to 25% in Luxembourg. In general, Eastern European countries display a lower rate of taxation over consumption, whereas Northern and Central European countries display a higher one. Finally, we consider the redistributive impact of energy consumption taxation and

1 As we are writing, the Spanish government is considering cutting the electricity rate of VAT (from 10% to 5%) to counteract raising prices. If implemented, such a rate cut would be the second in two years (electricity was previously taxed at the 21% rate). Similarly, on 1 February 2022, the Belgian government reached an agreement on a new package of measures to support consumers in the face of the energy price shock. The government agreed on a temporary VAT cut on electricity from 21% to 6%.

2 Authors suggest that this is the result of contrasting mechanisms. On the one hand, lower expenditure households may be particularly affected by taxes on heating fuels as they likely live in more poorly insulated dwellings. On the other hand, lower expenditure households are more likely to live in smaller dwellings with a smaller surface area to heat and may save heating fuels by heating up to lower temperatures.

3 Note that our analysis is based on tax rules in place just before the COVID and the Ukranian crises.

its drivers in terms of mean incidence over household disposable income and regressivity. We find that a group of Southern European countries (Greece, Italy and Portugal) displays the highest incidence of energy consumption taxation because of above-EU average shares of energy consumption and taxation. In the case of Italy, such a high incidence is combined with a highly regressive energy consumption taxation, making it the most unequalising system in the EU. By contrast, the Netherlands shows a very regressive tax system together with high rates of taxation; however, its tax system is far less unequalising because of the low incidence of energy taxation on household income. Most Eastern European countries show a below-EU average negative redistributive effect of energy consumption taxation despite its higher incidence on household budget, due to lower levels of regressivity.

Our work contributes to the literature along several lines. Firstly, it provides a comparative assessment of the redistributive impact of energy taxation across the EU. As previously mentioned, to the best of our knowledge there are no recent studies in this area. This is an important gap for the EU policy makers at a time of defining common policies for the achievement of environmental goals, such as those in the Fit for 55 package.[4] Indeed, while climate targets might be aligned across the Union, the redistributive effects of the policy measures meant to achieve them are unlikely to be the same across countries. Therefore, assessing the ex-ante inequality-cost of raising energy consumption taxation is a crucial task to understand public support for this type of measures and, therefore, governments' capacity to adopt them. Secondly, while quantifying the redistributive impact of energy taxation, we systematically disentangle its drivers in terms of the incidence of energy consumption taxation and its regressivity. This allows shedding light on the drivers of the inequality-cost above mentioned. For example, differences in income shares of consumption might imply that raising energy taxation results in substantially different redistributive outcomes depending on the country under consideration. Finally, we build on the methodology employed by the previous literature on the topic, particularly Thomas and Flues (2015), by combining two types of surveys in our analysis, i.e., the Household Budget Survey (providing information on household consumption) and the Standard Income and Living Conditions (providing information on household income, labour and demographic). This allows us to simulate household's disposable income and, therefore consumption, considering the tax-benefit rules in place in each country. This arguably results in a more accurate distributive analysis than the one based on the self-reported income information in HBS.[5]

The remainder of this paper is organised as follows. Section 2 presents our methodology and data, introducing our microsimulation suite and providing the definition of the indicators we employ in our study. Section 3 then discusses the main results of our analysis, while Section 4 offers some concluding remarks.

[4] Communication from the Commission to the European Parliament, the council, the European Economic and Social Committee and the Committee of the Regions "'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality".

[5] As noted by Lamarche et al. (2020), income data collected in the HBS survey are based on a limited number of questions resulting in a rough income variable, not comparable to disposable income in SILC for most countries. This is a significant drawback, also because income data from SILC are those employed by Eurostat for the calculation of official inequality and poverty indicators.

2 Methodology and Data

In this section, we present the methodology and the data underpinning our work. We begin in Section 2.1, describing the data and the microsimulation model that we employ for the analysis of the energy consumption taxation in the 27 EU Member States. Then, in Section 2.2, we describe the data availability and finally, in Section 2.3, we move to define the main indicators used for the redistributive analysis.

2.1 The microsimulation model

For the estimation of indirect tax liabilities at the household level for the 27 EU Member States, we employ the recently developed Indirect Tax Tool extension of EUROMOD (henceforth the "ITT").[6]

EUROMOD is the European Union tax-benefit microsimulation model.[7] It combines country-specific coded policy rules with representative household microdata (mainly from the European Union Statistics on Income and Living Conditions database, EU-SILC) to simulate tax liabilities and cash benefit entitlements. EUROMOD simulations therefore consider the role played by each tax-benefit instrument, their possible interactions, and generate the disposable household income (i.e., income after direct taxes and cash benefits).[8]

The ITT extends the scope of EUROMOD, allowing for the simulation of indirect taxes. To simulate indirect tax liabilities, the ITT combines the underlying microdata of EUROMOD with household expenditure information for ca. 200 commodity categories. These mainly come from the harmonised Eurostat Household Budget Surveys (EU-HBS), being 2010 the latest available release at the time this model was developed.[9] Starting from the household disposable income simulated by EUROMOD, the ITT applies the indirect taxation rules in place in each country (i.e., VAT, specific and ad-valorem excises) to simulate household adjusted disposable income, i.e., income after direct taxes, cash benefits and indirect taxation. In our analysis, we simulate the policy system in place in 2019 in each EU country; this allows us to abstract from COVID and global energy crisis related policies and economic impact.

To combine EU-HBS data (i.e., the source dataset) with the EU-SILC data of the same year (i.e., the recipient dataset), a semi-parametric procedure, developed by Akoğuz et al. (2020), is used. Such a procedure combines the estimation of Engel curves employed in earlier studies (such as Decoster et al. 2010) with matching techniques. It consists of three main steps. Firstly, a common set of relevant covariates is identified in the source and in the recipient dataset. Secondly, in the source dataset, consumption goods are aggregated into 20 macro-categories and expressed in terms of consumption shares of income. These aggregated consumption shares are regressed against the set of covariates identified in the first step. Thirdly, the estimated coefficients are used to construct fitted shares of consumption in both the source and in the recipient dataset (i.e., in each of these datasets, 20 fitted consumption shares will be constructed for any household based on the regression model above). A Mahalanobis distance metric is used to find the closest match between any household in the source and in the recipient dataset. Once households from the recipient (SILC) and source (HBS) datasets are matched, the consumption shares of the full basket of consumption from the latter is imputed to the former. When running the analysis for policy years which are successive to the year the underlying dataset refers to, appropriate uprating factors are used to update income information.

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6 See Akoğuz et al. (2020) for a comprehensive description of the Indirect Tax Tool for 18 EU Member States, including the construction of the underlying micro dataset, the simulation of indirect taxes as well as the validation of the model. Akoğuz et al (2022) documents the extension of the model to the remaining 9 EU Member States.

7 See: Sutherland and Figari (2013) The model is publicly available with an open access software (see: https://euromod-web.jrc.ec.europa.eu/)

8 More information on the main methodological assumptions as well as on the most recent policy systems covered and their main features can be found in Maier and Ricci (2022b).

9 Eurostat harmonized 2010 HBS datasets for Austria and the Netherlands were not available and the data of Luxembourg contained no information on income. For Austria and Luxembourg, the ITT uses national HBS data. In particular, for Luxembourg the 2013 national HBS was used as this was the first year where the income information was adequate for the imputation method. For the Netherlands, Eurostat 2015 HBS dataset was employed instead, with the proper price adjustments.

2.2 Measuring the redistributive effect

To assess the redistributive effect of taxation over the consumption of energy products we employ a standard framework based on Lorenz curves and concentration indices based on the original contributions of Kakwani (1979) and Reynolds-Smolensky (1977).[10] The redistributive effect of an indirect tax t over a consumption of product *p*, RE_{t_p}, is defined as the difference between the Gini coefficient of household income before taxes, G_x, a after taxes, G_{x-t_p}. Namely:

$$[1]\ RE_{tk} = G_x - G_{x-t_p}$$

The Gini coefficient of the post-tax income is based on the new ranking of households, which can differ from the ranking of pre-tax income whenever the tax is large enough for households to move around the distribution. To abstract from such a re-ranking effect, the Reynolds-Smolensky index ("RS", henceforth) compares the distribution of pre-tax income with the distribution of the post-tax income respecting the original ranking of individuals, C_{x-t_p}. The RS index of a tax *t* over a consumption item *p*, RS_{t_p}, is therefore defined as:

$$[2]\ RS_{t_p} = G_x - C_{x-t_p}$$

The RS depends on two main characteristics of the tax, *t*: (i) its relative progressivity, measured by the Kakwani index, K_{t_p}, and (ii) its relative size, measured by its mean incidence over household income, t_p:

$$[3]\ RS_{tp} = G_x - C_{x-t_p} = \frac{t_p}{(1-t_p)} K_{t_p}$$

The Kakwani index measures the progressivity in relative terms, i.e. how much the policy does affect household income across the income distribution. It is defined as the difference between the concentration index of the tax, C_{t_p}, and the Gini coefficient of pre-tax income, i.e.:

$$[4]\ K_{t_p} = C_{t_p} - G_x$$

On other hand, the mean incidence of an indirect tax *t* over a product *p*, t_p,is defined as the tax liabilities, T_p, paid as a share of household disposable income,[11] i.e.:

$$[5]\ t_p = \frac{T_p}{YD}$$

In Section 3.3, we use the characterization in equation (3) to systematically decompose the redistributive effect of energy consumption taxation in the EU.

Moreover, to understand the drivers of energy consumption taxation incidence over household disposable income, in Sections 3.1 and 3.2 we decompose the mean incidence of energy consumption taxation, t_p, breaking it down

[10] See, e.g., Enami et al (2017) or Verbist and Figari (2014).

[11] The term "tax incidence" has often been used in the literature to refer to the welfare effects of taxation considering who eventually bears its burden in consideration of factors such as the pass-through from firms to consumers. In our paper, we refer to incidence as the budgetary impact of taxation on household income (tax payments to income ratio). In the literature, this has often been referred as the "average tax rate". In our work, we employ the term "mean incidence" to clearly distinguish it from the ¨implicit tax rate" (tax payments to consumption expenditure ratio).

by: (i) its implicit tax rate and (ii) its income share of consumption. The implicit tax rate, u_{t_p}, is the ratio between the total tax liabilities paid over a consumption product *p*, T_p, and the consumption expenditures of over this product, E_p, i.e.:

$$[6]\ u_{t_p} = \frac{T_p}{E_p}$$

While the income share of consumption on product *p*, c_p, is the share of consumption expenditure for this product, E_p, over household disposable income, *DY*:

$$[7]\ c_p = \frac{E_p}{DY}$$

The mean incidence of a tax over household disposable income is just product of the implicit tax rate in equation (6) and the income share of consumption in equation (7), i.e.:

$$[8]\ t_p = \frac{T_p}{DY} = \left(\frac{T_p}{E_p}\right)\left(\frac{E_p}{DY}\right) = u_{t_p} c_p$$

Using equation (8), we can therefore re-express the RS index in equation [3], as follows:

$$[9]\ RS_{t_p} = \frac{u_p c_p}{(1 - u_p c_p)} K_{t_p}$$

3 Results and Discussion

In this section, we present the results of our analysis. We begin, in Section 3.1, by analysing the differences in income shares of energy consumption across the EU Member States. We then move, in Section 3.2, to analyse energy consumption taxation and its incidence over household income. Finally, in Section 3.3, we study the redistributive effects of energy consumption taxation in a cross-country perspective, disentangling the role played by differences in regressivity and mean incidence over households' income.

When analysing energy consumption and taxation patterns, we present our results at the level of disaggregation corresponding to COICOP (Classification of individual consumption by purpose) level 3 (4 digits). This includes seven energy products: electricity, town/natural gas, liquefied hydrocarbons (e.g. butane, propane, etc.), liquid fuels (e.g. fuel oil) and solid fuels (e.g. coal, biomass, etc.), other heating (e.g. district heating, hot water, etc.) and vehicle fuels. However, when moving to the analysis of redistributive effects of energy consumption taxation, we focus on the aggregated categories of housing and vehicle fuels. The reason is to account for the substitutability among energy products, which can be alternatively used for the same purpose (e.g. heating of a dwelling).

3.1 Energy consumption in the EU

In this section, we investigate how the share of energy consumption in household budget varies across the EU, and the relative weight of each energy product. For this purpose, we plot in Figure 1 energy consumption as a share of household disposable income by product categories, in each Member State as well as for the EU as a whole.[12] There, we can appreciate that households in the EU spend on average about 11% of their disposable income on energy consumption. The income share of expenditures on housing-related energy consumption (electricity, gas, and other fuels/heating) is 6.5%, while the remaining is accounted for by vehicle fuels. Within housing, the component with the largest weight on income is electricity (3%, about half of total expenditures on this category), followed by natural gas (1.2%).

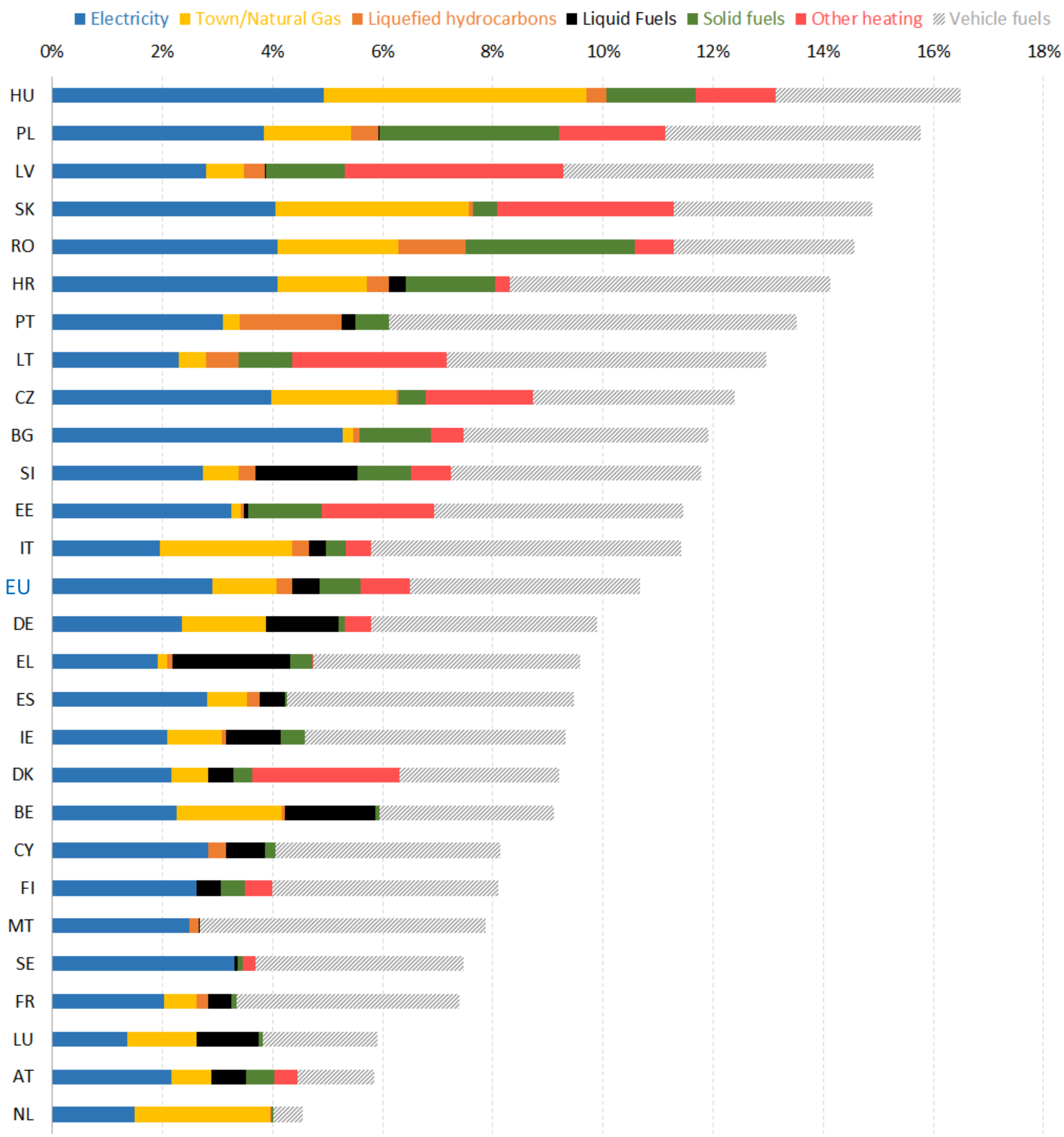
However, there is a significant degree of heterogeneity within the EU in the relative weight of energy consumption with differences up to 12 percentage points (p.p.). In particular, energy consumption generally represents a larger share of household income in Eastern European countries. Among those, Hungary, Poland, Latvia and Slovakia are the countries with the highest income shares of energy consumption at about 16.5%-15% of household disposable income. At the other extreme, energy consumption represents a lower share of household income in Central and Northern European countries. This is especially the case of the Netherlands, Austria and Luxembourg where energy consumption represents the lowest share, less than 6% of household income. These regional differences can be largely ascribed to differences in per capita income and purchasing power across the EU Member States. These play an important role given that the pre-tax price of energy is largely determined in international markets and broadly similar across the EU.

While there are significant differences in the relative importance of the consumption of different energy products across the EU, it is generally the case that electricity and vehicle fuel represent the largest shares. At the EU average level, electricity accounts for 27% of total energy consumption whereas vehicle fuel for nearly 40% of it. These shares vary across countries, but it is typically the case that vehicle fuel represents the largest share in the energy consumption mix of the EU.

The income shares of consumption on vehicle fuel are the largest in Eastern and Mediterranean economies (particularly in Portugal, Spain, Italy, Malta, Latvia, Lithuania and Croatia), often above 5% of household disposable income. Whereas, aside from a handful of exceptions, expenditure shares of electricity appear the largest in Eastern Europe (particularly in Bulgaria, Hungary, Croatia, Czechia, Romania and Slovakia), in many cases representing 4% or more of household income. In Croatia and Bulgaria, as well as in Portugal, the combined consumption of electricity and vehicle fuels represents about the 10% of household income.

[12] Throughout our analysis, the EU average is constructed as the unweighted average over the EU 27 Member States. We do not weight for population shares to avoid the average being dominated by a few large countries.

Figure 1. Consumption shares of energy products by country (% disposable income)

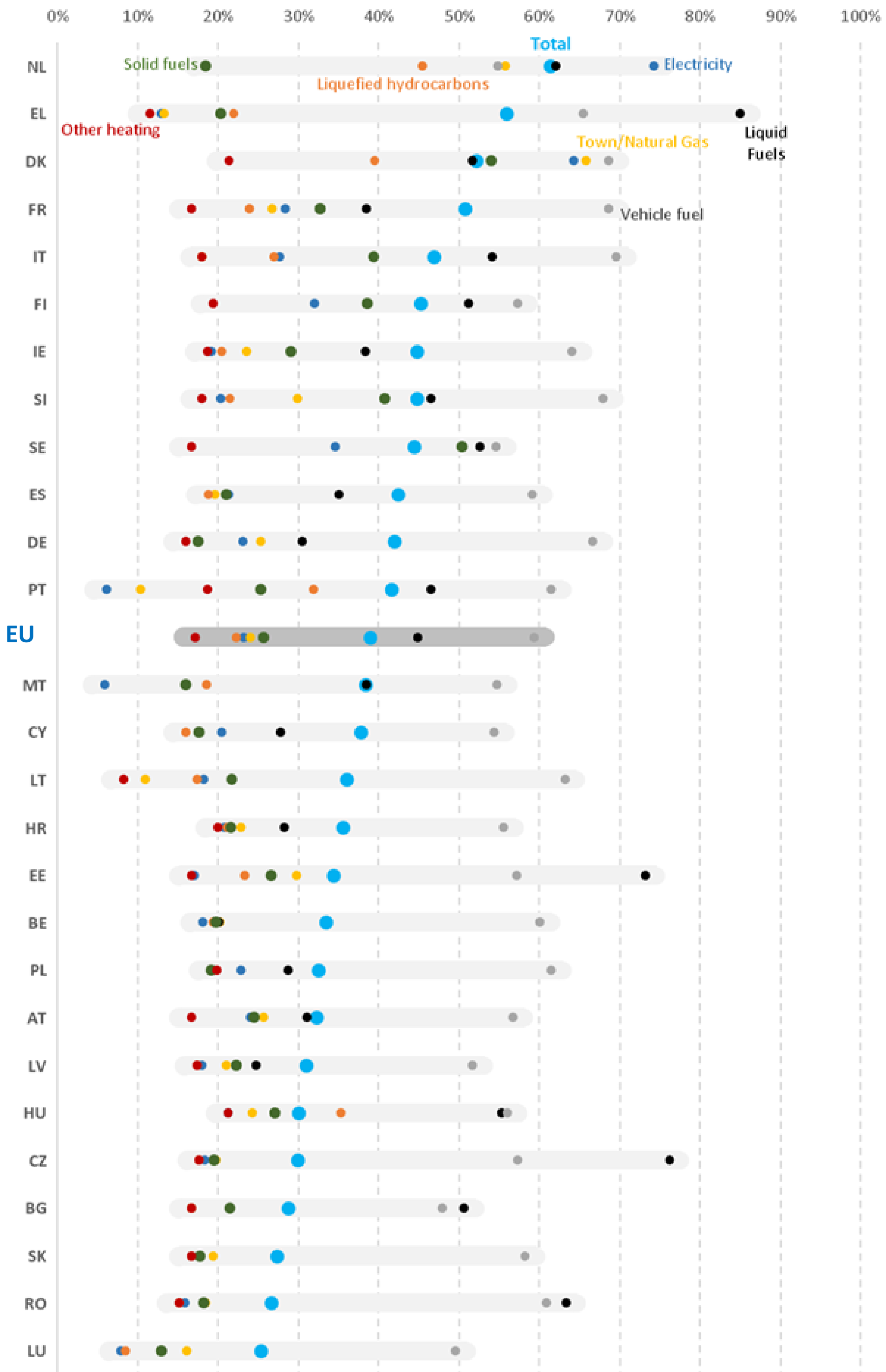


Note:Income shares of consumption by Member State. "EU" is the (unweighted) mean.

3.2 Energy consumption taxation in the EU

We now move to analyse how the taxation of energy consumption varies across the EU Member States. We consider the total taxation of energy products, including both VAT and specific excises, estimating implicit tax rates defined as in Section 2. Again, we perform these calculations at the level of disaggregation corresponding to COICOP level 3 (4 digits). We also calculate the implicit tax rate for the whole energy consumption bundle. Results are displayed in Figure 2, where we plot implicit tax rates for individual Member States and for the whole of the EU, in 2019.

Figure 2. Implicit tax rate on energy products in the EU in 2019



Note: Implicit tax rates are the share of total tax liabilities over household consumption expenditures on energy products, by Member State. "EU" is the (unweighted) mean.

Looking at Figure 2, it is immediately clear how EU Member States display sizeable differences in the taxation of energy consumption. When looking at the overall implicit tax rate (i.e., "Total"), we can appreciate how this varies from about 60% in the Netherlands to less than half of it in Luxembourg and Romania, where it amounts to 25-27%. More generally, Eastern European countries (particularly, Romania, Slovakia, Bulgaria, Czechia, Hungary, Latvia and Poland) tend to feature the lowest implicit rates – below or about 30%. Whereas, on the other hand, a far less homogenous mix of Northern, central and Southern European countries (the Netherlands, Denmark, Greece and France) features the highest overall implicit tax rates - above 50%.

When considering the breakdown of the implicit tax rates by product, dispersion is even higher. Indeed, the taxation of energy products spans from nearly 85% of liquid fuels in Greece, to 6% of electricity in Portugal and Malta**.** Also, while rates vary significantly across countries, vehicle fuel (e.g., petrol and diesel) and liquid fuels (e.g., heating oil) generally feature the highest rates of taxation. At the other extreme, "other heating products" (e.g., district heating) are usually the least taxed. Moreover, solid fuels (e.g., coal, biomass) are in various cases taxed in the low range despite their important adverse environmental and health impact. While less polluting energy sources, like gas, are more heavily taxed. In some Member States, the implicit tax rate is mostly driven by one or two products, which constitute a relatively large share in the household energy mix (Figure 1).

By comparing the implicit tax rates in Figure 2 with the consumption shares in Figure 1, we can appreciate that countries featuring the highest taxation burden are often those featuring the lowest shares of energy consumption over household income, and vice versa. This implies that the distribution of the mean incidence (energy-consumption taxation over household income) across countries is ex-ante ambiguous. We therefore investigate this aspect in Figure 3 where we plot the mean incidence of energy consumption taxation over households' disposable income across the EU. There, a few observations can be drawn.

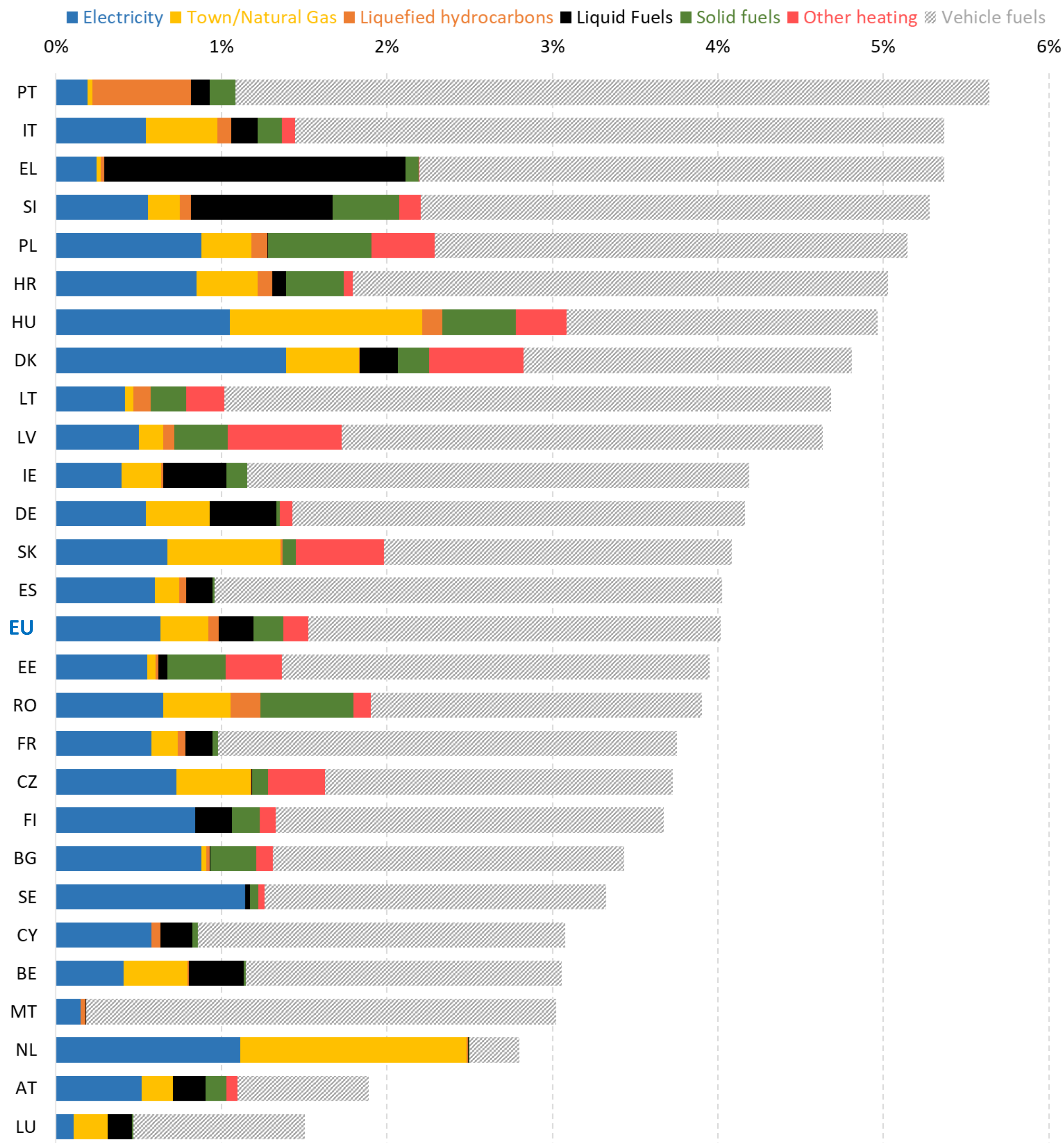
Firstly, a group Southern and Eastern European countries, including Italy, Greece, Portugal, Slovenia and Poland displays the highest mean incidence of energy taxation, above 5% of household disposable income. However, as we can see by comparing Figure 1 and Figure 2, the drivers of this higher incidence are rather different for these countries. Italy and Portugal present a combination of medium to high consumption and taxation of energy. Greece, on the other hand, shows a lower consumption share but high taxation rates. Whereas in Eastern Europe, Poland shows a high consumption share of energy accompanied by a low taxation. Slovenia is instead in a mid-position for both consumption and taxation. Secondly, a group of Northern and central European countries including Luxembourg, Austria and the Netherlands features the lowest mean incidence of energy consumption taxation on household disposable income at about half the level just discussed, i.e. around or below 2.5%. Austria, Netherlands and Luxembourg are the countries with the lowest incidence because of a significantly lower consumption share and, in the case of Luxembourg of taxation burden too. Thirdly, vehicle fuel shows the highest taxation incidence in virtually all countries, absorbing on average 2.5% of household disposable income in the EU. The incidence of vehicle fuel is followed by the one of electricity and natural gas whose weights are however more heterogeneous across the EU.

3.3 Redistributive impact of taxation of energy products in the EU

The presence of different income shares of consumption across households together with differences in the taxation of energy products imply that the tax burden is unequally distributed across households. In this section, we measure the redistributive effect of energy consumption taxation employing the decomposition framework outlined in Section 2. Hence, the redistributive effect of energy taxation is decomposed in its two drivers: (i) the mean incidence of the tax policy (the share of household income that it absorbs) and (ii) its relative progressivity/regressivity (the distribution of the tax burden across households).

To account for substitutability among energy products, in this section we aggregate the seven energy products so far considered into two energy bundles: (i) housing (including: electricity, town/natural gas, liquefied hydrocarbons, liquid fuels and solid fuels, other heating) and (ii) vehicle fuel. We start by summarising our discussion on the incidence of indirect taxes according to these two macro categories, in Section 3.3.1, and finally we analyse the regressivity and redistributive effect of energy taxation in Section 3.3.2.

Figure 3. Mean incidence of energy products taxation by country (% of household disposable income) 2019



Note:Mean incidence is the average share of simulated total tax liabilities (VAT + excises) on household disposable income by Member State. "EU" is the (unweighted) mean.

3.3.1 The mean incidence of housing and vehicle energy taxation and their drivers

In Section 3.2, we discussed how the mean incidence of energy taxation varies across countries and we hinted at its main drivers. For the purpose of the redistributive analysis, we now characterise its mean incidence for the aggregate categories of housing energy and vehicle fuel. We do so in Figure 4, which summarises three dimensions: (i) the mean incidence (area of the bubbles), (ii) the income shares of consumption expenditures (vertical axis) and (iii) the implicit tax rate (horizontal axis). These figures are presented for the whole of the energy bundle as well as for the energy consumption categories of housing and vehicle fuel.

Beginning with the aggregate bundle of energy products, we observe a negative correlation between the income share of consumption of the energy bundle and its implicit tax rate. This is in line with our discussion in Section 3.2, where we noted that countries featuring the highest income share of consumption of energy tend to report, as well, the lowest rate of taxation and vice versa. Broadly speaking, we can identify three different regional patterns across the EU: i) *central and Northern Europe*, featuring high implicit tax rates and low consumption shares (e.g., the Netherlands, Denmark, Sweden, Finland and France), accompanied by Greece[13]; ii) *Eastern Europe*, with high consumption shares and low implicit tax rates (e.g., Poland, Croatia, Hungary, Lithuania, Latvia, Slovakia); and iii) *Southern Europe*, with slightly above average income shares of consumption and taxation rates (e.g., Portugal, Italy and to a lower extent Spain and with exception of Slovenia). Groups (ii) and (iii) generally feature the highest mean incidence of energy consumption taxation.

We then move to consider the energy bundle disaggregated by housing and vehicle fuel. We see that the negative correlation between the income share of consumption and the implicit tax rate is largely driven by housing energy, whereas in the case of vehicle fuel it appears more nuanced. With the main exception of Mediterranean countries, housing energy consumption tends to absorb a larger share of income while being less taxed than vehicle fuel. Furthermore, when comparing housing energy and vehicle fuel, we see that housing energy features more dispersion in terms of consumption shares and rates of taxation. This is mostly driven by very large differences in terms of income shares of consumption (up to 10 p.p.) and rates of taxation (up to 40 p.p.) between Eastern and Northern Europe (plus Greece). Nonetheless, these differences are such that both groups of countries typically feature the highest incidence of housing energy taxation. On the other hand, the taxation of vehicle fuels is less disperse. Indeed, the rates of taxation are far more similar across countries and typically higher than for housing energy. The largest mean incidence of taxation on vehicle fuel is observed in Southern Europe (particularly Portugal and Italy) and in Latvia. It is the result of higher shares of consumption (particularly in Portugal and Latvia) and higher rates of taxation (particularly in Italy). Looking at the breakdown of total indirect tax liabilities by excises and VAT (see Figure E.1 in the Appendix E), it appears that in virtually all countries excises on fuel absorbs the highest share of household income, whereas excises on housing energy the lowest. On average, for the EU 27 Member States, VAT represents about half of the total tax burden over energy consumption.

On top of the cross-country heterogeneity, we observe an even greater level of within-country heterogeneity in the mean incidence of energy taxation across the distribution of household disposable income. This can be appreciated in Figure 5 were we plot the mean incidence of energy consumption taxation as well as the maximum and the minimum for the EU by income deciles (figures by country can be found in the Appendix B of this paper). In several countries, the incidence of energy taxation over the first decile is as large as twice its mean level. This is, for instance, the case of some of the Member States displaying the highest incidence of energy taxation: in Portugal, Italy, and Slovenia, a mean incidence of energy taxation of about 5 – 5.5% translates into about 10% incidence for households sitting at the bottom of the income distribution. On the other hand, Romania is the only country where energy taxation affects richer households more than the poorer ones. When looking at the correspondent of Figure 4 for the first and tenth decile (this can be found in the Appendix C of this paper), it appears the differences in incidence are typically driven income shares of consumption. Indeed, significantly higher shares of consumption in the first deciles more than offset the impact of differences in consumption composition, which are such that richer households typically face a higher rate of taxation.

In the next section, we take a closer look at the regressivity of energy taxation across the EU and we analyse its redistributive consequences.

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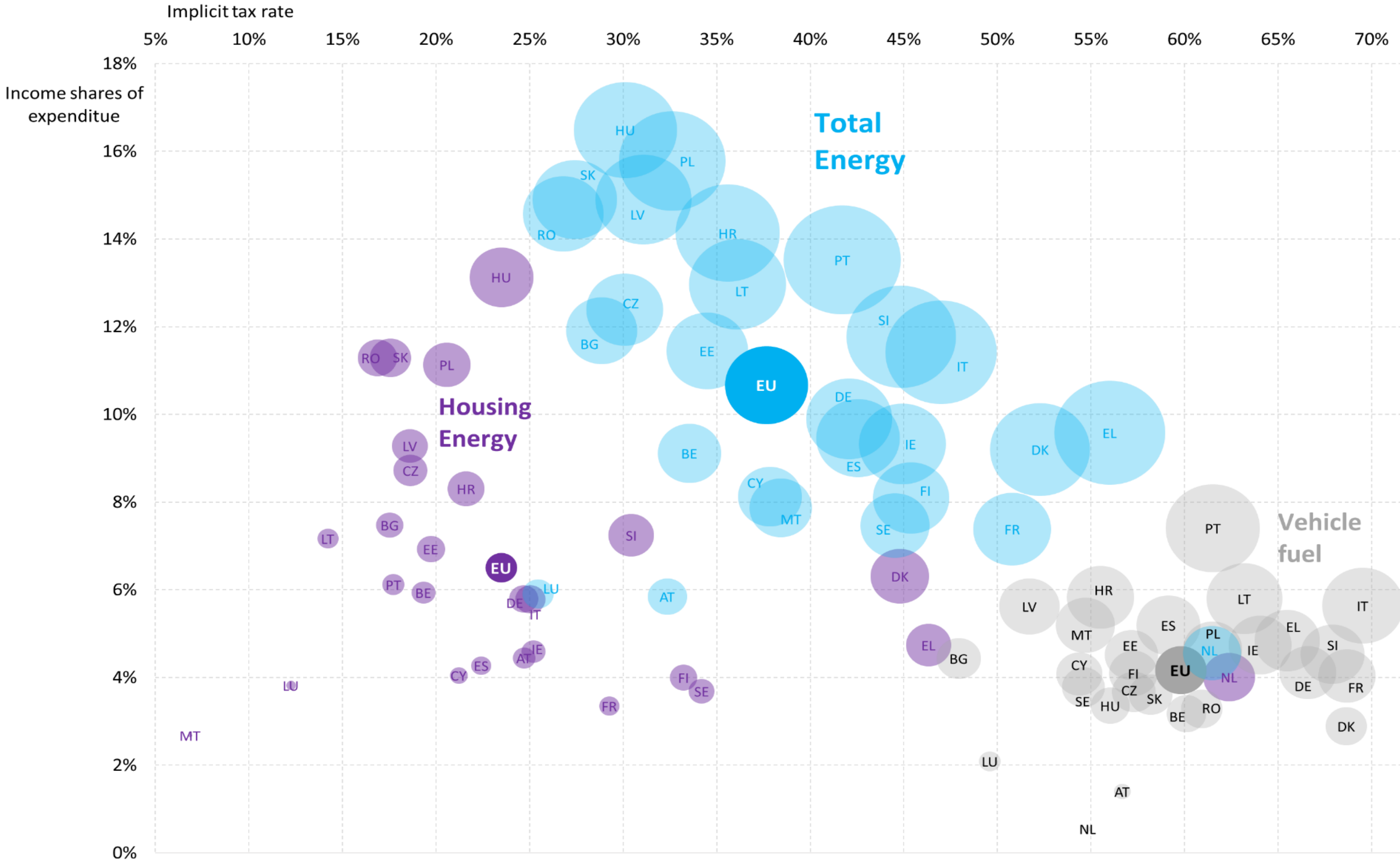
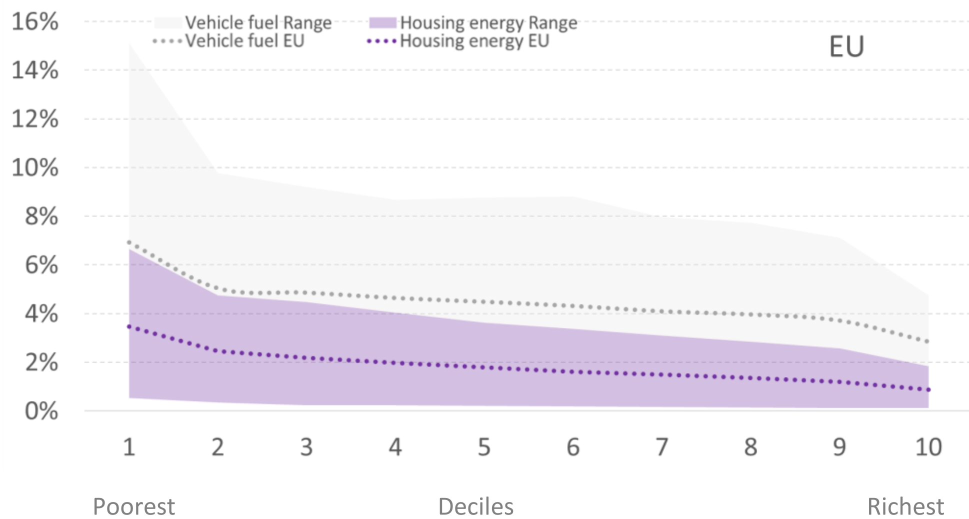
[13] Greek indirect taxation was significantly reformed in the last decade following structural reforms and bailout programmes.

Figure 4. Mean incidence, consumption share and implicit tax rate by main energy product categories in EU 2019.



Note: Each bubble represents one Member State, while "EU" is the unweighted arithmetic EU average. The size of the bubble (area) represents the mean incidence (taxes over household disposable income). The horizontal axis reports the implicit tax rate (taxes over household consumption expenditures), while the vertical axis reports the income share of consumption (household consumption expenditures over household disposable income).

Figure 5. Mean incidence over household disposable income of energy consumption taxation by decile of equivalised household disposable income, EU 2019 (housing energy vs vehicle fuel).



Note:Shaded areas represent range across EU Member States, while dotted line indicate the (unweighted) mean for the EU.

3.3.2 Regressivity and the redistributive effects of energy taxation

To analyse how the energy consumption taxation affects households along the income distribution, we calculate the Kakwani index for housing and vehicle fuel consumption taxation, as well as for the whole of the energy bundle. This is plotted in Figure 6. A negative value of the Kakwani index indicates that taxes are regressive, on the contrary, a positive value indicates progressivity. Countries are ranked according to the value of their Kakwani index for the taxation of total energy consumption.

From Figure 6, we can appreciate that with the only exception of Romania, energy consumption taxation is regressive in all EU Member States. Regressivity is the strongest in the Netherlands (which is also the country featuring the highest energy taxation) followed by Italy and Germany. Looking at the tax incidence by decile in the Figure B.1 in Appendix B, the regressive nature of the energy consumption taxation in these countries is apparent. Households in the poorest deciles suffer a burden of taxation which is between 2-3 times as large as the one of the tenth decile. In Italy, the incidence of energy taxation over the poorest deciles is one of the highest, measuring about 13% of household disposable income. At the other extreme, in Romania we observe a slightly progressive energy taxation. That is mostly driven by a progressive taxation of vehicle fuels, which more than offset the regressive effect of housing energy taxation. Also, while Romania is the only country featuring a progressive energy consumption taxation, in several other Eastern European countries, including Hungary, Slovakia, Bulgaria and Czechia, the taxation of vehicle fuel is slightly progressive or neutral. It is thanks to the progressivity of vehicle fuel taxation that Slovakia, Bulgaria and Czechia display one of the least regressive energy consumption taxations in the EU.

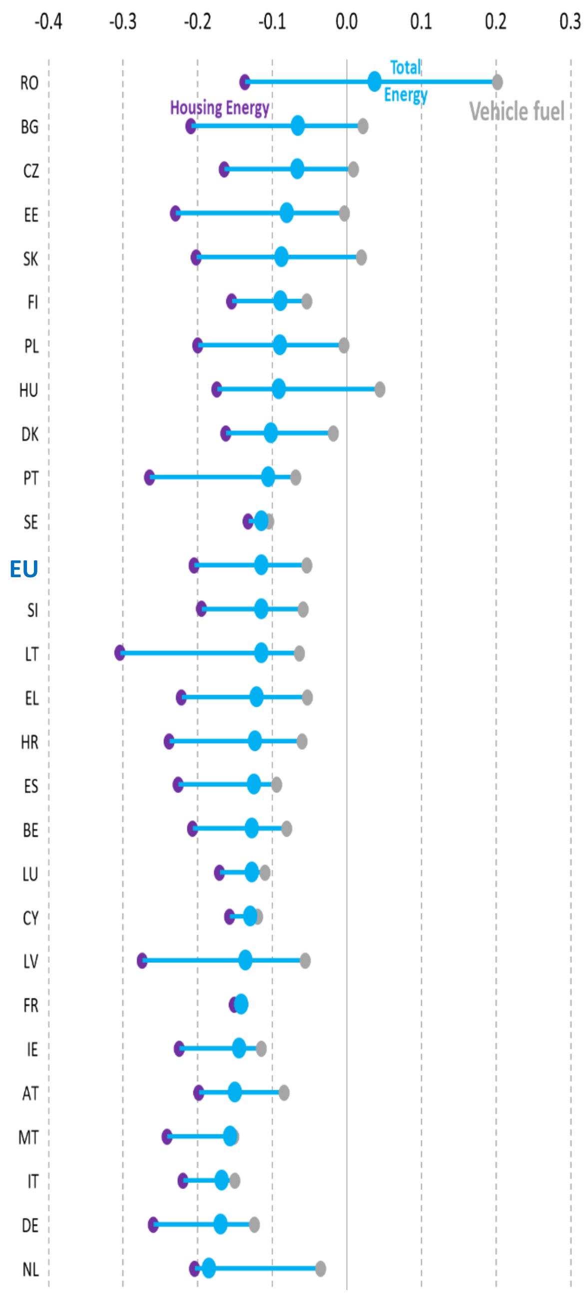
More generally, while there are significant differences in magnitude, the taxation of housing energy is more regressive than the one of vehicles fuel in all countries. This pattern is to be ascribed to a higher elasticity of income of vehicles fuel consumption, such that its consumption grows more starkly with income than housing energy consumption does. Namely, the consumption of housing energy represents higher income shares among lower-income households and it represents a higher share of incomes in lower-income countries. When looking at the breakdown by excises and VAT, it appears these two are about equally regressive in the case of vehicle fuel. For housing energy, differences in regressivity are instead relatively more pronounced, but there is no clear cross-country pattern (see Figure E.2 in Appendix E).

Finally, we move to consider the redistributive impact of energy consumption taxation, namely its "inequality cost". As discussed at the beginning of this section, the redistributive effect without re-ranking (RS) is measured as the difference in the Gini coefficient of household disposable income before the taxation of energy consumption and the concentration index of the post-tax income, respecting the pre-tax ranking. The redistributive effect depends on two characteristics of the policy: (i) its regressivity (the Kakwani index just discussed) and its (ii) size (the mean incidence discussed in previous subsection). The idea is that a highly regressive policy may be less unequalising (i.e., increasing less income inequality) than another one which, despite being less regressive, has a higher incidence (i.e., size) over household income. Therefore, the analysis of regressivity alone is not enough to understand the inequality cost. We plot the redistributive effect in Figure 7 for the whole of the energy bundle, as well as for housing and vehicle fuels separately. As for the Kakwani, countries are ranked according to the redistributive impact of energy taxation.

Looking at Figure 7, we can appreciate that indirect taxes on energy products are inequality-increasing across the board, except from Romania where the effect is almost neutral. The strongest negative redistributive impact of energy consumption is observed in Italy and Germany, followed by Greece and Latvia. In the case of Germany, the regressivity of energy taxation seems to be the main driver of its redistributive effect, while for Latvia and Greece there is a combination of high mean incidence (explained by high consumption) and an about-average level of regressivity. On the other hand, Italy displays a prominent level of regressivity and incidence. When looking at the breakdown by excises and VAT, VAT appears to account for more than half of the redistributive effect. Moreover, excises on vehicle fuels and VAT on housing energy generally appear to have the largest redistributive impact. Excises on vehicle fuels tend to have the largest impact in Southern Europe, whereas VAT on housing energy tend to have the largest impact in Eastern Europe.

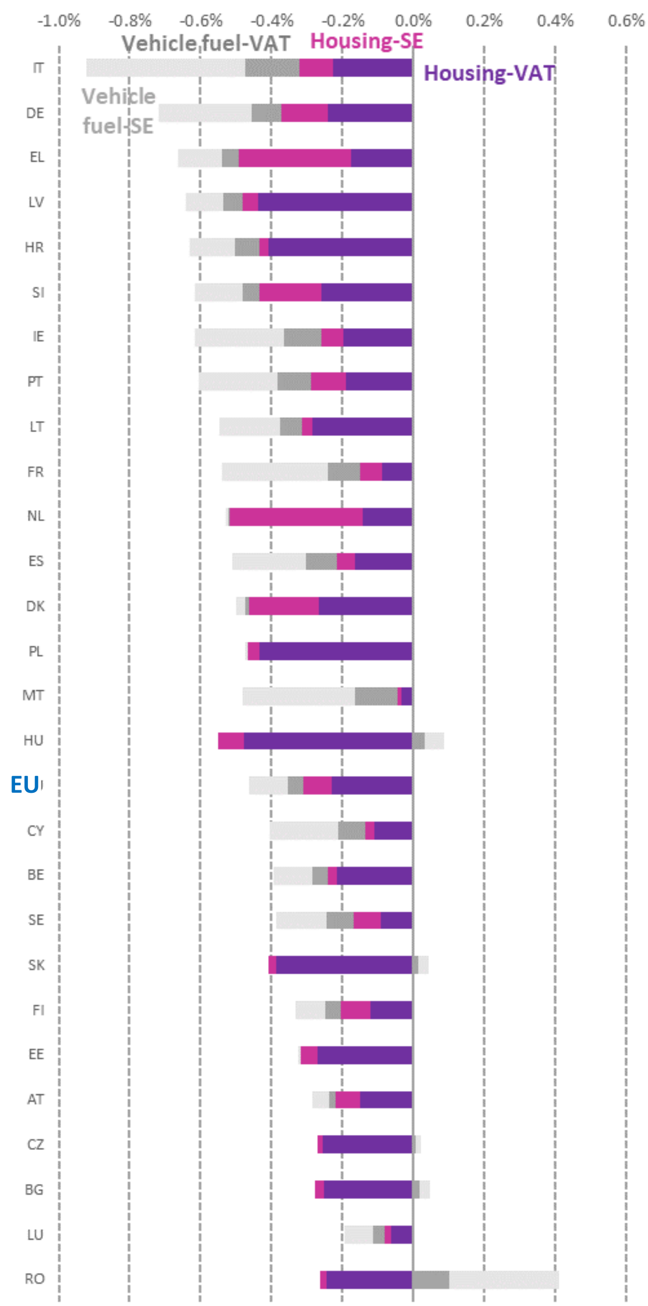
Finally, a few aspects of the redistributive effect of the taxation of energy products in the EU are worth mentioning. Firstly, there is a significant cross-country heterogeneity in terms of the drivers of the redistributive effect of energy consumption taxation. This can be appreciated in Figure 9, where we rank the EU Member States according to the metrics used in our study, i.e.: (i) the income share of consumption, (ii) the implicit tax rate over the energy bundle, (iii) the incidence of energy consumption taxation on household income (iv) its regressivity and (v) its redistributive effect. There we can see that some of the countries featuring the most regressive taxation (i.e., The Netherlands, Malta or Austria) are not among those with the highest redistributive effect, because of below-average mean incidence of energy taxation on household income. Conversely, there are countries with above-average income share of consumption and incidence of taxation (such as Poland, Hungary and Lithuania) but with relatively low negative redistributive impact, given low levels of energy taxation regressivity. Secondly, looking at the breakdown by product of the redistributive effect (see Figure D.1 in Appendix D), it emerges that on average the taxation on housing energy is the most unequalising in the EU. However, a few Mediterranean countries (Italy, Spain, Greece, Portugal, Cyprus, Malta) constitute an important exception displaying vehicle fuel as the main driver of the negative redistributive effect. Thirdly, when zooming-in on the analysis by energy products, see Figure 8 (where products are plotted according to their regressivity, redistributive effect and mean incidence), we can appreciate that most regressive components of energy taxation in the EU (solid fuels and liquefied hydrocarbons) are not those featuring the strongest negative redistributive impact (which are, in fact, vehicle fuels and electricity).

Figure 6. Regressivity of indirect taxes on households' consumption of energy products.



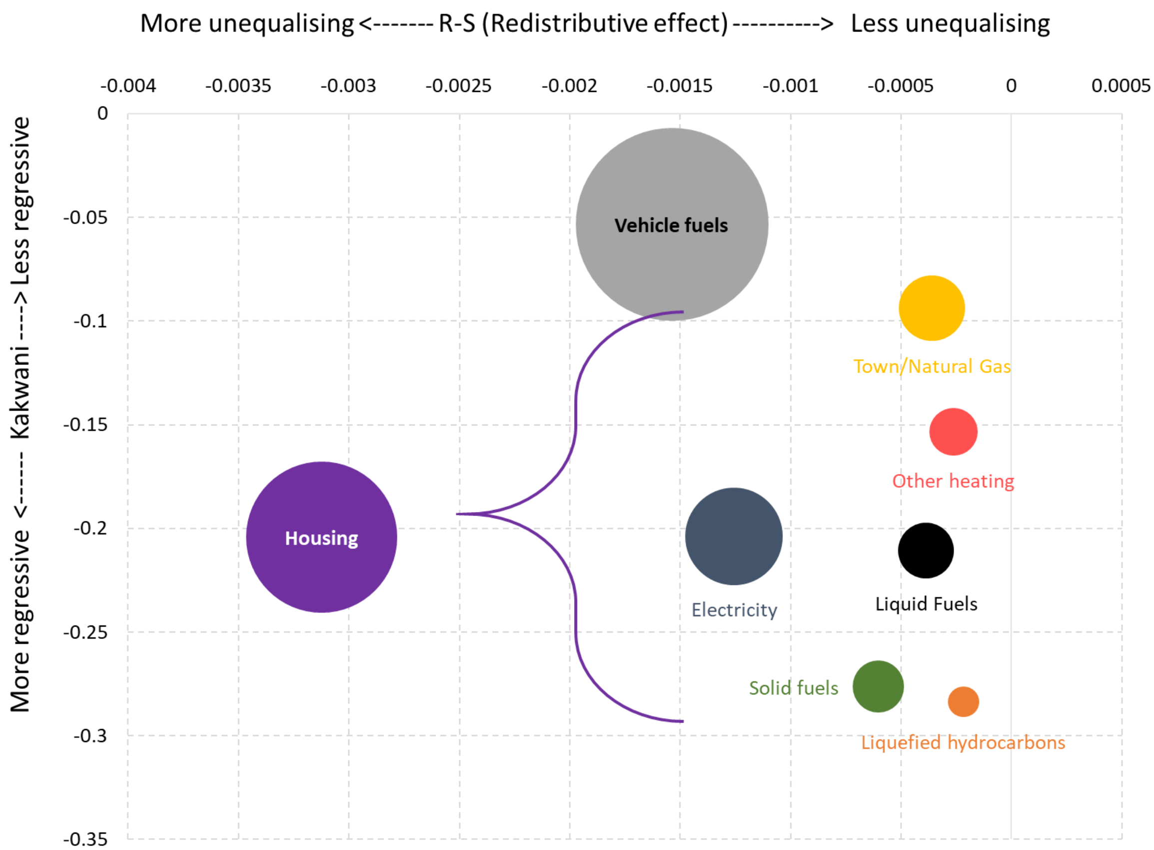
Note: A negative (positive) value of the Kakwani index indicates that the tax is regressive (progressive).

Figure 7. Redistributive effect of indirect taxes on households' consumption of energy products



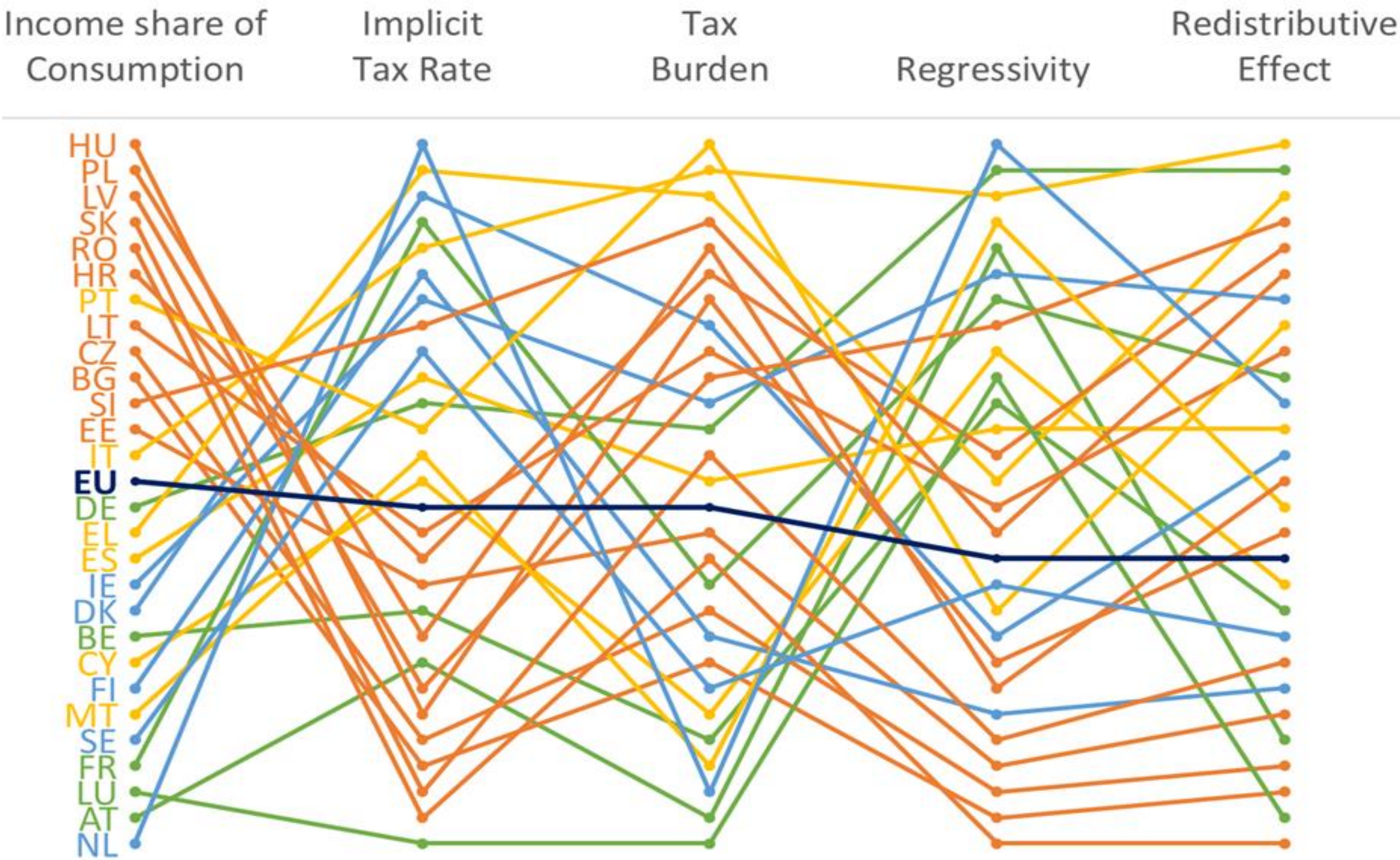
Note: The redistributive effect is measured with the Reynold Smolensky index (RS), which is calculated as the difference between the Gini coefficient of equivalent household disposable income (DY) before indirect taxes on energy products and the concentration index of post-tax income based on the pre-tax ranking of households. A negative (positive) value indicates that the redistributive impact is negative (positive), which means that the tax is inequality enhancing (reducing).

Figure 8. Regressivity, incidence and redistributive effect of energy taxation, by product, EU 2019.



Note: The Kakwani's index (vertical axis) measures the progressivity of a tax, such that a negative (positive) value indicates that the tax is regressive (progressive).

Figure 9. Ranking of Consumption share, Implicit Tax Rate, Incidence, Regressivity and Redistributive effect of energy taxation, EU 2019.



Note:For each indicator, the vertical axis represents the relative position of each country with respect to the rest of the EU. Countries with higher income share of consumption, implicit tax rate, degree of regressivity and inequality costs are higher ranked. Countries are grouped, by colors, according to regions: Central Europe (green), Southern Europe (yellow), Eastern Europe (orange) and Northern Europe (blue).

4 Conclusions

The taxation of energy consumption is a central topic in the current policy debate. On the one hand, energy taxation is a key lever for the achievement of the European Green Deal targets. On the other, the global energy crisis is causing dramatic increases in the price of energy products across the EU, raising calls for reducing their taxes to support households. Measuring the total incidence of taxation over energy consumption is therefore a crucial task to inform policy makers. While the regressivity of consumption taxes is well documented in the literature, there is limited evidence on the inequality-cost of energy consumption taxation across the Member States of the EU.

In this study, we use the Indirect Tax Tool of EUROMOD (ITT) to estimate energy consumption taxation on households in each Member State. The ITT is underpinned by an extended version of the EUROMOD standard input data featuring imputed consumption data from household budget surveys (mainly EU-HBS). Thanks to that, it can extend the scope of EUROMOD simulations (i.e., direct taxes, social contribution and cash benefits) modelling the indirect tax system in each country. Therefore, it allows estimating household tax liabilities on their energy consumption.

Our estimates indicate that the implicit tax rate of the energy bundle ranges between 60% and 20% in the EU. While rates vary significantly across countries, vehicle fuel (e.g., petrol and diesel) and liquid fuels (e.g., heating oil) generally attract the highest rates of taxation. At the other extreme, 'other heating products' (e.g., district heating) are usually the least taxed. Moreover, solid fuels (e.g., coal, biomass) are in various cases taxed in the low range despite their important environmental and health impact. While less polluting energy sources, like natural gas, are more heavily taxed. Energy consumption taxation is typically in the lower range in Eastern European countries where energy consumption represents a larger share of household income (up to 16.5% of household disposable income). On the other hand, a far less homogenous mix of Northern, central and Southern European countries features the highest overall implicit tax rates. However, while energy consumption is typically a lower share of household income in central and Northern European countries (in some cases less than 6% of household disposable income), it is less so in Portugal, Italy and Greece. As a result, these three countries display the highest incidence of energy consumption taxation over household income in the EU.

We then assess the regressivity and the redistributive consequences of energy consumption taxation. With the only exception of Romania, our estimates suggest that energy consumption taxation is regressive in all EU Member States. Regressivity is the strongest in the Netherlands, Italy and Germany. In these countries, households in the lowest deciles suffer a burden of energy taxation, which is between 2-3 times as large as one of the tenth decile. Consistently with the literature,[14] we find the taxation of housing energy to be generally more regressive than the one of vehicles fuel. This pattern is to be ascribed to a higher elasticity of income of vehicles fuel consumption, such that its consumption grows more starkly with income. Looking at the redistributive effect, taxes on energy consumption are inequality-increasing across the board, except for Romania where the effect is almost neutral. The strongest negative redistributive impact of energy consumption is observed in Italy and Germany, followed by Greece and Latvia.

In our analysis, we stress how the redistributive effect can be driven by rather different factors. For example, in the case of Germany, the regressivity of energy taxation appears to be the main driver of its redistributive effect, while for Latvia and Greece, it is a combination of high mean incidence (explained by a higher income share of consumption in the former and higher rates of taxation in the latter) with an about-average level of regressivity. A more extreme case is the one of Italy, which features a high level of regressivity and incidence. We therefore emphasise the importance of considering not only the regressivity of energy consumption taxation but also its relative share over household income. In fact, some of the most regressive systems (e.g. the Netherlands, Austria and Malta) are comparatively not much inequality enhancing, while other less regressive systems (e.g. the one in Greece) are rather inequality enhancing because of the high incidence of energy consumption taxation over household income.

Overall, our paper shows that a comprehensive characterization of the taxation of energy consumption across countries requires a careful consideration of both the rates of taxation and of the income shares of consumption. This is especially important in the EU, given that countries presenting the highest rates of taxation are often those featuring a lower share of energy consumption over household income. This means that the redistributive impact of energy consumption taxation is ex-ante ambiguous and its measurement is a

[14] See, among others, Vandyck et al. (2021) and Thomas and Flues (2015).

key task at a time of designing common tax policies to achieve climate targets. Finally, our estimates indicates that VAT represents about half of the total tax burden over energy consumption in the EU. This provides a compelling argument to account for VAT, together with excise duties, when measuring the taxation burden over energy consumption.

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Annexes

Annex A. Classification of Energy Taxes

According to Eurostat (Table A1), energy taxes are one of the four tax categories that compose environmental taxes (next to pollution taxes, resource taxes (exc. taxes on oil and gas extraction) and transport taxes). The energy tax base is a physical unit of something that has a proven specific negative impact on the environment but restricted to certain items concerning the energy sector (inc. CO2 taxes).

Table A1. Classification of Environmental taxes in Eurostat

Energy		
	Energy products for transport purposes	
		Unleaded petrol
		Leaded petrol
		Diesel
		Other energy products for transport purposes (e.g., LPG, natural gas, kerosene or fuel oil)
	Energy products for stationary purposes	
		Light fuel oil
		Heavy fuel oil
		Natural gas
		Coal
		Coke
		Biofuels
		Electricity consumption and production
		District heat consumption and production
		Other energy products for stationary use
	Greenhouse gases	
		Carbon content of fuels
		Emissions of GHG (inc. proceeds from emission permits recorded as taxes in the national accounts)
Transport (excluding fuel for transport)		
	Motor vehicles import or sale (one off taxes)	
	Registration or use of motor vehicles, recurrent (e.g., yearly taxes)	
	Road use (e.g., motorway taxes)	
	Congestion charges and city tolls (if taxes in national accounts)	
	Other means of transport (ships, airplanes, railways, etc.)	
	Flights and flight tickets	
	Vehicle insurance (excludes general insurance taxes)	
Pollution		
	Measured or estimated emissions to air	
		Measured or estimated NOx emissions
		Measured or estimated SOx emissions
		Other measured or estimated emissions to air (excluding CO2)
	Ozone depleting substances (e.g., CFCs or halons)	
	Measured or estimated effluents to water	
		Measured or estimated effluents of oxydisable matter (BOD, COD)
		Other measured or estimated effluents to water
		Effluent collection and treatment, fixed annual taxes
	Non-point sources of water pollution	
		Pesticides (based on e.g., chemical content, price or volume)
		Artificial fertilisers (based on e.g., phosphorus or nitrogen content or price)
		Manure
	Waste management	
		Collection, treatment or disposal
		Individual products (e.g., packaging, beverage containers, batteries, tyres, lubricants)
	Noise (e.g., aircraft take-off and landings)	
Resources		
	Water abstraction	
	Harvesting of biological resources (e.g., timber, hunted and fished species)	
	Extraction of raw materials (e.g., minerals, oil and gas)	
	Landscape changes and cutting of trees	

Source: https://ec.europa.eu/eurostat/cache/metadata/en/env_ac_taxind2_esms.htm

The OECD uses a less detailed classification (Table A2) in its revenue statistics and energy taxes are just considered within item *5121 – Excises* of its classification of taxes. See OECD (2021, paragraph 65) for details. On the other hand, the report Taxing Energy Use - TEU (OECD, 2019) considers specific taxes on energy use meaning explicit carbon taxes as well as excise taxes on fuel and electricity consumption but excluding emission permits subject to Emission Trading Schemes.

TEU generally does not cover:

- Tax expenditures or subsidies that operate through the income tax system (tax credits for alternative fuels or tax-deductible commuting expenses).
- value added taxes (VAT)

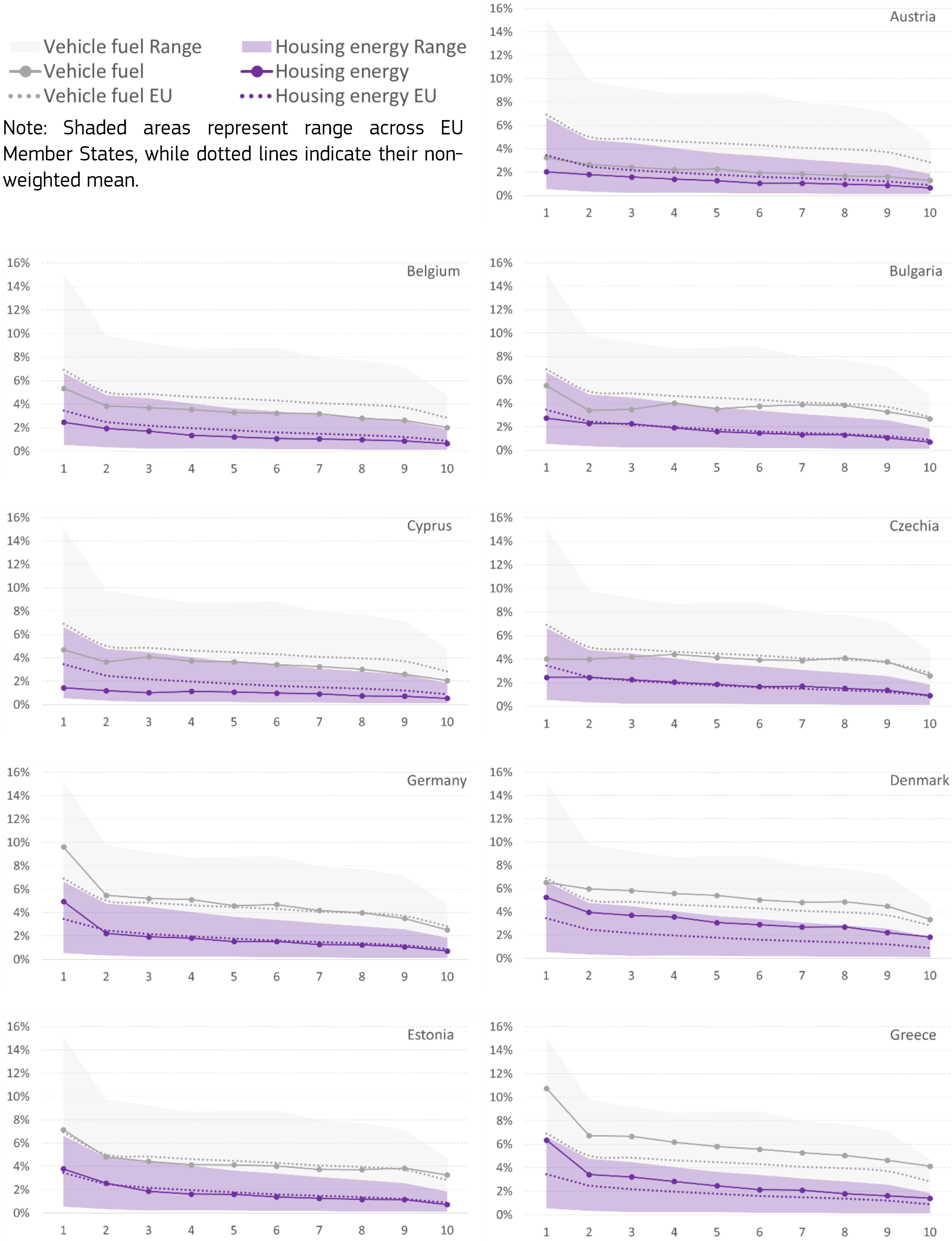
Finally, OECD (2014) considered the excise taxes and VAT but not specifically for energy products but for whole consumption. We will take this approach but focusing in energy consumption.

Table A2. Comparative classification of excises across different standards

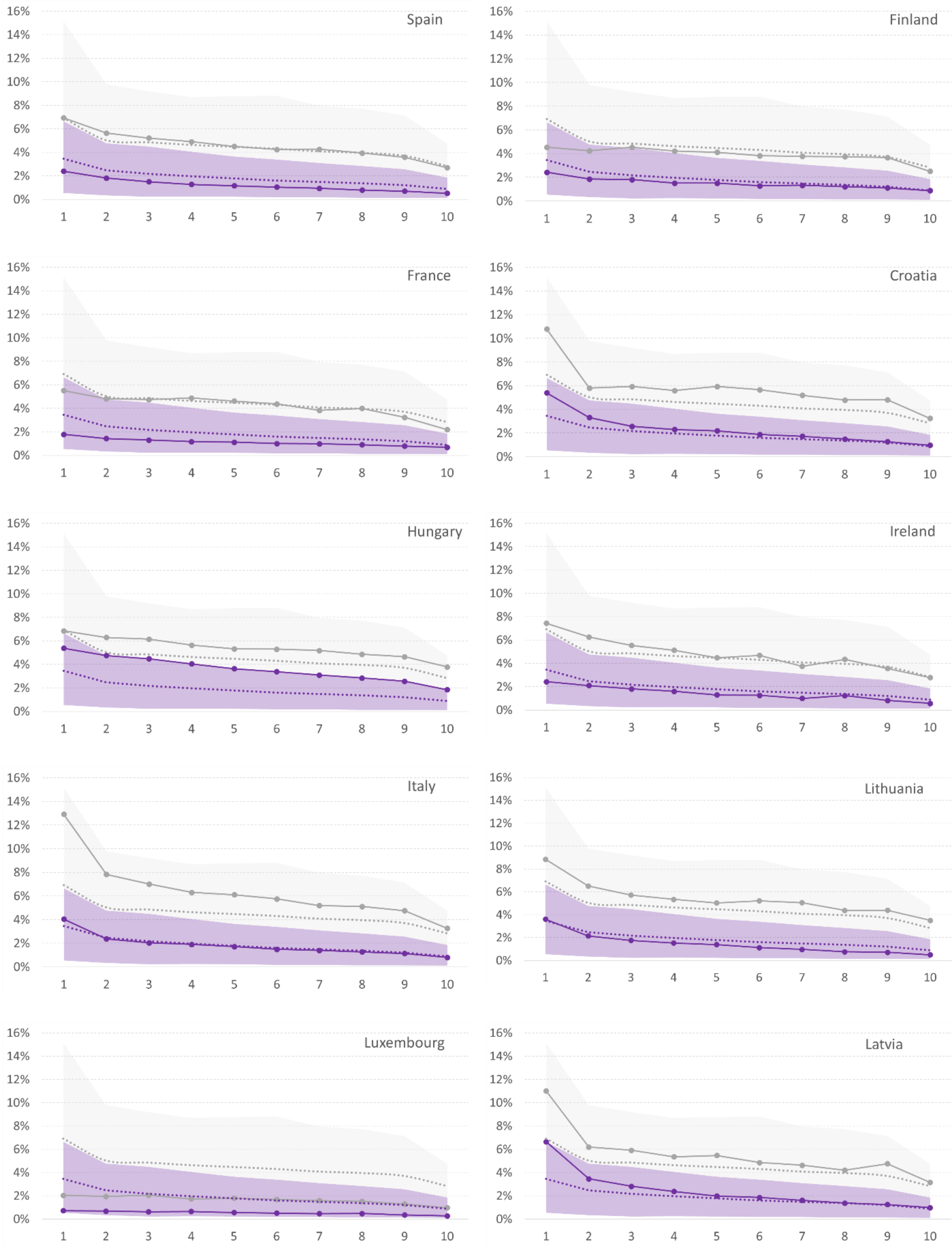
Standard		**SNA2008**	**ESA2010**	**GFSM2014**
Institution	**OECD**	**UNSD**	**Eurostat**	**IMF**
Excises	5121	D2122-7.94b; D214-7.96b	D21223; D214A, B, D	1142

Source: OECD (2021), excerpt from paragraph 93.

Annex B. Mean incidence (% household disposable income) of taxes on energy consumption by deciles of equivalised household disposable income, 2019 (housing energy vs vehicle fuel)



Note: Shaded areas represent range across EU Member States, while dotted lines indicate their non-weighted mean.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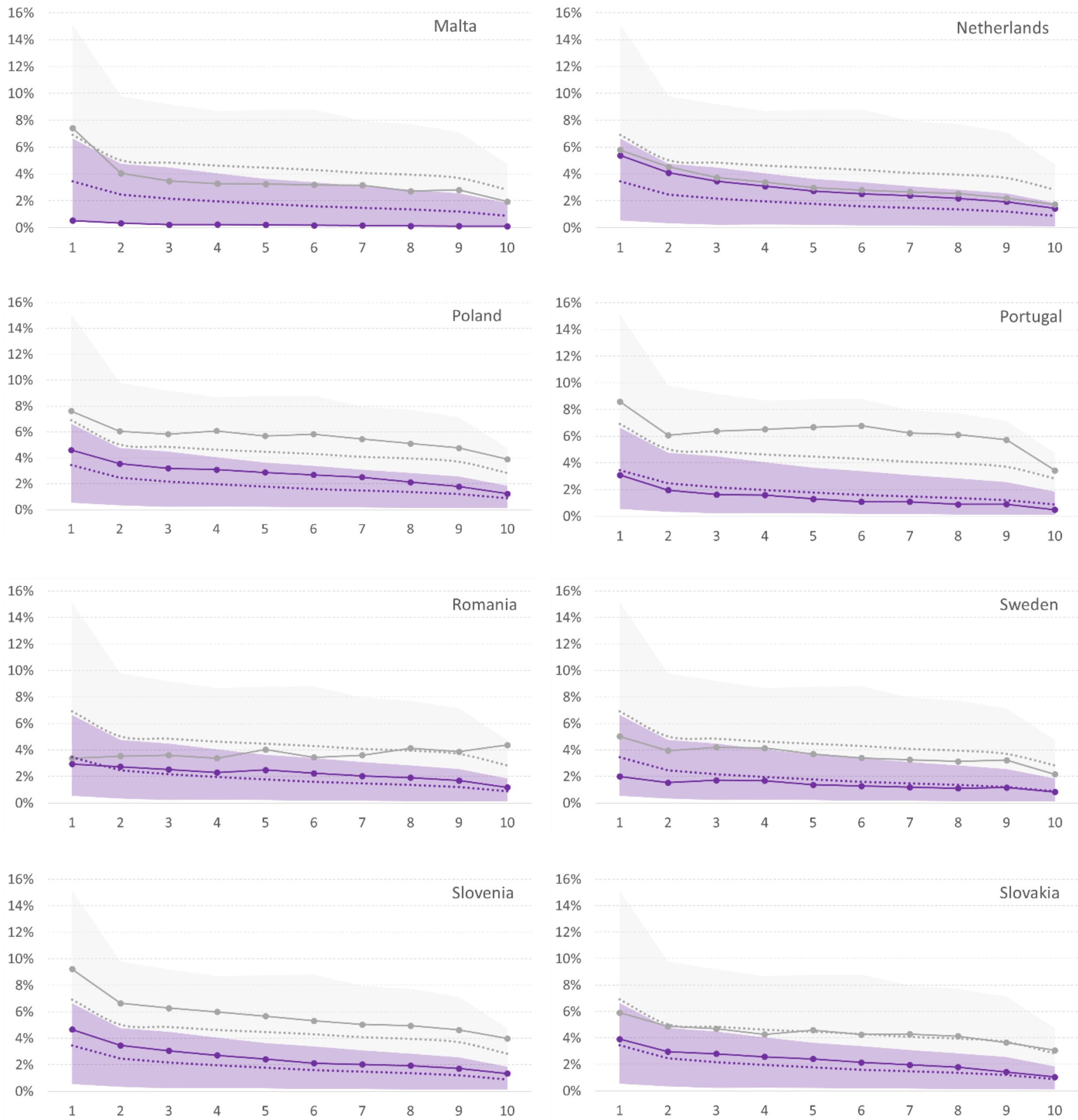
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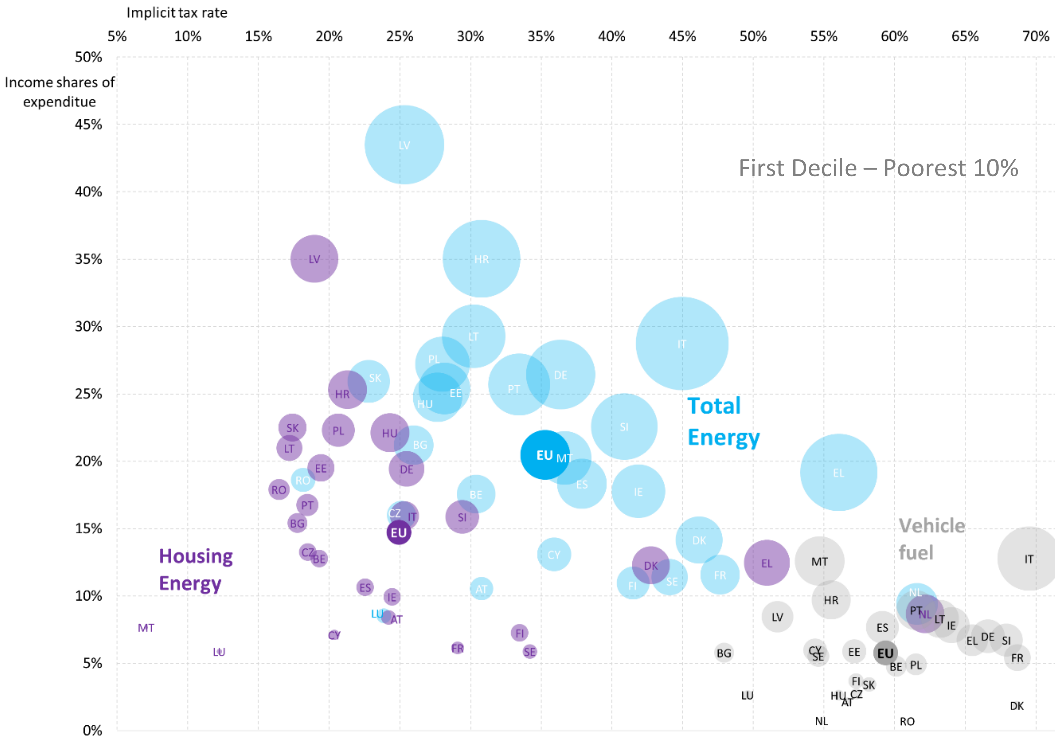
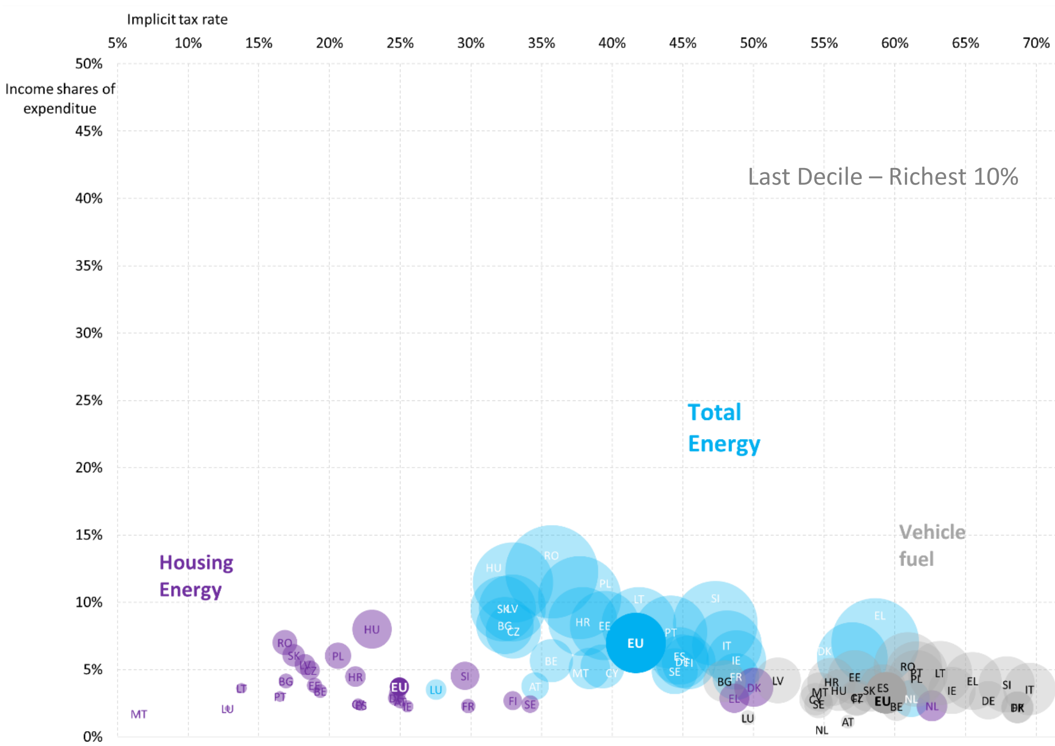
Appendix C. Mean incidence, consumption share and implicit tax rate by main energy product categories and decile, EU 2019

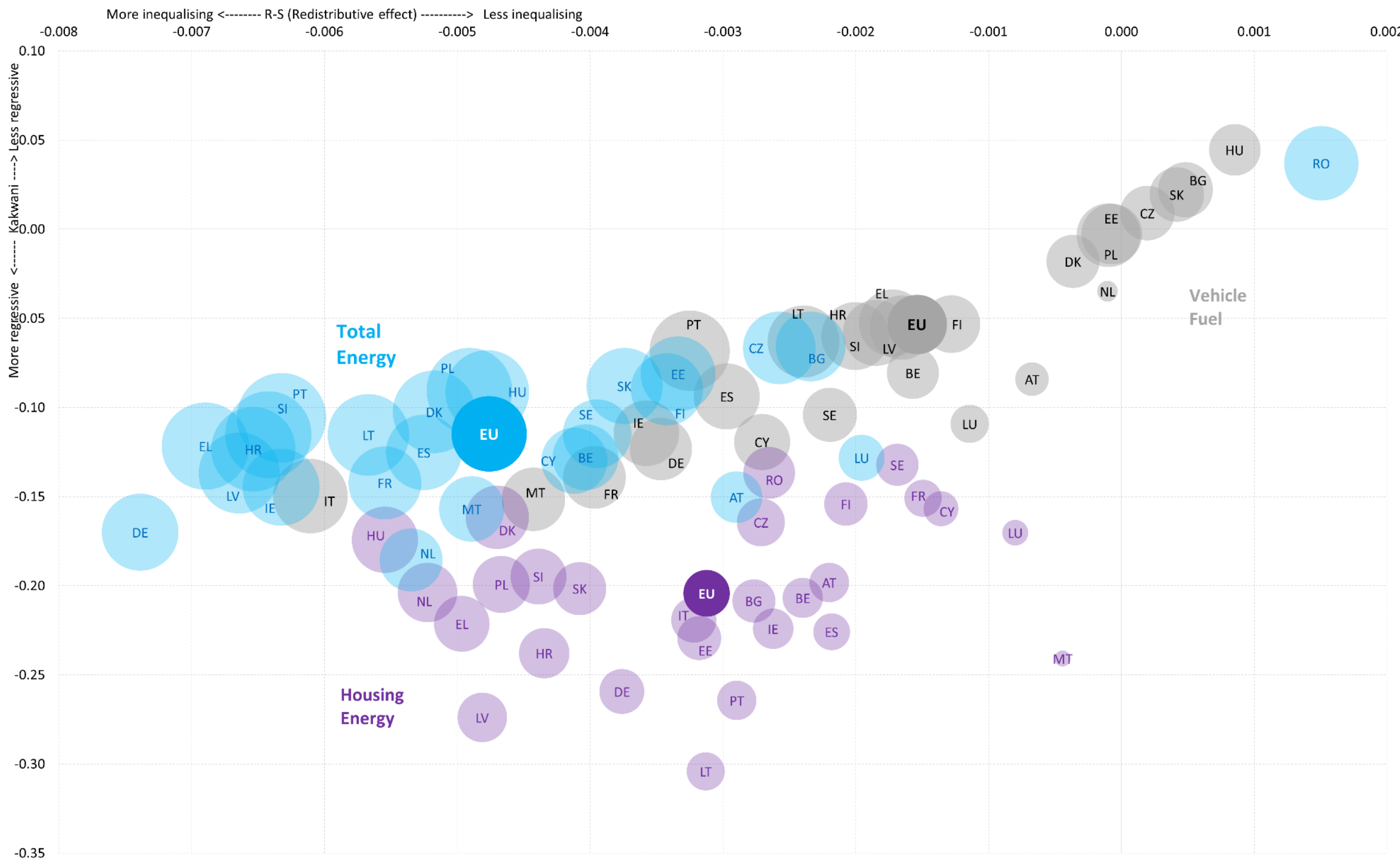




Note:Each bubble represents one Member State, while "EU" is the unweighted arithmetic EU average. The size of the bubble (area) represents the mean incidence (taxes over household disposable income). The horizontal axis reports the implicit tax rate (taxes over household consumption expenditures), while the vertical axis reports the income share of consumption (household consumption expenditures over household disposable income).

Appendix D. Mean incidence, regressivity and redistributive effect by main energy product categories and decile, EU 2019

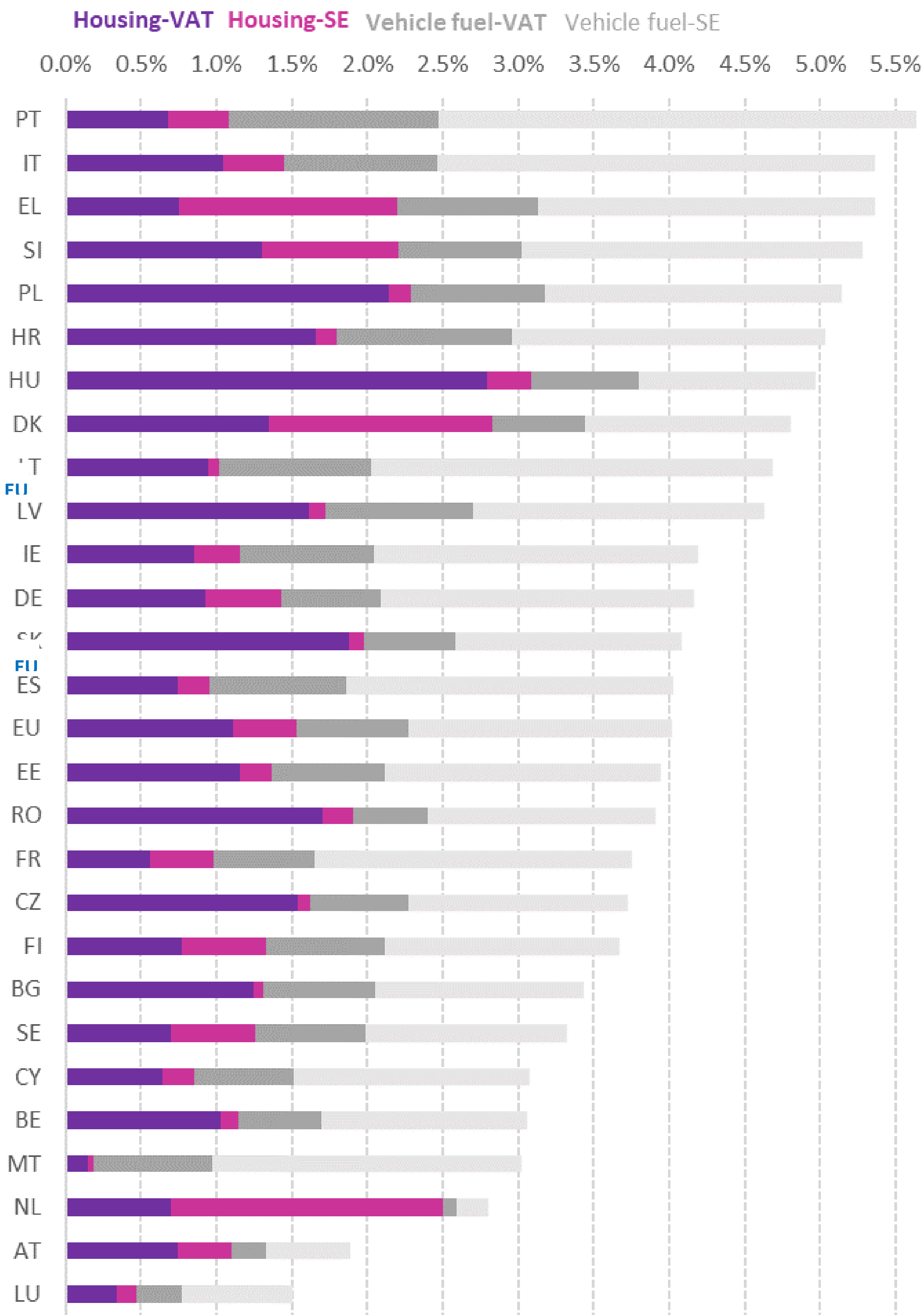
Figure D1. Mean incidence, regressivity and redistributive effect across the EU, 2019.



Note: The Kakwani's index (vertical axis) measures the progressivity of a tax, such that a negative (positive) value indicates that the tax is regressive (progressive). The redistributive effect (horizontal axis) is measured with the Reynolds-Smolensky index, which is calculated as the difference between the Gini coefficient of equivalent household disposable income before indirect taxes on energy products and the concentration index of post-tax income based on the pre-tax ranking of households. The mean incidence (size of the bubble) is the ratio of the total tax liabilities over the total household disposable income.

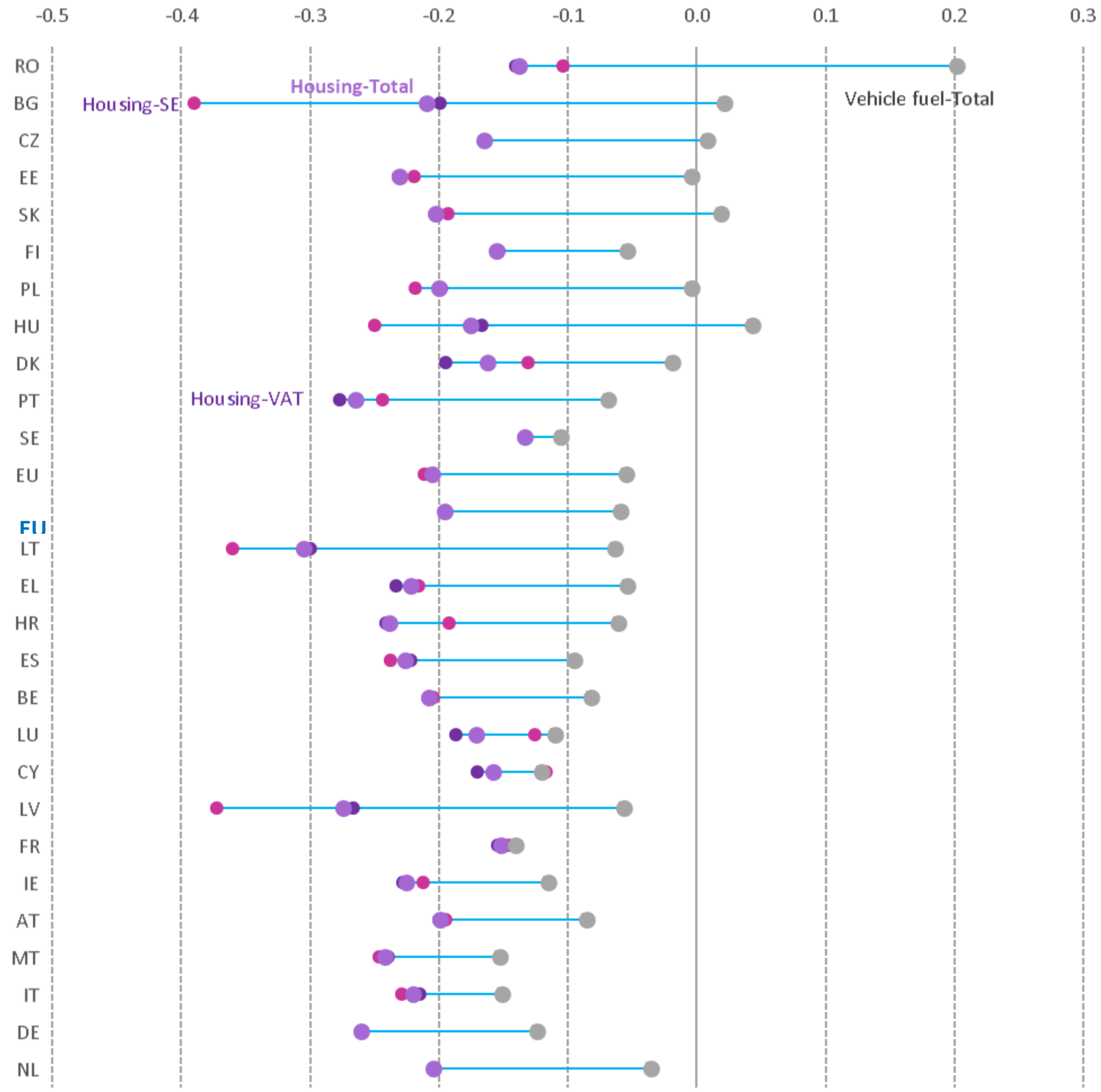
Appendix E. Breakdown specific excises / VAT (housing energy vs vehicle fuel)

Figure E.1. Mean incidence of energy taxation, by product, EU 2019.



Note:"SE": specific excises, "VAT" Value-Added Tax. Mean incidence is the average share of simulated total tax liabilities (VAT+excises) on household disposable income by Member State. "EU" is the (unweighted) mean.

Figure E.2. Regressivity of energy taxation, by product, EU 2019.



Note: "SE": specific excises, "VAT" Value-Added Tax. A negative (positive) value of the Kakwani index indicates that the tax is regressive (progressive). "EU" is the (unweighted) mean.

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