D4.6|Final report on social and cultural factors impacting energy choices and behaviour

Deliverable:	Final report on social and cultural factors impacting energy choices and behaviour
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Executive summary

The general aim of the ENABLE.EU project is to define the key determinants of individual and collective energy choices in three key consumption areas - mobility, heating & cooling and electricity - as well as in the shift to prosumption. Within this context, ENABLE.EU conducted a nationally representative survey among the population in the 11 project's partner countries – Bulgaria, France, Germany, Hungary, Italy, Norway, Poland, Serbia, Spain, Ukraine and the United Kingdom. The survey included five blocks of questions covering five topics (heating and cooling, mobility, prosumers, electricity and governance), plus a block of general questions. The questionnaire was designed in order to respond to the specific objective of cases studies on: Low Carbon Mobility**;** From Consumer to Prosumer, Heating & cooling. Participatory approaches were also used in these three case studies. This deliverable synthesizes the case study results and extends the research previously done in ENABLE.EU with an econometric analysis aiming at quantifying the relative importance of socio-cultural factors and attitudes in energy related choices, regarding mobility and heating.

Low Carbon Mobility case study

The Low Carbon Mobility case study was conducted in Hungary, Italy, Norway, Poland and Spain. This case study aims to: (1) better understand citizen's choices, habits and preferences regarding low carbon mobility and alternative transportation modes to private conventionally-fuelled cars; (2) identify key drivers and barriers, including political, technological and behavioural ones, for low carbon mobility and alternative transportation modes to private fuelled-cars; and (3) explore potential solutions and best practices to shift away from private conventionally-fuelled car dependence and reduce the negative impacts of transport on citizen's health and well-being, the climate and the environment. This case study reveals that weekly routine trips follow similar patterns across countries and that travel mode varies with the destination. Factors considered important and very important when deciding the travel mode are mainly safety, availability and reliability, while environmental impacts and reputation are the least valued. Carsharing is identified in most countries as a practical solution, although this service is developing differently from country to country.

From Consumer to Prosumer case study

The case study on Prosuming was conducted in Italy, Norway, Serbia, the UK and Ukraine. This case study provides a mapping of the prosuming as a phenomenon and the gender ideologies related to it. It aims to understand how the relations between gender, energy practices and choices may differ within and across households, as well as societies, and the implications this may have. It emphasizes the importance of producing knowledge that highlights social and cultural factors needed to advance people/gender sensitive policymaking, which can facilitate people's choice of investing in environmentally friendly energy solutions and practices. It points to relevant aspects such as feed-in tariffs, legislation and right to sell excess electricity, bureaucracy to become a prosumer that should be considered when designing energy policies and direct energy investments for prosuming in ways that are gender-sensitive, as well as socially, economically and environmentally sustainable.

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The Heating and Cooling case study

The Heating and Cooling case study was implemented in France, Germany, Hungary, Spain, and Ukraine. The aim of this case was to obtain better understanding of the factors that influence household behaviour related to heating and cooling. This case study found that European consumers are diverse in terms of behavioural habits heating requirements; financial resources that can be allocated towards low-carbon investment; housing conditions including insulation, home size, ownership; their preferences, willingness and motivation to change their habitual behaviour; their motivation for making changes; their beliefs and misunderstandings about low-carbon options. Still, most factors previously identified overlap in several countries and could be tackled with similar policy options.

A quantitative analysis of the factors influencing mobility choices

The quantitative analysis of mobility seeks to understand households' travel behaviour, and in particular citizens' choices on how to perform routinely trips. A model explaining households' choice of the travel mode has been developed to quantify the impact of different factors. Three travel modes are analysed: private vehicle, public transport and active modes. The factors used to describe these choices include considerations on the households' preferences, the characteristics of the trip and of the households as well as the specific country where the household lives. Through a multinomial logistic regression, the impact of these factors on the probability of choosing one mode or another has been quantified.

Results show that people tend to act consistently with their preferences. Seekers of comfort, flexibility, privacy and reliability seem to prefer the private vehicle to other modes, while those households concerned about the environment prefer active modes or public transport. Infrastructure, and in particular how its quality is perceived, is an important factor explaining the use of a mode or the other, particularly for workplace destinations. Moreover, socio-economic factors highlight groups for which targeted policies could increase the propensity to reduce private car use in favour of more sustainable transport modes. Families with children and fulltime workers, for instance, might be targets of interest. Finally, the policies to promote this transition should account for the presence of the country specific context, since this is also a significant determinant of households' travel behaviour.

A quantitative analysis of the factors influencing heating costs

The aim of the quantitative analysis on heating energy consumption was to identify relationships between heating expenses (as a proxi for energy consumption) and variables related to the energy choices of households. The analysis draws on data from the Heating and Cooling section of the ENABLE.EU household survey. Regressions for the five countries involved were performed using standardized monthly heating cost of households as dependent variable, while the explanatory variables were grouped into five categories: 1) variables related to household income, 2) external influencing factors, 3) knowledge and availability of information, 4) environmental awareness and 5) energy using behaviour, controlling also for the most important dwelling and household characteristics. According to the estimation results, neither objective nor subjective income (i.e. whether one finds it difficult to live with their income) status plays an important role as a determinant of heating bills. The only exception is Spain, where rich people tend to spend significantly more on heating, and subjective income also influences heating consumption even among people having similar income level. With respect to external barriers, we were not able to identify any general pattern in the five countries analysed. Regarding information barriers our results show that access to information plays

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an important role in case of Spanish households, while having a smaller effect in Hungary and Germany. The assumption that people who care more for the environment tend to reduce their energy consumption resulting in lower heating bills was partly validated: we identified such a pattern in Germany, France and to some extent in the Ukraine. Daily routines, in general, do not influence energy consumption significantly, only a slight effect could be detected in Spain, showing that bad routines can have a negative effect on energy cost savings. To conclude, we found evidence that factors other than dwelling and household attributes can influence heating costs to some extent, but the magnitude of their effects seems to be much smaller, and the impacts are very diverse in the different countries.

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1.General introduction

1.1 The ENABLE.EU project

The Energy Union Framework Strategy laid out on 25 February 2015 aims at fostering a cost-efficient energy transition able to deliver secure, sustainable and affordable energy to all European consumers. It has embraced a citizen-oriented energy transition based on a low-carbon transformation of the energy system. At the end of the day, the successful implementation of the Energy Union will materialise in a change in energy production and energy consumption choices. Such choices are heavily shaped by particular economic prerequisites, value systems, gender-based preferences, efficiency of governance and the maturity of civil society.

The ENABLE.EU project attempts to understand the key drivers of individual and collective energy choices, including in the shift to prosumption (when energy consumers start to become also energy producers). The project will develop participatory-driven scenarios for the development of energy choices until 2050 by including the findings from the comparative sociological research. As differences between European countries remain salient, ENABLE.EU will have a strong comparative component.

The final aim of this project is to contribute to more enlightened, evidence-based policy decisions, to make it easier to find the right incentives to reach the twin goals of successful implementation of the Energy Union and Europe's transition towards a decarbonised energy system. To reach this final aim, ENABLE.EU will seek to provide an excellent understanding of the social and economic drivers of individual and collective energy choices with a focus on understanding changes in energy choice patterns. Results will be disseminated to relevant national and EU-level actors as well as to the research community and a wider public.

ENABLE.EU is organized in 6 scientific Work Packages (WP) (WPs 2 to 7). WP 4 focuses on identifying attitudes towards the low-carbon energy transition in Europe, including through case studies. WP 4 used both participatory and quantitative methods to collect and analyse data. Results are based on respondents' answers and declarations.

1.2 Aim of this report

The aim of this report is twofold: it synthetizes the **five case study** deliverables developed within WP4 of the ENABLE.EU project and it presents **an additional econometric analysis** to quantify and estimate the relative importance of the main drivers of mobility choices and heating costs.

The previous deliverable associated to WP4 are:

- D 4.1: Final report on comparative sociological analysis of the household survey results
- D 4.2: Synthesis report on the "low carbon mobility" case study
- D 4.3: Synthesis Report on the case study "From Consumer to Prosumer"
- D 4.4: Synthesis report on the "heating & cooling" case study
- D 4.5: Policy paper with recommendations for 'triple dividend' low carbon options in the field of heating and cooling.

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2 The household survey results

2.1 Introduction

ENABLE.EU conducted a **nationally representative survey** among the population in the 11 project's partner countries – Bulgaria, France, Germany, Hungary, Italy, Norway, Poland, Serbia, Spain, Ukraine and the United Kingdom - aiming to address particularly the **public acceptance and attitudes towards the low-carbon energy transition** in Europe.

Although there have been numerous studies on the same topics in the last decade as the literature demonstrates[1], the ENABLE.EU survey is much more ambitious. It covers a large spectrum of **factors driving** both the **individual and collective** (e.g. on household level) **energy choices** and the respective behaviours, thus deepening the understanding of the recent constitution and combination of socio-cultural, economic, technological and governance factors that affect the everyday practices of the European citizens.

The survey covers four interrelated issues:

- Household's **socio-economic characteristics** (gender, age, income and education levels). Particularly the possible gender-based perceptions, value judgments and practices have been addressed for all the issues;
- Household's **energy needs and use** of energy in everyday situations (e.g., going to work, heating the home, using transportation) with a focus on the predefined three key consumption areas (heating and cooling, mobility and use of electricity) and governance and prosumers' issues;
- The **changes** undergone by individuals or households in the last years regarding their **energy habits**, energy consumption patterns and everyday energy practices or lifestyles;
- **External** (e.g. social norms, policies, and infrastructure) **and internal factors** (e.g. attitudes, values and beliefs), **affecting** as both drivers or barriers the individual and collective **energy choices** and the respective behaviours, thus giving some insights into possible cognitive and moral factors driving individual and collective decision making.

The survey results aim at addressing four out of the five project's specific objectives (SOs):

- SO1: Define the key **determinants of** individual and collective **energy choices** in three key consumption areas - transportation, heating & cooling, and using of electricity, and governance and prosumers' issues;
- SO2: Expand the knowledge of the **interactions** between the individual and collective energy choices;
- SO3: Increase understanding of the **social acceptability** of energy transition through a participatory foresight and assessment process engaging key stakeholders and selected households;
- SO4: Expand the knowledge of the **governance and social mobilisation practices**, which can foster collective energy choices towards the completion of the Energy Union.

In line with these specific objectives and the four interrelated issues to be covered, the survey addressed three main **research questions**:

- What are the main every day and long-term **energy choices** regarding the use of energy at home and everyday household activities, and how they differ among the countries?

[1] Final comprehensive literature review setting the scene for the entire study, D2.2, June 2017, online at http://www.enable-eu.com/downloads-and-deliverables/

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- What is the combination of **factors that influence** the **energy choices** on individual and collective (household) levels and how they differ across the countries?
- What are the characteristics, describing the vulnerable groups and the **groups** that have been less knowledgeable and **less involved in the energy transition**?

The survey was organised on **six** separate but inter-related **blocks of questions:** one block for each five key area - heating and cooling, low-carbon mobility, shift to prosuming, use of electricity, and governance – and one block for general questions. The general block covers all 11 countries, while the thematic blocks only cover those countries that are included into the respective five case studies (i.e. low-carbon mobility, shift to prosuming, heating and cooling, use of electricity and governance). The survey allows both in-depth analysis of country specifics and cross-country comparisons.

Table 1: Country coverage by key areas (block of questions) in the survey questionnaire

	BG	FR	DE	HU	IT	NO	PL	RS	ES	UA	UK
General questions	X	X	X	X	X	X	X	X	X	X	X
Mobility questions				X	X	X	X		X		
Shift to prosuming questions					X	X		X		X	X
Heating and cooling questions		X	X	X					X	X	
Use of electricity questions	X		X					X			X
Governance questions	X	X	X	X		X	X	X		X	X

2.2 Interpretation of survey results

2.2.1 Overview of the results: energy choices of EU citizens and cross-country differences

The results show large differences between countries in relation to the way of living and energy use.

Housing, heating and cooling

Housing

The vast cross-cultural differences between the survey countries become evident as soon as the type of dwelling is considered. Living in single-family houses (both detached and attached to other houses) range from nearly 75% in Hungary and 79% in the UK to only 27% in Spain and 36% in Italy. More than half of the British respondents (57%) live in single-family house attached to other houses, while a large part of Spanish respondents (47%) live in buildings with 2 to 5 flats. The disparity between individual energy choices begins as early as the type of dwelling, which is among other factors also driven by cultural, urban and architectural differences. There is a strong link between the type of dwelling, its size (e.g. single-family houses being overall larger than apartments) and the household energy behaviour. Living in the largest category of dwelling (more than 120 m2) ranges from 41% of the population in Norway to only 4% of the population in Ukraine, where 58% of population live in dwellings smaller than 65 m2.

When it comes to average age of the dwellings, cross-country comparison clearly distinguishes between different sub-groups of countries. Germany, France and Norway have more than 30% of people living in dwellings built after 1990, while in Bulgaria and Hungary the respective shares account for 9.8% and 12.5% of the population, respectively. The UK has the biggest share of oldest dwellings (46.4% built before 1970s), Spain is in the middle and Italy has a pattern very similar to the East European countries' group. In the Central

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and Eastern European (CEE) countries (Serbia, Ukraine, Poland, Hungary and Bulgaria) the dwellings built during the socialist period prevail (i.e., before 1990s), while the Western European countries exhibit diverging patterns.

The age of the dwelling could be considered as one of the important indicators of its energy efficiency, but it is by no means the only factor determining the energy bills. Renovated old houses are much more energy efficient in terms of heating and cooling than the poorly insulated large blocks of flats built between 1970 and 1990 in many of the post-communist countries. Insulation is very common in Norway, the UK, Germany and France, where the majority of the population lives in dwellings having at least one sort of additional insulation. In the CEE countries like Ukraine, Hungary, Serbia and Bulgaria, 50% to 68% of the population reports having no additional insulation in their dwellings (Poland is an outlier since, despite being part of the CEE countries, external wall insulation is very common). Countries with warmer climate such as Spain and Italy have similar shares of the population without any insulation.

In most of the countries, more than half of the households predominantly rely on a single type of energy source for heating. Only in Norway and in the UK, the majority of households rely on two or more types of energy sources for heating.

Among the countries with a single energy source type, district heating is more common in most of the Central Eastern Europe (CEE) countries (Serbia, Poland, Ukraine, and Bulgaria). Natural gas from a central source is a very common source of heating in Germany, Italy and Hungary (over 45%), and arrives as second source in Spain, Ukraine, France (over 20%) and Poland (11%). It is also the most common choice (19%) for UK households who use a single energy type for heating. Electricity is largely used as a single source for heating in Spain (39%), Bulgaria (28%), France (25%) and Norway (25%). Finally, 33% of Serbian households rely on wood for their entire heating (this explains why a large share of Serbian households do not have precise control over the temperature in their homes), followed by smaller shares in Bulgaria (17%) and Hungary (16%). Poland is the only country where coal is used as a preferred single energy source by a considerable share of households (i.e. 10%). The country also has the highest share of households using district heating which partially relies on coal for heat generation.

When adjustment of the temperature is possible, most of the households tend to use this option and prefer adjusting the temperature either manually or automatically. The latter is most common in the UK with 44% and in Germany with 40% of people adjusting the temperature automatically, followed by France with 27%. Generally, less than 1/3 of households prefer to set a constant temperature in the heated parts of the dwelling without dynamically adjusting it. Norway is an exception with as much as 39% of households following the same strategy. This could be explained by the lower and more constant average external temperature during the heating season, which makes the adjustments less necessary. The country, where the adjustment of the temperature at home is most widespread is the UK.

Electricity and gas smart meters are generally more common in Spain (69% of households), the UK and France but as a whole are not widespread yet with the exception of electricity smart meters in Spain. The reasons for not having smart metering system at home vary from country to country with the cost being mentioned as too high by 56% of the Ukrainian respondents who do not have smart meters and by one-fourth of those in Bulgaria, Hungary, and Spain. Another reason (particularly widespread in Hungary, Serbia, and Spain) is that utility companies have not yet adopted smart meters. A large share of respondents in most countries (more than a quarter in all countries but Hungary and the UK) are not aware of whether they can use smart meters at home. When it comes to the negative perception of smart meters, data misuse and privacy violation are mainly a concern in Germany, the UK, followed by France and Bulgaria. Mentions of fear for

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health remain rather limited, with French respondents being the most reluctant (11.9%). In several countries, significant percentages of the population do not know whether they have smart meters or not.

Electricity usage

The use of electrical appliances varies considerably from country to country. Differences could be explained to some extent by factors related to climate, cultural and economic reasons.

Due to the large cross-country difference in owning different electrical appliance, it is very difficult to compare the average age of appliances in the different countries. The three most widespread and with the highest energy consumption electrical appliance types are compared across countries in terms of age of the units owned by the households: TV, air conditioning, cooker, fridge, and washing machine.

The countries where households have the smallest share of older appliances (more than 10 years) are the UK, Norway, France and Germany. Households in Spain (1st), Serbia (2nd), Hungary (3rd) and Italy (4th) have the largest share of older appliances. Given the GDP of countries in the list, one possible explanation of Spain's households using the oldest electrical appliances could be some cultural reasons. It should also be noted that larger share of the households in Ukraine report not having an electric cooker or oven (47%) and a washing machine (9%), making their results not directly comparable with other countries (in average 1%). The main reason is the use of gas cookers that are the most widespread type in this country.

In term of newest appliances, Germany is at the first place with 41% of the cookers, 44% of the fridges and 40% of the washing machines being up to 3 years old; followed by the UK.

Using dishwashers varies considerably from country to country. The newest appliances are again in Germany. They are followed by Norway (33%) and France (26%).

Large shares of respondents do not own portable electric heaters – from 86% of the surveyed Hungarians to 38% of Norwegians. Citizens in Bulgaria often tend to purchase less efficient and very cheap portable heaters, which could explain the relative high percentage (16%) of new appliances in this category for Bulgaria. The usage of electrical water heaters varies a lot from country to country and is very common in Germany.

Air conditioning usage also varies a lot across countries with Bulgaria and Serbia leading with the newest appliances "up to 3 years old". In terms of TV sets (home theatre systems) Germany again reports having the newest appliances with 54% of the households having a TV that is up to 3 years old. The oldest TV sets are reported in Ukraine, where 34% of the households have TV sets older than 10 years.

In terms of energy efficient bulbs, over 80% of households in France, Spain, the UK, Italy and Poland have at least half of their electrical bulbs that are modern and energy efficient. For at least 60% of households in these countries and in Norway, most or all the bulbs are energy-efficient. On the other hand, the largest percentage of households that have no energy efficient bulbs is in Serbia (50%). Bulgaria, Ukraine and Hungary follow with about 20% of the households that have none of their light bulbs replaced with ones that are more efficient.

While there are certainly economic drivers behind the choice of more energy efficient appliances in the household, there are cultural differences too. While Germany is the leader in percentage of newest appliances, it tends to fall behind in terms of energy saving light bulbs. While Spain has the oldest electrical appliances (cooker, fridge, washing machine), they tend to invest in energy efficient light bulbs more often than most of the other countries.

These results suggest that the behaviour of energy users could be potentially influenced by information campaigns, which could convince a household to make the small extra step.

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2.2.2 Individual attitudes towards the environment and energy policies

General attitudes towards environmental issues are positive with the exception of Spain, where 73% of the population think that environmental problems are usually exaggerated. More than half of the respondents in Ukraine, Serbia, Italy, and Poland agree with the optimistic statement that environmental issues will be resolved through future technological progress. Respondents in Germany and Norway are much more sceptical about it (less than 23% agree).

Most people tend to demonstrate attitudes towards personal involvement in dealing with environmental issues. Among respondents less willing to do anything about the environment if others do not do the same, the largest shares are in Poland, Italy, Serbia and France, (between 26% and 39% of the respondents). The percentage of respondents agreeing with this statement in the other seven countries is between 12% and 18%.

Those who would not make any compromise in their lifestyle for the benefit of the environment are less than 20% in most of the countries, and only in Poland do they represent 24% of the population. Answers change dramatically when practical policy measures that could cost the citizens extra money are discussed. The vast majority of the citizens agree that such policies should not cost them extra money. The highest shares are in Spain and Italy (85%-86%), while the lowest is in Norway (57%).

When policy priorities are discussed, energy prices and their regulation are very important for large shares of the population in most of the ten countries (over half of respondents, with more than 80% of Bulgarians and Germans). The development of clean energy sources is considered a priority by more than half of the population in France, Germany, Ukraine and the UK and by 44% of the Hungarians and 40% of the Serbians and less than 30% of Bulgarian respondents. Energy efficiency of private and public buildings is mentioned less often as a major policy priority for the country. This answer was given by 26% to 56% of the people, with the highest share being in the UK and the lowest in Hungary. Finally, full liberalization of power markets and phasing-out of nuclear power plants are seldom mentioned: in most of the countries, less than 20% of the respondents mentioned these answers with the exception of 23% of the Serbian supporting market liberalization and 29% of the French considering that nuclear phase-out should be a policy priority for their country.

When it comes to public funded programs, subsidies or financial incentives for introducing or implementing environmental measures, less than 20% of the population in the ten covered countries report participating in (using) such programs. This share is highest in France, followed by UK, Norway and Germany. The lowest shares are reported in Serbia and Hungary, with less than 2% of the population using public funding or financial incentives for any of these environmental measures. On the other hand, more than 10% of respondents in France, the UK, Ukraine, Norway and Bulgaria benefitted from programmes or subsidies aiming at improving energy efficiency.

When assessing the effectiveness of different national policies related to energy, respondents in the nine countries tend to give average or below average scores, especially people in Ukraine, Germany and Serbia tend to be rather dissatisfied with the effectiveness of these policies, while in Norway, Poland and the UK, they give slightly higher scores for effectiveness. The most effective policies on average are “increasing the share of energy generated by renewable energy source” and “improving the energy efficiency of the residential sector”, while “mitigating the effects of climate change” receives generally the lowest scores.

With regard to purchase of equipment, energy efficiency was reported as being a primary factor for choosing a particular item by 80% of the respondents in Germany. Interestingly, while Norwegians seem very

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concerned with the environment, in this question they are second to last with 41% who considered the energy efficiency of their new household appliances. The reason could be rather economic in the case of high-consumption appliances or cultural in the other cases, than environmental concerns. Long-term decrease in electricity bills might be less important for Norway than for other countries. Still, the trend clearly shows that respondents from richer countries tend to focus more on the energy efficiency of their appliances. In Germany, in particular this is also clearly visible in the highest share of households with new appliances, less than 3 years old.

Respondents in Hungary, Italy, Norway, Poland and Spain are generally supportive of government actions related to the improvement of the transportation system. The most supported actions with highest scores involve reducing fares and improving quality of the public transportation, regulating standards of manufacturing, reducing emissions through enforcing new standards for manufacturers and expanding the existing road infrastructure. Naturally, measures affecting people's lifestyles and higher taxes are by far the least supported action.

In terms of country differences, Spanish citizens are generally the most supportive while Hungarians tend to be the least supportive of governmental actions in the transportation system, with the exception of building new roads, which might be supported for other reasons than concern for the environment.

Among the population in the ten covered countries[2], the share of people who have not undertaken one of the four suggested actions[3] is highest in Serbia (58%), followed by Bulgaria and Ukraine with 46% of the population. The respective share is considerably lower in the UK, France and especially in Germany and Norway where almost no one answered that they have not undertaken any of the four measures aiming at decreasing the environmental impact.

2.3 Conclusions

The survey results confirm the existence of vast differences among the studied 11 countries, which are results of the different combination of socio-cultural, economic and technological factors that influence both the experience and the attitudes of the people.

In general, the survey results pointed out to the extreme diversity of the countries regarding the experience and the attitudes that drive the energy choices on both individual and collective level. In the following sections, we provide research findings in three different energy consumption areas – i.e. mobility, prosuming and heating & cooling.

[2] Bulgaria, France, Germany, Hungary, Italy, Norway, Poland, Serbia, Ukraine, United Kingdom. Only Spain is not covered.

[3] The actions listed as options in the question are:

- You have bought a new car and its low fuel consumption was an important factor in your choice
- You regularly use environmentally-friendly alternatives to using your private car such as walking, biking, taking public transport or car-sharing
- When buying a new household appliance e.g. washing machine or fridge, you choose it mainly because it was more energy efficient than other models
- You have switched to an energy supplier which offers a greater share of energy from renewable sources than your previous one

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3 "Low carbon mobility" case study

3.1 Introduction

Mobility is an essential aspect of current society. **Private car** is the main mean of transportation in many European urban areas. Petrol-fuelled private vehicle use is causing several problems. One of the most important is connected to the **environment,** where transport is generating externalities with respect to climate and local air pollution. Moreover, road transport in cities is the cause of problems connected to quality of life such as **congestion** and **noise**. The high presence of private vehicles also requires a high share of urban space to be dedicated to cars, which could otherwise be used differently. Furthermore, a high presence of vehicles on the streets is harmful to society increasing the **risk of accidents** and causing **health problems** due to local air pollution.

This drives the need for lowering carbon intensity of road transport. In principle, this can be achieved in two ways: by **reducing the amount of emissions** produced by the vehicles involved, or by **changing people's travel behaviour** towards more sustainable mobility. The first group includes fostering alternatives (hybrid and electric vehicles) and developing measures to make them competitive with respect to the conventionally fuelled ones. In the second group, the main objective would be to change the current paradigm towards collective and shared mobility.

3.2 Methodology

To contribute to enabling the transition towards low carbon mobility, the project ENABLE.EU carried out a Low Carbon Mobility case study in Hungary, Italy, Norway Poland and Spain. A **mobility household survey** to a sample size representative of national population and a series of in-depth **interviews** were carried out.

3.2.1 Mobility Household Survey

The mobility household survey was conducted in order to **understand** citizen travel behaviour, travel mode choices, the main factors influencing the mode choice, and the use of mobility related services such as bike-sharing and carsharing on a national scale. It also aimed at analysing research findings in the sector and exploring **potential solutions** that can contribute to changing current mobility patterns.

The mobility survey was implemented in Hungary, Italy, Norway, Poland and Spain. It was conducted face-to-face in Hungary, Italy, Poland and Spain, an online in Norway.

3.2.2 In-depth interviews

The analysis of potential solutions focuses on shared mobility and, in particular, **business to consumer (B2C) carsharing**. B2C carsharing consists of **renting a car for a short period of time**, at a cost directly related to the usage of the vehicle. Carsharing could contribute to reduce the carbon intensity of the urban transport sector by complementing lack of public transport and providing an alternative to private car dependency of households. It can also contribute to reducing the bias in evaluating the cost of a car trip as it connects the price to the use of the vehicle. Moreover, it can be a tool to spread new and environmental-friendly technologies such as Battery Electric Vehicles (BEVs) and other alternative fuelled vehicles, as well as new vehicles with high fuel efficiency standards.

Carsharing business models can mainly differ in two aspects: the type of journey and the parking system. With respect to the type of journey, we can distinguish between one-way and round-trips. With regard to

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the parking system, we can divide the models between free-floating and station-based. In general, round-trip carsharing operates under a station-based system, while one-way carsharing operates under a free-floating scheme. However, other mixes of these two options exist.

In our carsharing study, we seek to provide a snapshot of the development of this sector in the participating countries, by interviewing both stakeholders and carsharing users. By comparing the results from different countries, we derive insights on the current practices and policies recommendations. With this aim, face-to-face and by phone semi-structured in-depth interviews with *emblematic households* and *stakeholders* were conducted. The topic focused on shared mobility and in particular on the carsharing sector with an emphasis on the role of electro-mobility, as well as the relation with public transportation and private vehicle ownership.

The *emblematic household* interviewees were selected from among carsharing users. In the case of *stakeholders,* interviewees were selected among three groups: the business sector, the public administration and pressure groups. The aim of the interviews was to depict the current development of carsharing in the country and to understand what may facilitate its development both at political and social levels.

3.3 Mobility household survey results

Household usual travel behaviour was analysed with respect to a typical week and the most usual way of travelling. Five specific destinations/trip purposes of the weekly routine have been investigated: journey to work/university, going grocery/other shopping, to recurrent leisure activities, to take children to school and to their recurrent activities.

3.3.1 Frequency at which households travel to destinations

The pattern of answers is relatively similar within the countries in terms of frequency. The trip to the workplace/university is performed at least once a week by about 50-60% of the respondents, apart from Norway where the level reaches 75%. For those who travel weekly to that destination, the average frequency is around 5 days per week in all countries, making it the most frequent trip. Grocery/shopping is the destination that shows the highest value of share of population in each country, around 90%. On average, the trip is taken around 3 times per week. Recurrent leisure activities are the destinations that present the highest variability across countries. Some differences are also shown in the frequency of the trip that hits its highest level in Spain at 3.5 days per week and its lowest frequency in Hungary at 1.8. The average frequency in Italy, Norway and Poland ranges between 2.5 and 3 times per week. Finally, destinations related to children's school and their leisure activities are fairly similar across countries. The former shows population shares that range between 17 and 20% and is performed between 4 and 5 times per week. The latter ranges between 10 and 22% of the population and is taken between 2 and 3 times per week.

3.3.2 Distribution of destinations

The distribution of destinations between different areas (*urban*, *periphery* and *countryside)* vary from country to country. Common to all countries and destinations is the prevalence of urban areas. The only exception is household locations in Italy and children's school locations in Norway, where the periphery of urban areas predominates.

In Hungary, most of the trip destinations of the respondents are located in urban areas (77%-83%) followed by the countryside (10%-30%) and peripheral areas (below 7%). There is a slightly higher share of households living in the countryside (30%), while the share for other locations is between 10% and 20%.

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In Italy, answers were quite similar for all destinations with the exception of household location, where half of the respondents stated they lived on the periphery of an urban area, while 37% stated inside the urban area and only 13% gave countryside as the answer. Additionally, urban area is highly prevalent in the other locations ranging between 68% and 76%, followed by periphery between 20% and 30% while countryside scored less than 5%.

Norway is the country where there seems to be the highest variation between the different areas. Still urban areas is the most answered location for most of the destinations but never reaches 50% of the answers as in the other countries, with the only exception being workplace locations (63%). Periphery of urban area ranges approximately between 30-40%, while countryside between 15-30%.

In Poland, urban area is still the most recurrent answer for each location, especially for leisure activities, children's school and grocery shopping. Peripheral areas are marginal especially in children's school and activities, and household locations. While countryside reaches the highest level of 40% for household location and the lowest of 4% for workplace location with the share in the remaining location ranging between 12% and 23%.

Very few respondents answered countryside in Spain, although this may be due to a miscomprehension of the translated term "countryside". The vast majority of the locations are set in urban areas while periphery of urban area also got a low rate of answers at around 6-7% with the lowest value in household locations (1%) and the highest share in workplace/university (18%).

3.3.3 Travel modes used to reach destination

With the exception of Spain, where active modes (bicycle and walking) present the highest share (around 60%) for most of the destinations, private vehicles seem to dominate in most of the recurrent journeys in the other countries in terms of time spent to travel. Overall, the trip to workplace/university shows the highest rate of time spent travelling by public transport, followed by children's school and leisure activities, while the lowest levels are shown for the grocery/shopping and children's activities destinations. In this case, there seems to be greater variability between different travel destinations rather than countries. In most of the cases active modes represent the second mode of transport in terms of time spent after private vehicle, with the exception of the journey to workplace where these values are lower compared to public transport ones.

3.3.4 Elements affecting choice of travel mode

In almost all countries, factors of **safety**, **reliability** and **availability** have been considered a priority, followed by the **travel time**, **cost, flexibility** and **comfort** factors. Factors related to **reputation, privacy** and environmental impacts of **local air quality** and **CO2 emissions** are the ones valued less importantly.

Cost factors were found to be decisive in all countries, especially in Spain, Poland and Italy. **Travel time** seems in general to be considered even more important, with the only exception being Spain where they were at similar levels with cost factors. **Comfort** also ranked high in the household preferences apart from Norway where it scored notably lower with respect to the others. **Flexibility** received similar votes in each country with around 70/80% of the population stating the factor to be *important* or *very important*. **Safety** was evaluated as influential (*important* or *very important)* by at least 80% of the sample with the only exception being Norway where it scored lowered (68%). **Privacy** scored fairly low compared to other factors apart from Poland where 70% of people marked it as 'important' or 'very important'. An interesting result, although predictable, is the low scores of **environmental factors**, where there seems not to be much difference between local air quality and CO2 emissions. The lowest levels of concern for these factors were found in

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Norway, while southern European countries, Italy and Spain, report slightly higher levels. **Reliability** and **availability** scored high and similarly in each country, with around 80% of the population valuing them at least as important. Finally, **reputation** is the least evaluated factor in almost all countries, with the lowest values recorded in Norway, although it still reaches significant levels in Poland and Spain.

3.3.5 Carsharing (B2C and Peer-to-peer) and bike-sharing

Given that carsharing (B2C and peer-to-peer) and bike-sharing are not available everywhere, the great majority of the respondents stated they never use them. Most respondents that use these modes do it just occasionally. Carsharing is used by 8% of the surveyed population in Spain, 7% in Norway and 4% in Italy, while it is less used in Poland (1.4%) and Hungary (0.3%). Peer-to-peer carsharing is slightly less common in each country and is more frequent in Norway compared to the others. With respect to bike-sharing, Norway stands out, with more than 20% of the surveyed population using this mode.

3.3.6 Support to specific lanes for public transport and shared mobility

The policy "giving privileged access to specific lanes for public transport and shared mobility" received the highest level of support in Spain and Poland, with around 70% of those populations. Italy follows with 56% of supporting households and Hungary with 47%. The lowest level of support was seen in Norway, with 34%.

3.3.7 Satisfaction with carsharing and bikesharing infrastructure

The level of satisfaction is fairly low in carsharing and bikesharing , in particular in Norway and Spain. This is interesting especially with respect to carsharing since these two countries had the highest level of use of such a method. Poland and Hungary in both cases showed the highest levels of people indifferent to this infrastructure which may also be a result of the limited diffusion of these modes in those countries. Italy is midway in both graphs with a slight prevalence of lower satisfied households.

3.4 In-depth interviews results

3.4.1 Summary of findings in Hungary

Two companies provide free-floating electric carsharing services in Hungary serving the denser districts of Budapest. The dynamically growing free-floating service is relatively new. The first company began operations at the end of 2016, operating electric cars exclusively. The second service provider entered the market in the beginning of 2018 operating with both electric and traditionally fuelled cars.

Qualitative research in Hungary draws on 9 in-depth interviews with household users, and 6 interviews with the representatives of stakeholders in the industry. The most frequently cited reasons by **households** for joining one or both carsharing schemes were the opportunity to take advantage of free parking, as well as the flexibility and convenience provided by the system. Most interviewees use the service occasionally, for shorter distances, claiming that their carsharing scheme membership did not significantly decrease the amount of travelling with public transportation and instead replaced their use of taxi service. In general, users are satisfied with the quality of service and stressed the positive outcome of competition in the market. All but one user could imagine not owning a car, if carsharing companies offered easily accessible, comfortable cars. As regards the preferences for electric mobility, about half of the respondents would be willing to pay a higher fee for electric cars than for traditionally fuelled vehicles. However, convenience might override the preference for eco-friendly driving: all but two of the interviewed users would choose the traditional vehicle if it requires more time and walking to access an electric car.

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Stakeholders of the e-mobility sector do not specifically have carsharing related objectives, but they think that this mode of transportation fits well into the complex supportive vision of the government related to e-mobility. The appearance of the state oil company in the market drew public attention to the carsharing service, which, together with its general popularity among young users, is considered by all stakeholders as a good 'marketing' device helping to promote e-mobility in general. However, opinions diverge as to the use of traditional cars in the service. Both carsharing companies are operated on a commercial basis, benefiting only from the incentives available to all electric vehicle owners.

As regards the future prospects for development, stakeholders agree that integrating carsharing into the information system of the public transportation company of Budapest would be a major step towards the coordination of low-carbon travelling modes. Although the opportunity of free parking adds to the profitability of service providers, they consider the predictability of regulatory rules as a crucial factor in planning their future activities and expanding their service. Interviewees mentioned less cars on the streets, more free space, less noise and air pollution, and wider selection of transportation services as the most important contributions that e-carsharing can provide in urban areas. Stakeholders consider publicity, availability of infrastructure and parking facilities, and the favourable regulatory environment to be the key factors determining the success or failure of carsharing schemes.

3.4.2 Summary of findings in Italy

In Italy, the phenomenon of shared mobility started already in the early 2000s. However, it is only in 2013 that carsharing experienced a boom both qualitatively and quantitatively. From 2013 to 2017, the number of shared vehicles is five times bigger, while the number of subscribers has increased by eighteen times. Today, the number of shared electric vehicles represents 24% of the total cars and scooters shared. The percentage is even more important considering that electric cars for private use represent less than 1% of the Italian automotive market.

The Italian case study was conducted among households and stakeholders based in the city of Rome as the city offers different carsharing options (station-based, free-floating and also electric), and 7% of the population has a carsharing subscription. The interviews to households were based on a sample of 6 contacts covering different users' profiles. Moreover, three stakeholders representing policy makers, pressure groups and carsharing operators were involved in the research.

From the **carsharing users' side**, the analysis revealed some common patterns. All respondents seem to consider carsharing as a complementary option to the other modes of transport, not the primary way of moving around the city. The occasions to use carsharing are left for non-ordinary trajectories and when both their private vehicles and public transport are not available. The frequency in use is therefore rather episodic, a couple of times per month. The main factors influencing the carsharing adoption mainly relate to economic and practical reasons. Carsharing is seen as a 'gap filler' in the respondents' mobility options. They consider it handy and easy to use, less expensive than a taxi and faster and more comfortable than public transport.

The current barriers users are facing are limited to two main aspects: the restriction of the zone covered by the service (only city centre) and the availability of the cars. In general, all respondents are happy with their experiences with carsharing and hope the sector will develop further.

From the **stakeholders' side**, the respondents are all in favour of carsharing and they see it at the core of the future transport options. However, to create a sustainable urban mobility system, they share the opinion that considering carsharing alone is a mistake in perspective. All shared mobility services should be developed jointly, starting with public transport. Strong synergies between public transport and all other

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shared mobility services are undeniable, especially on the last mile, and they could be further reinforced by the creation of carsharing areas near public transport nodes, like rail or metro stations or large bus terminals.

Carsharing also contributes to the reduction of privately owned cars. The more carsharing develops, the less people will need a private car, or at least it will reduce the number of cars per household. However, where the urban mobility system heavily relies on public transport, carsharing could also have side effects such as inducing people to move from bike, walk or public transport to the (shared) car, hence generating new mobility.

As for electric carsharing, the stakeholders interviewed are all in favour of a further expansion of electric shared cars in the city. Electric carsharing is seen as a boost for a widespread of electromobility that could lead to an important reduction of pollutant emissions, thereby improving air quality and quality of life of citizens. To further improve electric carsharing and electromobility in general, they consider that an extensive network of recharging infrastructures should be installed across the city. They even suggest making charging points interoperable among all energy suppliers, ensuring fast recharging, and combining them with ad-hoc parking spaces in the nearby. Overall, they see the zero emissions vehicles as the future of shared mobility, implying that electromobility and carsharing should progress hand in hand.

3.4.3 Summary of findings in Norway

Station based carsharing is the dominant model of carsharing in Norway. The biggest and longest running provider is a member-owned non-commercial co-operative. The main providers in Bergen and Trondheim have the same model. Carsharing has been growing a lot in the last ten years, is still growing and new providers are entering the market.

Eight users and six stakeholders (providers, local government and interest organizations) were interviewed.

Users

Carsharing in Norway is typically used by households who do not own a car, and is used as a supplement to public transport, walking or cycling on a daily basis, meaning, at least in the Norwegian context, carsharing does not seem to replace use of public transport, but rather accommodate for this being your everyday mode of transport. Typical use pattern is for weekend trips and for transporting larger items (i.e. it is used when public transport is less convenient).

The main motivation among interviewees seems to be “practical concerns”. This is also what the providers report as users’ main motivation. When discussing why they started to use carsharing, the focus is on the benefits of not owning a car. While users do mention the economic benefits of not owning a car, this is not mentioned as a main motivation, but rather as an additional benefit. The average car sharer has a high income, and this is the case with the group interviewed for this project as well.

All interviewees are positive towards electric cars being a bigger part of the carsharing fleet, but most also mention that range is critical. They need to feel confident that they can reach their cabin or make other longer trips, as this is an important part of their carsharing usage.

Providers

Bigger cities where they are already established, and “seamless transport” or “mobility as a service”, are where providers see potential for further development. A pre-condition for the providers to themselves somewhere new is access to public transport, or a dense and sufficiently urban city or town where people do not need to travel long distances on a daily basis. The providers, especially the Oslo based ones, emphasize centrally located parking space for carsharing cars as the main threshold for further growth.

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Providers are somewhat reluctant towards changing their fleet to only electric cars. However, they do consider electrification as something that will happen eventually and see this as a positive development with time. One argument is that it is too early for the carsharing fleet to become fully electric given that weekend trips to the cabin is an important part of the usage. Also, some are sceptical as to whether the charging infrastructure is sufficiently developed yet. It is also mentioned that the "know-how" of using an electric car is not yet developed enough in the general population, and that this might make electric cars a further barrier for using carsharing, or that users might have negative experiences. Municipalities might push the development of electrification of the carsharing fleets when accommodating for carsharing, and we do indeed see this in recent developments in Oslo and Bergen.

3.4.4 Summary of findings in Poland

Currently carsharing in Poland is provided mainly by seven companies in the biggest cities and metropolises. Most of these companies operate in one or two cities. In total, three or more carsharing companies are present in Warsaw, Poznan and Wroclaw. All companies operate in free-floating system, however in same cases they use also station-based system. Some of the operators focus on business clients.

Carsharing was well received by the citizens and is developing rapidly in Poland. Smaller cities aim to introduce carsharing as well. Private companies recognize its profitability and there is a growing number of companies offering carsharing. According to the data from the beginning of 2018, about 1.5% of Polish citizens had used carsharing. At the end of 2017, the number of carsharing users was estimated at several tens of thousands. Along with the dynamic development of carsharing, there is a growing interest in media and websites focused on carsharing.

Cars provided by carsharing companies are new and meet the high emission norms but most of them are conventional (however, some hybrids and some electric cars are also available). The companies assess that electric car fleets will be profitable at some point in the future so electric carsharing will become more popular then.

Carsharing is usually viewed as supplementary to public transport; however, there are also cases when people choose carsharing instead of Uber, taxi or private car. This usually happens when they go out during the evenings or weekends, in urgent situations, when having business meetings in the city centre. Carsharing is regarded as convenient, well-managed mean of transport. Users praise the operators for the system management and high cars' standard. Many people appreciate hybrid cars with automatic transmission system as well suited for the city. Warsaw car users praise them for being convenient and eco-friendly. In Wroclaw, a possibility to drive an electric car is an additional incentive to use carsharing. On the other hand, users also stressed the low price of carsharing as an important factor. Therefore, the above-mentioned advantages of electric cars will not necessarily translate in bigger popularity, if the cost difference remains high. In the long run, carsharing may reduce the number of cars in the cities (users would refrain from buying the second car if carsharing is available).

Public administration view carsharing as an opportunity to reduce traffic, limit pollution and promote environmental-friendly transport. On the other hand, municipalities do not want to support it financially (focusing on its promotion and e.g. offering parking spaces) and want to develop public transport in the first place. This leaves the initiative for the private companies.

3.4.5 Summary of findings in Spain

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Carsharing in Spain is currently provided by 7 main companies in Madrid, Barcelona, Bilbao, Seville and Palencia. These companies follow two different business models. Three of them are Free Floating One-way carsharing companies that allow users to leave the vehicle at a convenient point within a limited perimeter of the city. They have a 100% electric vehicle fleet and are all located in Madrid. The other 4 are station-based carsharing that require the user to leave the vehicle at one carsharing station. They are located in the aforementioned cities with a varied fleet depending on the company.

The sector experienced rapid growth in the last two years thanks to the entry of free-floating electric carsharing companies in Madrid. The biggest market is in Madrid where 5 companies are operating with about 2000 shared cars, of which 1500 are electric, followed by Barcelona with 2 companies, while Bilbao, Palencia and Seville have one company operating.

The current development of this sector and motivations for using this transport mode was explored through 28 in-depth interviews with carsharing users and experts from different Spanish cities. The analysis revealed that the mode is mainly used for leisure activities; younger users seem more inclined towards using more than one carsharing operator, where available, and in general to use multiple modes to get around (e.g. bicycle, walking, shared bike, public transport).

Most of the interviewed users started using the service when they discovered and experienced it rather due to a change in habits or a specific event. The frequency of use varies depending on the carsharing model: free-floating users use the mode more often and for shorter trips compared to station-based users.

Factors influencing the adoption of carsharing mainly seem to be related to convenience of use, such as practicality, availability, immediateness and flexibility compared to other transport modes. However, the mode has been also appreciated for its affordability, innovative character and environmental friendliness. This last aspect has been cited only by electric carsharing users.

The use of carsharing could reduce private car purchases but may also reduce public transport use. In fact, the majority of free-floating carsharing users stated after joining the service that they reduced their use of public transportation, while station-based users stated their use of public transportation remained the same.

The vast majority of users owning at least one car stated that the service may allow them not to buy a second car or to reduce the number of cars owned in the household; Users not owning a car stated the service helped them not needing to buy one.

The electric technology is demanded by users. The majority of users would prefer the service being offered by electric cars and, all else being equal, the majority of them state they would be open to paying a bit more for the electric technology. Those who use electric carsharing have a generally positive opinion of the vehicle type and say that their experience could make them consider such vehicle in an eventual purchase.

On the stakeholder side, carsharing is regarded as an opportunity by the public administration to complement public transportation and reduce carbon emissions thanks to electric vehicles. Parking facilitations and restricted areas access, as well as a specific legal standing are key policies identified to drive carsharing development.

According to business stakeholders, carsharing should be pursued as the benefit to society it could bring is threefold: economic, avoiding car purchasing and maintenance costs; social, mainly connected to the freeing of public space, and environmental. The use of electric vehicles in carsharing services is at the moment seen as viable only by free-floating operators; while station-based carsharing have concerns with respect to the autonomy due to the higher length of the trips.

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Moreover, cities would benefit from the integration of carsharing with other urban services and in particular public transport to make it easier to avoid using private vehicles. Both types of carsharing services can contribute in this sense to sustainable mobility. However, it will be important to ensure that the flow of carsharing users will come from people reducing their private vehicle use rather than their public transport use.

3.5 General discussion and conclusion

The destinations are quite similar across countries. Trip to grocery/shopping is the one performed by the greatest share of the population, while the trip to work is the most recurrent. These trips and the trips related to children school and activities, follow similar patterns across countries. Leisure trips, on the other hand, seem to show greater variability both in terms of population shares having recurrent activities and number of days per week.

The travel modes used tend to vary more depending on the type of trip rather than across different countries. In particular, public transport seems to be used less for activities related to shopping and involving children. A drawback of public transport is the inconvenience when carrying shopping bags or other equipment.

The survey showed differences in diffusion of carsharing between the countries, with a higher number of users in Norway and Spain. The number of people in all the countries who have used these vehicles is limited given that the service is available almost exclusively in medium/big cities, although carsharing is increasing in terms of both number of users and companies/vehicles available. Levels of satisfaction with the carsharing infrastructure are low in each country, while a relevant share of people stated that they were in favour of enforcing the speeding up of public transport and shared mobility through specific fast lanes.

The way in which carsharing is being developed differs from country to country. Free-floating carsharing (i.e. the vehicles are normally freely parked on the street of an urban area, where they can be booked) is dominant in Hungary, Poland and Italy, while station-based carsharing (i.e. the vehicles occupy a specific parking lot reserved for it) is dominant in Norway. In Spain, free-floating is dominating in Madrid while it is absent in other cities. These two models seem to both have advantages and constraints:

- Station-based carsharing mainly targets trips outside of the urban area and is hence less in competition with urban public transport, meaning they are more complementary. From an environmental perspective, the main advantage of station-based carsharing is its complementarity with public transport, which helps households to avoid using or, in some cases, having their own vehicle. However, some stakeholders in Norway and Spain were sceptical about the use of electric vehicle technology for the station-based system.
- Free-floating carsharing based on both conventional and electric vehicles (this have already proven to be successful in Spain, Italy and Hungary) targets urban travel and, although, they might complement public transport, they might also compete as both operate within the urban area. Free-floating carsharing helps the environment especially when it relies on a fleet of electric vehicles, by increasing their presence in the urban area and by allowing people to discover this technology. However, some stakeholders expressed concerns about the number of vehicles and the distribution efforts required to ensure they are available everywhere in the area. This might lower the scheme's efficiency and its environmental impact, particularly when the service is not provided by electric vehicles.

The sector has so far been mainly driven by private initiatives with some cases of public services, public-private partnerships and member-owned companies. Carsharing is mainly developed in medium-large cities,

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although certain stakeholders pointed out the potential of shared cars in rural areas where they could bring benefits by substituting public transit with low demand. The potential electrification of carsharing services is seen as a foreseeable future development by business stakeholders and is highly rated by policy makers who consider electro-mobility an important asset in order to meet emissions limits.

Most of the interviewed households in the different countries use this service mainly for leisure activities, in particular to reach specific destinations that are poorly connected by public transport. However, there also seem to be people using this service on a more regular basis to commute to work. Some other uses are related to shopping and moving equipment where public transport might be inconvenient. The service seems to be more popular among the medium-highly educated between 25 and 45 years old, although older users are also becoming common.

In most of the countries, users seem to choose carsharing mainly for its flexibility and comfort aspects. However, the costs of the service also seem to be an important factor for users. Environmental concerns related to air quality and global warming tend to be of secondary importance. The experience was positively evaluated by the vast majority of people who were able to try electric vehicles through this service. Many interviewees preferred electric to conventional vehicles and some of them declared they would also be ready to accept a higher price for the technology.

A system in which carsharing and public transport are connected and complement each other would benefit a model shift towards sustainable transport. Local authorities seem to mainly rely on the public transit offer to reduce private vehicle use and consider the complementary aspect of carsharing positively. On the other hand, business stakeholders would benefit in visibility and gain new users from an integrated offer with public transport. This could be done by developing instruments such as mobile applications mapping the different services available.

A sustainable model shift must support the switch from private car to carsharing use, but not all the trips that are now made by shared cars have replaced journeys by private car (e.g. it also replaced public transport use in some cases). Defining specific measures and incentives to prevent this can make sure this service is correctly developed.

The diffusion of carsharing service might benefit from a series of policies, including parking facilitation, private car access restrictions, integration with other modes, incentives for adopting electric vehicles and investing in charging infrastructures.

The future of carsharing will be linked to technological development. The urban environment can be improved through the implementation of electric vehicles both with respect to local air quality and CO2 emissions levels. Furthermore, carsharing could reduce inequalities with respect to the access to electric vehicles. It might also help users to live without a private vehicle and this could help reduce the number of vehicles per household.

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4 "From Consumer to Prosumer" case study

4.1 Introduction

The concept of prosumer denotes a consumer who produce electricity primarily for its own needs but can also sell the excess electricity. Prosumers are hybrid consumers/producers - generally they are connected to main electricity grid services, consume main grid electricity and their own produced electricity, and sell excess produced electricity back to the main grid.

In the international context of climate change there is an imminent need for a 'green' transition of the energy system in the EU region. In order to foster sustainable energy consumption, EU policies have acknowledged the importance of empowering consumers to become their own managers of their energy needs. This transition has led to an increase in households that invest in their own solar energy systems that produce electricity for their own consumption, as well as enabling selling of excess produced electricity into the electricity grid.

Prosuming has been enabled by new technological innovations that allow for more communication and integration between decentralised and centralised electricity systems supply. In order for end-users to embrace these services, a good understanding of the needs, background, and required learning curve are necessary. Otherwise, the services risk being improperly or insufficiently used, abandoned, and may even become a road-blocker for future meaningful efforts to engage the prosumers.

This report focuses on **residential prosumers** who have invested in **solar energy systems** on their property that produces electricity for their own consumption but are also connected to the main electricity grid supply and who sell excess produced electricity to the main grid supply.

4.2 Methodology

This case study aimed at identifying the main motivations for a consumer to become a prosumer in Italy, Norway, Serbia, UK and Ukraine, how this choice could affect the energy practices of families and what are the main barriers that can be encountered (and the role gender and other cultural and social aspects play in it).

The case study gathered information from each case-study country combining four qualitative methods: (1) mapping of prosuming in the national energy system; (2) mapping of gender ideologies in prosuming in media and advertisement; (3) semi-structured interviews with prosumers; (4) diary notes made by prosumers.

4.2.1 Mapping

The first phase of the case-study involved mapping prosuming and gender ideologies concerning prosuming. The purpose is to explore how gender is presented and perceived in society. First, the mapping consisted of providing a general overview of prosuming within the national electricity systems, including policies and regulations concerning prosuming. Second, the mapping consisted of collecting and presenting an overview of gendered presentations in promotion material for Household Solar Power Plants (HSPPs) and gendered presentations in media coverage of interviews with prosumers and prosumer policies and regulations. As far as possible obtaining material from promotion material and media coverage was done systematically using different web search services, however this differed from country to country depending on services available. The number of promotion material and media coverage also differed extensively as residential prosumers is a new phenomenon in Norway and Serbia, while well established in the UK and Italy.

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4.2.2 Interviews and diaries

The second phase of the case study involved conducting semi-structured interviews and collecting diary notes from 10-12 residential prosumer households in each case-study country. As the objective was to learn about both households' motivations and experiences as well as the significance of gender in this process, the case-study design focused on recruiting heterosexual couples who were residential prosumers and the interviews were set up in order to talk to the woman and man alone. Most interviews were conducted in the prosumers' house, which allowed us to also look at the solar PV systems, the inverters and ask the informants to show us how they checked information concerning production. The research design aimed for interviews with couples, but some interviews were conducted with families who only consisted of one adult residential prosumer. The case study also included asking the prosumers who participated in the study to fill out a daily diary form and notes for a week. Some informants did not fill out diaries.

In several of the countries, it was difficult to find and recruit prosumers. The sample of interviewed in Serbia are not prosumers in the true sense as, though they have invested in HSPPs, they cannot sell excess produced electricity to the central electricity grid supply according to law.

4.3 Mapping of gender results

Energy policies in Europe are formulated in general in a gender-neutral way, which assumes that men and women have the same perspectives, needs, experiences, values, resources and aspirations concerning domestic energy access, production and use. In contrast to energy policies, solar **energy companies** and media journalists may through promotional material and media interviews choose to present prosumers and technology in other ways highlighting the topic as male or female domains to reach target audiences or reflecting general opinion.

Gendered presentations in promotion material for HSPPs

In general, the promotional material for HSPPs collected are presented in neutral and technical language with no associations to gender roles. However, several have illustrations of men working on installations of solar systems. Paragraphs referring to "experts", "specialists", and "advisers" are almost always accompanied by pictures of men. From the material analysed, one advertisement had a clear gendered presentation.

A new line of advertisements differs from the general trend as they portray values of diversity and equality in their aim to attract new customers. These advertisements tend to differ from the general technical and financial focus, as they are more family oriented, portray homely values and speak to the consumer more personally.

The promotion material and advertisements generally seek to reach their target audience, which reflects what images and gendered or non-gendered way are used.

Gendered presentations of household prosumers in media coverage

Regarding gendered representations of prosumers who have been interviewed in newspapers and magazines, there is a focus on the male prosumer across the countries. Though interviews tend to present the 'family' in headlines and preamble, women (and children) are seldom present in the article text or pictures and it is almost exclusively men who are presented in relation to the technical aspects or together with the technical components such as the panels and inverters.

Interviews with prosumers focus on the technological advancements and innovative aspects of domestic solar systems, as well as environmental and economic benefits. Most articles (including pictures) present the

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prosumer as men. The male dominance is stronger whenever technical and financial issues are discussed, while women are consulted on environmental motivations or portrayed in relation to home aesthetics.

The material from Ukraine and Serbia appear to be somewhat more gender balanced. In the UK, two articles contradict the trends described above.

Gendered presentations of media coverage of policies and regulations for prosuming

In media coverage of policies and regulations for prosuming in Italy, Norway, Serbia and Ukraine the topic is presented in neutral and technical language with no associations to gender roles. In the articles from the UK, men are more often represented as the experts.

4.4 Prosumer interviews and diaries results

4.4.1 Summary of findings in Italy

The prosumers interviewed stated that the main motivations for investing in HSPPs were **environmental and financial**: strong commitment to reduce their carbon footprint and opportunity to decrease the cost of household energy consumption.

The **experiences** of being prosumers among the interviewed were mainly **positive**, although some of the prosumers had experienced minor problems and five (25%) stated that they had only negative experiences (this number is higher than for the other case-study countries). Problems identified relate to bureaucracy and/or problems with the utility company, poor quality work by technicians doing the instalments and resistance from neighbours.

The interviews revealed how gender was an important social and cultural factor in the process of becoming prosumers in Italy. The motivations and final decision to become prosumers was generally made by the families together. However, men seemed to be more at ease with and interested in the technological aspects and for these reasons they gathered information, kept contact with the installation company and relevant institutions.

Though women were less involved directly in the process of becoming prosumers, they had modified their habits to shift their load of energy consumption to daytime after becoming prosumers more so than men. This coincides with women's care work responsibility in the family, as revealed by the diary notes of electricity-related domestic activities.

Despite finding gendered differences in how women and men related to the solar technology, gender was not perceived as relevant to becoming and being a prosumer by the majority of the interviewed. Despite this affirmation, the majority perceived men to be more interested in technology (including solar) than women. Several felt that women are more interested in environmental aspects, while men are motivated by the energy technology and financial aspects. Most described an average prosumer as someone who have favourable economic conditions, though five stated economy as irrelevant. Some also described the average prosumer to be a person from 40 years old and upwards and someone with a high social standing. Most also expressed that the most suitable type of residence for prosuming was a separate house in rural or sub-urban surroundings.

Among the Italian prosumers interviewed, the motivations for becoming prosumers converge towards financial and environmental reasons, indicating that prosuming is attractive beyond special interest in technology. This explains why gender is seen as irrelevant for prosuming, even though most of the prosumers interviewed perceived men to be more interested in the technology. However, the differences in interest

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and skills towards the technology and the gendered divisions of care work labour and household space in the families interviewed reveal that women and men do not relate to the technology and electricity in the same way.

4.4.2 Summary of findings in Norway

The main motivation listed by the interviewed prosumers were environmental aspects: non-fossil energy transition and the need to help develop the Norwegian solar market to facilitate the green shift energy transition.

Several of the interviewed prosumers also had a strong interest in the technological aspects of producing solar electricity in their home. The strong technological interest was shared among both men and women working in the energy sector. Technological interests were not mentioned by women not working in the sector, while the interviewed men not working in the sector saw the opportunity to gain experience with solar technology.

A third important factor mentioned as motivation to invest in HSPPs were economic aspects. Many highlighted the long-term perspective. Many also mentioned the high upfront cost of the investment as a barrier for solar to reach a 'critical mass'. One of the prosumers interviewed only decided to become a prosumer when he was given the option to lease the panels for a small monthly fee.

The decision to invest in solar system was taken collectively between men and women in all the families interviewed, but it was almost exclusively the men that drove the process of becoming a prosumer (bring investing in solar systems on the agenda, take care of the practicalities and bureaucracy, etc.). Decisions often include a negotiation of different household priorities. Some cases illustrated the social complexities behind the decision to become prosumers. For most of the interviewed prosumers, was a specific occasion or event that propelled the decision to become prosumers.

The major part of household's electricity consumption is related to heating of people's houses in the cold seasons (October – April). This means that average households consume the electricity from the transmission grid during the cold season and overproduce electricity in the summer season, which is sold to the transmission grid. Several of the prosumers were committed to reducing electricity consumption for environmental reasons. Still, many of the prosumers interviewed stated that it was difficult to reduce their electricity consumption. Even if the prosumers interviewed had not changed their view on and values concerning electricity consumption, several had tried to shift the load to the times when it was optimal for the solar system to produce sun

The diary provided us with information on the gendered division of labour in the household related to electricity consumption: in general, women did most of the energy-related daily housework (e.g. cooking and washing clothes). The diary also provided information on practices to reduce electricity consumption: turning off the light before leaving for work (women were more prone to turn off lights) and showering for a few minutes at a time (and never daily). Due to a number of reasons, it was not possible for all to shift the load to daytime or wash only during sunny days.

Many families who choose to become prosumers already are interested and reflexive of their electricity consumption so the shift from consumer to prosumers does not result in major changes of practices or values. Still, most of the families were aware of and focused on trying to use most of the electricity they produced themselves and thus had changed certain habits. Some of the families who did not see the point in doing this also stated that they thought the price they received for the electricity they sold to the grid was

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equal to the price they paid so there would actually be no point. In general, it is more profitable to use the electricity you produce yourselves as the prices you get for selling excess electricity is lower.

Husband and wife took the decisions concerning house renovations in their home jointly. However, it was generally men who carried out the practical work or kept contact with craftsmen and it was often women who took the initiative for renovation of kitchens or bathrooms. When spaces were considered to belong to either of the spouses/partners, men had workshops in the basement or in the garage while women were seen as managers of the kitchen or washing room.

The diary notes also provided us with hands on information on different practices of men and women concerning interaction with the technology. There was a prevalence of men monitoring the electricity production of the solar system: 37 men versus 3 women. These data are not compatible with general patterns of monitoring, however, as the interviews were done in February 2018 it was still snowy and most systems did not produce any electricity. If the study had been done in summer the ratio of men and women monitoring would be even more skewed. Only the households who were focused on reducing electricity consumption checked regularly their consumption, and most often this was also done by the men and not women. However, not everyone had a clear overview of their electricity consumption and costs.

Most of the informants stated that they thought typical prosumers were often retired (as themselves) as they then had time and money to prioritise this. Or as a man with particular technological competence and environmental interest (like her husband). However, most did speak of a 'he' who was environmentally conscious and who was above 40 and therefore had economic means to take the investment. Mr. L explained that he saw two main prosumer groups at promotion meetings etc.; those who were only environmentally motivated; and those who were motivated primarily out of interest with the technology (but also environmental reasons).

4.4.3 Summary of findings in Serbia

The Serbian Energy Law, which entitles citizens to become prosumers, is not yet implemented in practice. For that reason, those interviewed in Serbia have invested in HSPPs but cannot be defined as prosumers as they cannot sell surplus produced electricity back to the grid. The majority of the interviewed 'prosumers' in Serbia were between 30-39 years old, thus younger than the average age of the interviewed prosumers in Italy, Norway and UK.

Lack of electricity provision or acceptable conditions of provision were the main motivations for becoming a 'prosumer' in Serbia (this contrasts with those of the other case-studies). The second most listed motivation was financial reasons. Several of the interviewed 'prosumers' also highlighted the use of RES as an important motivation, an interest in solar technology and to avoid using gas (safety reasons).

There are gender differences in how women and men relate to the process of becoming prosumers. Investments are related to the household economy and require a joint decision, but in most of the families it was the husband/male partner or other male relatives who took care of the practicalities in the process (e.g. bureaucracy, contact with vendors etc.). Men also seemed more interested in technological so they were in charge of collecting information and maintained contact with a solar panel installation company. However, in two of the families it was the woman prosumer who had taken care of the entire process. As described from Norway, there was often a certain event that sparked the decision to become a prosumer.

Interviewed 'prosumers' stated that they were satisfied with their HSPP. The positive experience was related to their environmental motivations and their independence from the public distribution network. They also felt that they had acquired sufficient information and quality products concerning their investment.

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A majority of the prosumers stated that they were careful and responsible in their electricity consumption. Some of the 'prosumers' interviewed planned their activities differently in order to maximise on the sunny hours. Only a very few reported to have opportunities to shift energy related activities and the load to daytime. However, the context of Serbia is different to that of the other case-study countries as several have batteries for storing the energy for using in the evenings. This requires a different attention to electricity use as they cannot rely on supply of more electricity than they produce themselves. Several of the interviewed 'prosumers' in Serbia were careful that light and appliances were turned off when not in use to ensure that they did not consume more than they produced and always had access to electricity when they needed it. Especially in the evenings and winter precautions were made to minimize electricity consumption. In addition, batteries are depleted by overuse (unless load-limiters are installed) and unless they have installed inverters (which are always necessary if you sell excess produced electricity to the transmission grid), several appliances do not work or will harm the HSPP. The interviewed 'prosumers' with batteries thus made sure that only suitable appliances were used. Five of the families interviewed are also connected to the central transmission grid. These families were less inclined to minimize their electricity consumption as they have access to the energy needed regardless of their own production.

A little more than half of those interviewed stated that both partners were equally involved in household decisions in all areas, but slightly less than half stated that women exercise more control over decisions and activities in the kitchen space. In all households, both genders pay equal attention to turning off the light before going to work. There is also no significant difference in the use of shower. Generally speaking, women did most of daily housework related to energy use. In most households, both partners participate in the preparation of dinner during the week, although women more often participate in this activity than their male partners. Many of the respondents have a washing machine, and they are mostly used by women. Monitoring electricity production is mainly an activity performed by a man. Most prosumers followed the production from the panels by using the display on the inverter.

Notes in the diary show how often and who in the family monitors the electricity production of the solar system. Most households monitored production and consumption through a converter or display. Men checked electricity production 29 times, while women only six times.

Out of ten interviewed families, five families reported that the husband pays electricity bills, and three said that the woman does, while in two households this is done by both the husband and the wife. Only households that were focused on reducing electricity consumption regularly checked their consumption, and most commonly that was performed by men, not women.

Both men and women made decisions together about renovating houses and specific spaces in their home, but mostly men performed practical work or had contact with handymen. However, women were often the ones who took the initiative to renovate the kitchen, rooms, bathrooms and decorative activities inside the house.

More women than men think they administrate the kitchen related tasks. Garage and all activities regarding using tools and repairs were usually stated by men. Regarding the decoration and renovation of the house, the decisions were most often a joint process of consultation between couples.

All interviewed families reported sharing their experience with the installation of solar panels and solar energy consumption with neighbours, friends, and colleagues.

Most of the people interviewed described a typical prosumer as a person with higher education, ecological awareness and good financial means. In addition, most described the typical prosumer as a cabin owner,

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highlighting that they are the pioneers driving the process towards solar household electricity production. Several also pointed out prosumers are often retired people who have been abroad for work migration. About half of the 'prosumers' interviewed did not find gender relevant to becoming a prosumer, but they nonetheless pointed out a general opinion that men are more interested in this field and that an important driver of motivation is interest in pursuing this technology and trends of being modern and forward-looking. However, it was also stated that ecological awareness is the most important driver and thus include men and women. More than half of the interviewed consider the main driver of women to be the financial aspects.

Although all the 'prosumers' interviewed were satisfied with their experiences of producing their own electricity from solar energy, and most of them wanted to upgrade their systems or include solar collectors for the heating of sanitary water, they were less positive towards prosuming regulations within the current national context. This was explained by how the regulations on prosumers (at this point) only allowed those who have a registered company, as a legal entity, the status of being privileged producer.

4.4.4 Summary of findings in the United Kingdom

The sample of interviewed prosumers in the UK came from several regions across the UK (excluding Scotland). Most of the households had at least one person with technical and/or financial expertise through their previous or current employment.

Prosumers generally described interest in solar panels as evenly split between partners in the household. However, responsibility for gathering information or installation was generally on the part of the partner who handled household finances or maintenance, which in most cases was the man. Several prosumers of both genders expressed interest in reducing energy costs and modes of self-sufficiency. Some (men) were interested in environmentally friendly technology.

The prosumer's interest in energy markets was varied, although all looked favourably on reducing carbon emissions and dependency on fossil fuels.

Environment was brought up by 16 participants as a primary or secondary motive. The remaining 12 interviewees did not mention environmental issues when discussing their motivation or suggested that environmental issues did not play a role in the decision. In six of the 14 households, one partner was environmentally motivated and one was not. In these cases, environmentalism was balanced by gender. For those who noted the environment as a main motivation, the notion of ethics and morality was frequently also mentioned. These respondents also mentioned solar panels as part of a more holistic approach to decrease their carbon footprint and help the environment. In these cases, they have also adopted other energy efficiency technologies and they often volunteer with or donate to environmental charity. Producing their own electricity seems to be seen as a source of pride or community spirit.

Some prosumers also discussed an interest in solar PV technology among their motivations for installing panels. This interest was specifically among male participants, while many female participants expressed reluctance or even fear of adopting new technology. Self-sufficiency came up in some interviews but it was rarely explicitly mentioned as a motivation to install solar panels.

Both male and female prosumers framed solar panels as a smart investment, although many interviewees suggested that they would not have installed the solar panels at the current feed-in-tariff rates. Two interviewees stated that the panels would not pay themselves off, but as environmental concern was their primary motivator they were satisfied with their choice anyway. In some cases, there seemed to be some regret in installing the panels due to the loss in investment. Several prosumers had considered solar panels for a long time but installed them quickly after learning that solar energy tariffs were about to be reduced.

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The impact of gender on the decision-making process towards becoming prosumers varied between households. In more cases it seemed that the man was the key driver behind the decision. In other cases, the decision came from both partners. In another case the decision and the entire installation process was undertaken by a single elderly woman before meeting her current partner. This could indicate that although the gender aspects in the decision making seems to suggest that more men were drivers of the decision than women, this is actually strongly tied with financial agency to take the decision to install solar panels.

Women appear less interested in the new technology aspect. However, in case where women worked in banks or accounting, they were the ones who dealt with the financial aspect. In most households, at least one of the partners had a relevant background in finance and/or technical fields, therefore making them a sort of "expert" that is or might be expected to deal with the decision and installation process. The research on and contact with solar installers was more often undertaken by the male partner. They also were more likely to have organised the paperwork and files, and most commonly referred to them and offered to show them during the interviews.

Men tended to be responsible for executing household maintenance and repairs, but women were generally responsible for suggesting maintenance tasks and for day to day tasks. This was not universal across all participants, but on the whole women seem to take care more of the day to day chores, and men would implement big changes or activities that were not habitual.

Prosumers generally identified positive experiences with their solar panels and installations. While some prosumers noted technical issues soon after installation, these were mainly small and quickly fixed by the installation companies (although in several cases the installers of the solar panels had gone bankrupt and there was significant uncertainty over the value of the warranty if repairs were needed). None of the households we interviewed had a battery, although many stated that they were interested, but waiting for the costs to decrease and/or the technology to improve. Aesthetics was often mentioned by women (less by men) as a factor into the decision.

Most prosumers said that original estimates of production and returns were conservative, and that their solar panels had "exceeded expectations". These feelings are linked to different aspects of the system, including financial, environmental, and technological.

Some interviewees took a keen interest in monitoring electricity generated but many claimed they tended to "almost forget" the solar panels were there, as no additional maintenance or work was required.

In most households there was a traditional split of labour with women taking charge of most domestic activities, although there were some exceptions. In terms of energy use this meant women were generally using more energy for cooking, cleaning and other domestic tasks than men. More women were also interested in decoration. The garage and tool shed were usually claimed by the men. The solar panels did not appear to enter in either sphere of influence. With regards to home improvement and renovations, decisions were most commonly a joint consultation process between the couple.

When asked about changes in behaviour after becoming a prosumer, there were mixed responses. Some couples had changed their behaviour in order to maximise the use of energy from the solar panels, whilst others had not. Generally, individuals who were adjusting their schedule to maximise the use of solar energy were those who were already quite engaged environmentally already financially conscious. Households revealed that they do not think that having a smart meter that provides real-time information would change much in their habits, either because they are already energy conscious and taking actions in that respect or because they are not willing to shift their habits.

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According to the information reported in the diaries, there is no relevant difference in the use of the shower and the attention in turning off lights. Not many of the respondents own or use a tumble dryer – and there is no apparent gender split in the few cases where the use of this appliance is reported. In most households the two partners take turns in preparing dinner or cook together, although women seem to be involved in this activity more often than their male partners. A clearer split appears in the use of the washing machine, mainly by the woman of the household, and in checking the electricity production, mainly the man. Nonetheless, for both activities we found at least one exception.

When asking interviewees who they perceive as the typical prosumer, a variety of answers were provided, but recurring factors were liquidity/disposable income and owning their own home.

Men and sometimes women would often shy away from talking about stereotypes and describing behaviours which embodied stereotypical roles, and alternatively taking pride in behaviours which opposed stereotypical role. When prompted about men or women being the key drivers, the responses were mixed, although most cases tentatively suggested that the decision could be driven by the man if financial, while women may take more interest in the environmental aspects. When asked about the gender difference in motivations, eleven responses split evenly between men and women did not clearly indicate a general preconception about men or women having different motivations. The remaining seventeen participants suggested that there were differences in motivation between men and women. A recurring response was that men might be more interested in the technology or women in the future and the environment although this was often tentatively suggested.

4.4.5 Summary of findings in Ukraine

As in Norway, the market for household solar PV systems is relatively new in Ukraine and the first intense period of installations began in 2016, continuing into 2017 and 2018. What is quite different from e.g. Norway is that instalment of solar PV systems is perceived as an economic investment on par with savings of bank investments.

Passive income and saving money were mentioned as the main motivation to become a prosumer by those interviewed. HSPPs were considered as more attractive investment in comparison with bank deposit. Being a prosumer was also seen as a way to stabilise the family economy from overspendings due to constantly increasing energy prices. Environmental reasons were only mentioned by a few of the interviewed prosumers. An important driver for the families living in rural locations was stability of electricity supply. The motivations for becoming prosumers were fairly gender balanced, with the exception of professional interest. Women also mentioned more frequently that money saving was a major reason.

The process of becoming prosumers in Ukraine involves becoming acquainted with information from several sources in order to successfully understand the legislation, connection requirements, receive the green tariff and contact with solar installation companies and electricity supply (utility) enterprises. In most cases it was the men prosumers interviewed who had driven the process of finding the information and taken care of practicalities in the process, though in a few cases women had been the initiators. In most of cases, decisions on technical aspects of solar systems were taken by the husband. In most cases, the decision to become a prosumer was taken jointly by the couple.

The interviewed prosumers in Ukraine generally had positive experiences of being a prosumer. Although, the interviewed prosumers also related problems concerning bureaucracy in the process. In addition, some stated that the experience and skills was a deficit at the utility companies and that there were technical limits in the distribution networks. Other problems and deficiencies of the system were listed.

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As most of the interviewed prosumers had relatively short experience (1-2 years) they spent a significant amount of attention to the daily operational mode of the system and monitor the production on PCs or inverters. They were most satisfied with the financial benefits. Several also pointed to how becoming a prosumer had increased their knowledge and awareness concerning energy consumption in the household, alternative sources/solutions to household energy needs, as well as awareness of environmental concerns.

The prosumers in Ukraine were very engaged in debates and rights of prosumers, which they highlighted in both the interviews and diary notes collected. Some interviewed prosumers declared their intentions to install additional PVs to produce more electricity and earn more money.

Several of the interviewed prosumers stated that the installation of a solar system has led to substantial changes in energy management. All the interviewed families also reported that they shared their experience and new awareness of energy consumption with neighbours, friends, colleagues and ordinary people. Some prosumers have decided to use PVs as one of the main business activities and promote their solar system on social media or relevant websites.

The energy practices of families interviewed also reflected gender roles in the households. The daily monitoring of the production and consumption of the system was generally undertaken by men while the electricity-related housework is performed by women.

The interviewed prosumers in Ukraine also considered solar power and electricity as the sphere of male interests and responsibility. However, at the same time quite often women were legal owner of the house and respective solar system and pay substantial attention to the economic aspects and ecological consequences. In some cases, there were strong divide between women and men's interest to the solar systems in the families interviewed.

Most of the interviewed stated that the average prosumer was between 25-50, had middle to high income and most likely a man. Income level was stressed the most as HSPP still have high up-front costs in Ukraine. Several also pointed to how prosumers often had entrepreneurial skills and thus an interest in making investments that were profitable. Some of the interviewed prosumers also stated that the 'average prosumer' is a person with a technical education or interest, as well as people who have a general desire for making positive changes in society (in terms of environmental aspects). Another important aspect mentioned, which is also related to income level, is that one needs to own a house in order to become a prosumer, as this is not possible for people living in flats.

4.5 General discussion and conclusion

Prosuming through HSPPs is becoming common, but there is still a significant underutilised potential. Italy and the UK are leading countries, while the market in Ukraine and Norway is emerging. In Serbia, few households have installed HSPP because regulations on prosuming are not in place yet.

The motivations that drive individuals and household's decision to invest in HSPPs and become prosumers differ according to national contexts, but centre around financial (UK, Italy and Ukraine) and environmental (Norway) reasons. Support schemes like feed-in tariffs seem to be of utmost importance for the growth in the number of prosumers.

The average prosumers identified generally have middle- to high income and higher education. In addition, prosumers tend to have occupations and interests related to energy and technology. This might constitute a

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challenge in making HSPPs and prosuming attractive and affordable to lower income groups, as well as to groups with less interest or skills in technology.

Almost all the prosumers interviewed in this study live in a detached or semi-detached house that they own. This is correlated with income, but also reflects the difficulties for residents of multi-apartment buildings to obtain permits to become prosumers.

The prosumers interviewed were generally satisfied with being prosumers and had positive experiences (usually related to both financial and environmental benefits), although several had encountered challenges related to bureaucracy.

4.5.1 What difference does gender make?

Gender aspects are important for understanding how and why energy practices and behaviour may differ within and across households and societies and what social, economic and environmental implications this may have. Energy policies are often formulated in a gender-neutral (the underlying assumption is that men and women will respond to and benefit equally from such policies), but research shows that the motivations for and barriers to taking up energy-saving technologies are gendered.

The decision-making on investments were done by the couples together, but it was men who in general drove the decision and process of becoming prosumers. In many households, there is also a gendered division of labour and engagement with the HSPP.

An essential aspect of prosuming is also related to any changes that occur in individuals and households' energy practices after becoming a prosumer. Here also, gender roles and gender relations matter as the gendered division of labour in the households mean that women and men do not engage with energy consumption in the same way, and they have different experiences and needs. The study revealed that women perform the majority of several of the energy-related everyday domestic tasks such as cooking and laundry. This information reveals the importance of a gender focus in understanding energy practices on the household level to inform policies. To maximize the use of solar systems (without battery solutions), it is necessary to shift the main load of consumption from evenings to daytime when the sun is shining as this often concerns work that befalls women.

Men and women's engagement with solar technology and prosuming is also embedded in how HSPP and prosuming are presented in the public eye. Re-producing the gender roles and gendered divisions of labour concerning energy, which excludes women from the technical sphere, has implications for women and men's ability to adopt new technology and change their energy consumption practices towards more environmentally friendly lifestyles.

4.5.2 Conclusions and policy recommendations

The study confirms the importance of support schemes such as feed-in tariffs for the growth in the number of prosumers. In addition, it shows the importance of establishing prosuming in legislation. Further, it highlights the need for consumers to receive adequate support in the decision-making process and in the transition to becoming prosumers. Gender should also be a concern for policy-makers seeking to design and implement sustainable energy policies.

The results also show that the motivations for becoming prosumers are quite varied: financial benefits, environmental aspects, technological interest, security etc. This urges the importance of a varied policy that considers all these motivations.

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There is also a challenge in making HSPP affordable to lower income groups. Subsidies, tax reductions or feed-in tariffs are important measures to decrease up-front costs for lower income households. In addition, reducing transaction costs are important to make the technology more accessible. Providing opportunities for low-income households to become prosumers can also be a measure to reduce energy poverty.

Learning from the above, governments can combine different policy tools to enable consumer access to prosuming.

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5 "Heating & cooling" case study

5.1 Introduction

Industrial and residential heating and cooling energy use makes up a substantial share of final energy consumption in the EU. Thus, increasing the efficiency of heating and cooling of buildings can substantially contribute to saving energy and reducing emissions. Moreover, it may offer multiple dividends by simultaneously mitigating problems with energy dependency, excessive greenhouse gas emissions, and improving the well-being of citizens.

The Heating and Cooling Strategy of the European Union assigns a crucial role to the heating and cooling sector in energy transition and is aimed at improving energy efficiency in buildings and industry. However, regulatory measures and interventions can be more effective if they account for the different consumer practices that influence the behaviour of households. The aim of this case study was to better understand the factors that influence household behaviour related to heating and cooling. It draws on findings from France, Germany, Hungary, Spain, and Ukraine.

5.2 Methodology

The case study adopted a focus group methodology, combined with participatory systems mapping. Several focus groups in each country enabled to get a deeper understanding of the challenges consumers face when trying to reduce their heating costs and related energy consumption, and the possible strategies and policy options to cope with these challenges. As cooling accounts for only a small proportion of energy consumption at present, research partners focused on heating by raising the following central question: "How can households reduce their heating costs?".

The research was supplemented by a quantitative analysis. A survey was developed and implemented in order to obtain information about households' heating and cooling habits and practices, the challenges households encounter when deciding which investments to make into improving energy efficiency, and their opinions about different policy options that target energy conservation.

Information from the focus groups, survey, desktop research and secondary database were compared. The comparative assessment revealed cultural and behavioural differences across countries, as well as the common behavioural patterns and common challenges countries share.

5.3 Focus groups results

5.3.1 Results in France

Identified challenges

- Poor insulation is often a problem, especially in old dwellings. The investment that is required appears to be too high and off-putting for many people.
- Poor ventilation and humidity in dwellings lead to condensation and mould growth on walls and windows.
- The characteristics of the dwellings are inadequate.
- Difficult dialogue between tenants and landlords. Most tenants explained that their landlords have little interest in renovating dwellings.

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- Lack of control over heating and the related bills. Some participants stressed that the district heating in their dwelling tends to heat insufficiently well.
- Choice and price of energy for heating. Participants often highlighted the difference between electric and gas heating in terms of price, comfort and installation. They showed many misunderstandings and reported how they struggled to find the right information about the types of heating system and the possibility of using a thermostat.
- Other challenges mentioned include: misunderstandings about how the system works, complicated energy bills, fear of breakdowns and hence not turning off the heating when not needed, the cost of removing an old heating system (e.g. radiators) on top of the installation costs of a new system, difficulty finding reliable professionals or independent advice, differences of opinion, awareness and behaviour between household members, the financial impossibility of moving out of an insalubrious dwelling, and a tendency to self-restrain energy use.

Identified strategies

To deal with these challenges, households mentioned several strategies that fall into two main types of action: personal efforts and external support.

Personal efforts include:

- Relying on themselves using tactics that are perceived as beneficial (e.g. wearing warm clothes, using lined curtains, airing dwellings regularly and at moments of the day when the outdoor air temperature is as high as possible). They also adopt 'eco-gestures' (e.g. using more economic cycles on washing machines) which can save up to €600 each year according to experts.
- Getting informed.
- Programming the thermostat.
- Investing and undertaking long-term refurbishment work: This is especially done by house owners who have relatively greater financial means than many of the participants who rent apartments.

External support types of action for managing the challenges include:

- Relying on financial support from public and private organisations: subsidies for low-income owners; social energy tariffs, energy checks; tax deductions/credits; no-interest loans.
- Public support or NGO help through guidance, advice and mediation, especially in the case of the most vulnerable households.
- Some additional strategies mentioned included: requesting social housing (or new apartment allocation); calling on Mediation actors; going to court as a last resort.

5.3.2 Results in Hungary

Identified challenges

- Room temperature: Physiological needs (e.g. small children or elderly people in the household) overwrite the importance of the heating bill.
- Controllability of room temperature (temporally and spatially): Controlling heating during the day or room by room is rather difficult in many houses and apartments.
- Number of heated rooms: Decreasing the number of heated rooms in the house is often a way of decreasing heating costs, but it may have adverse effects.

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- Efficiency of the heating technology: Efficiency plays an important role in heating, but more efficient heating technologies do not necessarily result in lower energy bills.
- Unnecessary extension of heating season.
- Difficulties of financing old boiler replacement.
- Lack of information (about good solutions) is a problem for many people.
- Financing insulation: People not aware of the payback period and the features of insulation.
- Replacement of doors and windows involves a significant investment.
- Mixed heating, including renewables: Heating costs do not necessarily decrease drastically when increasing the proportion of renewables in heating. Behaviour patterns (e.g. saving preferences or pro-environmental attitudes) are also important and should be considered.
- Availability and price of heating fuels vary across regions.
- Pensioners tend to shift from wood/coal or even gas to electricity heating leading to higher heating costs.
- Characteristics of the building.
- Traditional architecture: traditional ways of moderating the impacts of outdoor temperature (cooling down the house if it is hot outside, or the reverse) are not widely known and used.
- Heating with wood taken from illegally cut trees. A policy toolset to change this behaviour is needed.
- Heating with household waste is a huge problem because it is illegal, unhealthy and unsustainable. Pressure from the community will play an important role in the solution.
- Using collected biomass on a large scale is a huge intrusion into the ecosystem.

Identified strategies

- Taking over and copying good examples from reference groups (family, neighbours, celebrities, etc.).
- Knowledge of a direct relationship between energy consumption and the energy bill.
- Environmental awareness – beyond cost awareness.
- Collecting information, especially when a lack of information is the barrier to action.
- Energy awareness.
- Testing new ways of heating.
- Explore policy measures for people strongly stick to their habits.
- Proper clothing.
- Optimising temperature when at home: lower temperature at night.
- Level of temperature comfort it is an issue of both awareness and physiological needs.
- Effective and appropriate use of a programmable thermostat.
- Appropriate and effective way of ventilation.
- Laziness, carelessness, breaking the law due to lack of enforcement of regulations.
- (Mainly financial) barriers prevent significant steps being taken and is the main reason behind irresponsible behaviour.

Supplementary research on individual preferences related to behavioural change

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The necessity of reducing consumption provokes various individual reactions and the issue is also highly relevant with regard to cutting energy consumption. Q-methodology, which applies the special Q-sort technique for data collection, was used to test the different preferences of people related to behaviour change. The main objective of this research – exclusively carried out in Hungary – was to explore and interpret the priorities of individuals when it comes to the need to adapt habits and lifestyles to changes in consumption circumstances.

Six factors were identified which reflect different types of behaviour preferences: status orientation, strong habitual behaviour, risk aversion, well-being and welfare orientation (combined), strong pro-environmental and health orientation, conscious planning, spending and saving preferences. Energy awareness as such seemed not to be an explicit preference, although it is included partly in pro-environmental orientation, partly in saving preferences.

In the case of strong habitual behaviour, very low or no willingness exists to change current lifestyles, even if circumstances make less consumption necessary. However, new heating-related technological solutions and devices could be useful for people with such preferences, as they do not necessarily require behaviour change. However, the right communication to promote those technological solutions is crucial.

For people with strong pro-environmental and health preferences, rising awareness of healthy ways of heating which are also more environmentally friendly can be an effective policy to (further) change behaviour towards sustainability. For those who have conscious planning, spending and saving preferences, focusing on the patterns of saving, as well as providing advice about practical solutions in terms of heating may be appropriate.

5.3.3 Results in Spain

Identified challenges

- Household incomes and energy price. As both income and price increases, keeping all the rest constant, the energy bill will increase.
- Infrastructure, insulation, orientation of houses. Insulation and orientation can help reduce the heating bill. Square meters and cubic meters have a positive effect on the heating bill (i.e. houses with more rooms, ceteris paribus, require more heating and incur a higher bill).
- Temperature gradient, physical activity at home, number of members and children or elderly people. Temperature gradient (i.e. the difference between indoor and outdoor temperature), and physical activity at home have, ceteris paribus, a negative effect on the heating bill. Other factors, have, ceteris paribus, a positive effect on the heating bill.
- Technological variables were only mentioned in the focus group with academics and experts in energy. They have a negative effect on the heating bill.

Identified strategies

- Investment into insulation, thermal insulation: good thermal insulation practices are important for reducing energy consumption.
- Educate people about energy saving. This factor is very much dependent on the level of environmental awareness.
- Use of thermostats, preferably programmable thermostats that offer different ways to save energy.
- Habits at home: habits at home can influence energy consumption in relation to heating.

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- Taxes versus managing energy poverty. The academic group and the expert group considered that taxes on bad habits could be very effective in managing heating consumption. The citizens' group expressed a strong preference for having policies that could help them to understand energy bills.
- Subsidies: subsidies could increase the penetration of renewable energies and for increasing investment in insulation, while education related to energy savings and environment is necessary for changing habits at home.
- Energy price: an increase in competition between energy firms could lead to a reduction in the final energy price, although this could generate an increase in energy consumption.

5.3.4 Results in Ukraine

Identified challenges

- The temperature inside and outside of buildings influences directly the heating bill.
- Room temperature is one of the most important factors that influences the heating bill, but it is conditioned by availability of metering and regulation apparatus in a separate space. It may be effectively regulated in new or renovated buildings. For the majority of old buildings, it is mostly an unsolved problem. It is also a relevant issue for very old buildings with autonomous (separate) heating systems.
- Ventilation systems: the absence of an effective ventilation system is considered a challenge that directly impacts energy bills.
- Quality of heating services. Sometimes providers look for additional benefits and provide poor quality services. An inappropriate quality heating service results in high bills.
- Fuel types and prices: fuel prices impact what types of fuel are used, but mostly affect individual heating systems, as central heating systems are tied to one fuel type (mostly gas) and district heating systems can switch to cheaper types of fuel only if they are modernized.
- Availability of metering apparatus: this is considered a very important parameter that influences heating bills. The problem is still that not all multi-flat buildings are equipped with metering apparatus.
- Availability of regulators: these are considered to help reduce heating bills by changing the flow intensity of the heating system, but only in cases when the building or flat is equipped with metering apparatus.
- Characteristics of buildings and heating zone: these were considered as very important issues because in ineffective/non-modernized buildings consumers pay more for heating services than in new or modernized ones, and currently many apartments are still being measured and billed according to heating zones, and bills are calculated based on normative rates for heat for one square meter. The technical parameters of the building and insulation, and its quality, as well as any energy efficiency measures that have been implemented, directly influence bills. The higher the energy efficiency of a building, the lower the heating bill.
- Type of heating system (individual/central/district): individual heating systems are the most cost efficient and flexible in terms of providing autonomy; central heating systems are mostly ineffective because of the very limited insulation and lack of modernization; district heating systems might be flexible enough and affordable if they are new or modernized.
- Consumers' behaviour: there are consumers who undertake energy efficiency measures on their own, but there are also many consumers who wait for central or local authorities to implement energy efficiency measures instead of them.

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Identified strategies

- Investment opportunities in energy efficiency measures: these have become part of a strategy to support improvements in energy efficiency in the country.
- Awareness of energy efficiency behaviour: starting from 2014, energy efficiency became an important topic for discussion in mass media, TV and radio.
- Autonomy in heating: this is very relevant for private households and in cities where due to a reduced number of residents and the collapse of industries the average cost of heating has gone up and incomes are growing much more slowly. For many consumers, having an autonomous heating system becomes one of the ways to cut bills and increase independence from communal services.
- Trends: different strategies promoted through certain channels, including the state and business.
- Willingness to economize/save money/cut bills: most consumers have a very clear reference to the economic impact of their behaviour: the heating bill.
- Promotion of the self-governing of buildings: before the Ukrainian Law "On housing and communal services" was adopted, consumers in multi-flat buildings were not active in self-organizing regarding condominiums. However, further governmental regulations have stimulated them more and more. Condominiums would have the chance to choose heat suppliers with more attractive prices.

5.3.5 Results in Germany

Identified challenges

- Degree of insulation: participants argued that a higher degree of insulation decreases heating demand. Insulation is considered as a major investment challenge.
- Individual heating behaviour: this challenge covers all behavioural/habitual factors that influence energy consumption.
- Legislation: participants mentioned the Energy Performance Certificate and an 'energy distribution key'. The Energy Performance Certificate was seen as a factor that could decrease the amount of the heating bill, because tenants can compare dwellings with respect to their energy efficiency. The distribution of shared energy costs was seen as a major challenge and, from a moral perspective, as unfair.
- Size of dwelling: the larger the size of the dwelling, the more rooms need to be heated.
- Number of adjacent dwellings: detached houses consume more heating energy than houses in a closer neighbourhood. The same argument holds for apartments.
- Share of bill, influenced by neighbours' consumption: this challenge only holds for multi-family dwellings where common heating costs are split among the residents according to a fixed rule (energy distribution key).
- Technical status of heating system: this includes both the age of the heating system and whether consumption is manageable (e.g. through thermostats). Old heating systems consume more energy. The efficiency of the heating system is also an issue here.
- Options of suppliers and resources: Both having more resources to choose from (oil, gas, and renewables) and more suppliers will reduce heating costs because consumers can switch to the cheapest resource and supplier.
- Room temperature: If rooms are heated to a higher temperature, heating costs rise.

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- Number and duration of people at home: Having guests or relatives staying at home increases energy consumption because more rooms are heated for a longer time period.
- Outside temperature (weather): Long and cold winters affect the heating bill because rooms need to be heated more to create a comfortable temperature.
- Heating costs: The price of energy affects the heating bill. Participants focused in particular on the lack of transparency of prices due to state regulations (taxes, fees).
- Payback period of investment: If it takes a long time until investments reach their break-even point, fewer people will invest because they are uncertain about future states.
- Number of decision makers concerning renovations/investments: Too many different owners in one multi-family dwelling can block group decisions because of different interests.
- Cost splitting between tenants and homeowners: The expert participants mentioned tenant-homeowner conflicts as a major barrier. It is often unclear who will/should pay for investments. This conflict hampers important investments in energy efficiency.
- Comprehensibility of the energy bill: energy bills are not easy to understand.
- Housing costs: Unemployed people receive money from the state for housing costs. This amount, however, is rather limited. Hence, unemployed/low-income people usually live in apartments with low housing costs, which are also in a bad condition from an energy efficiency perspective (insulation, etc.).
- Number of thermostatic valves/degrees of hydraulic adjustment: thermostatic valves can be used for hydraulic adjustment. With hydraulic adjustment, all radiators have the same temperature. Without hydraulic adjustment, some radiators will stay cold, but the heating system will keep attempting to increase their temperature.

Identified strategies

- Information provision: Information should be provided regarding the environmental consequences of energy consumption.
- Legal regulations about efficient and sustainable heating systems: Tenants suffer from homeowners not investing in energy-efficient heating systems, thus policymakers should intervene and introduce a legal obligation to invest in new heating systems or refurbish existing ones.
- Individual-level billing: individual billing, without any shared cost component where technologically feasible, would reduce the influence of the energy consumption of neighbours. Hence, there would be a stronger incentive to save energy.
- Federal incentive programs: examples were mentioned such as favourable credits for energy efficiency investments and subsidies for energy-efficient heating systems. Incentive programs are also supposed to increase the uptake of investment into insulation.
- Subsidies for renewable energy resources used for heating: subsidies are understood to decrease prices, thus making renewable energy resources cheaper compared to conventional resources.
- Political information campaigns: providing information to increase environmental awareness and to inform citizens about habitual behaviours that can save energy.
- Diversification of energy sources: with more renewables and more energy resources in general, households are less dependent on one single supplier/resource.

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- Efficient energy markets/ Legal price regulations: Efficient (i.e. unregulated) markets are supposed to provide transparent prices, and therefore increase understanding of energy prices and make different resources comparable. Further, participants understood that unregulated prices should be the lowest prices because taxes increase the pure market price.
- Participation of tenants in decision-making: Participants who rented an apartment felt left out and unacknowledged in homeowners' decision-making. They asked for more regulation, which would mandate the inclusion of tenants in decision-making.
- Allowing simple majority votes: Because homeowners tend to block each other's decisions, participants argued in favour of simple majority votes.
- Financial incentives to save energy: the state pays the heating costs of unemployed persons; thus, they have no financial incentive to save energy.
- Investment in public housing: More investment would increase the quantity and the quality of apartments available to low-income households.
- Awareness of comfort and health benefits: the experts argued that households should be made more aware of the comfort and health benefits of energy-efficient housing.
- Number of smartphone apps: Smartphone apps are evaluated as a strategy to reduce heating costs.
- Possibility to refund (higher) housing-rents to unemployed persons: If the state paid higher housing costs for unemployed persons, they could afford to live in better-insulated houses.
- Degree of lobbying: the experts mentioned abolishing lobbying as a general side remark. Lobbying is supposed to increase inefficient legislation.

5.3.6 Common results

Common challenges

- The technical status and age of the heating system, as well as its efficiency: the technical condition and the age of heating systems often hinder their efficient energy use.
- Characteristics of the dwelling in terms of age, condition, orientation, location: if the whole dwelling is old and/or in bad condition, is oriented or located unfavourably in terms of weather conditions, this increases heating-and-cooling-related energy consumption.
- Issues with insulation: poor or no insulation decreases the efficiency of heating.
- Thermostat-related challenges: having a thermostat (or not) and using the thermostat in the right way influences energy consumption.
- Fuel types used for heating/use of renewable resources for heating: Different fuel types have different efficiencies and various environmental impacts.
- Fuel price and fuel price differences: Beyond the availability of different fuel types, their cost is often a challenge, especially for poor, vulnerable groups of society. The cost of different fuel types also has an influence on both the choices and the difficulties of households.
- Difference between inside and outside temperature: many households ignore the fact that cooling should be adjusted to the outside temperature in terms of not setting a drastically different temperature inside compared to the outdoor circumstances.

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- Individual heating behaviours: there are significant differences between the preferred temperature, the habit of heating heavily and the habit of wearing more clothes and maintaining a lower temperature, ventilation habits, etc.
- Sharing of the energy bill by a block of apartments: this often results in a lack of motivation to save energy by heating more rationally.
- Conflicts between tenants and landlords in terms of investing into a more efficient heating system or into insulation, lack of participation in decision-making.
- Conflicts within multi-apartment houses related to investing into renovation.

Common strategies

- Information-sharing and communication.
- Awareness-raising of consumers and policy makers: e.g. when promoting incentive programs both the social and financial benefits should be highlighted.
- Promoting the availability of technological solutions.
- Financial measures.
- Tools for fighting energy poverty.

5.4 Household survey results

The ENABLE.EU household survey included a specific block of questions covering three major sets of "heating" questions: Heating habits and patterns that impact energy costs; Challenges citizens face when aiming to reduce their energy consumption; Public acceptance of different policy options aimed at changing behaviour. A brief overview of opinions is provided.

5.4.1 Indoor comfort temperature

Focus groups identified the winter indoor temperature and heating habits as major factors affecting energy consumption and energy costs.

The recommended temperature values in the European standard EN 15251:2007 are a minimum 20°C for winter. The all-country average winter indoor temperature is around 20-21°C (considered neutral for the purpose of this study), but there is significant variation among countries. This phenomenon can be explained by overcompensation for the cold climate, cultural factors, the reduced availability of temperature control equipment in some countries (e.g. Hungary), and the impact of historically low energy prices.

A significant share of people (25.7%) tend to maintain a higher indoor temperature in winter than in the summer in respective countries. Overheating during wintertime and overcooling during summertime may have adverse health impacts.

5.4.2 Availability of control equipment

Insufficient availability of temperature control equipment may partially explain the overheating problem. Promoting the spread of thermostats may contribute to a healthier indoor temperature. District heating service companies may also help by keeping the temperature in the optimal range for their customers.

5.4.3 Heating habits

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Heating only the rooms that are actually in use was considered a way of reaching energy savings. Countries vary widely regarding how common this practice is amongst their citizens. Explanatory factors include culture, age, and the availability of technological options for turning down the temperature in selected rooms. Older people are more willing to heat only some rooms.

5.4.4 Challenges citizens face in case-study countries

Challenges citizens face when intending to reduce their heating-and-cooling-related energy costs overlap in the case-study countries. Still, there are challenges that are more dominant in certain countries than in other countries.

Financial challenges

Insufficient financial resources and the lack of available loan and subsidy programs are highly relevant problems in each country, dominating most in Ukraine and Spain. Calculating the payback on investment seems to be a major problem in Germany and Spain, while this is less relevant in Hungary and France.

'Lock-in' related challenges

Consumers are often locked into unsustainable lifestyles even though they are not willing nor happy to act unsustainably. These lock-ins may have life-stage related, financial, cultural, legal or technological reasons that make it hard for citizens to reduce their energy consumption. Those circumstances may not be relevant for the vast majority of citizens, but may still be pressing for sensitive groups. These 'lock-ins' are present in each country.

Challenges due to conflicting interests of occupants

Disinterest or the conflicting interests of owners and tenants in multiple-apartment houses were mentioned as factors hindering energy-saving investments. This problem proved to be most pressing in Germany. In multi-apartment dwellings, common heating costs are split among the residents, thus individual household reductions in consumption do not necessarily decrease the size of the heating bill. It is also often unclear there who will/should pay for investments.

Information-related challenges

Citizens lack meaningful and frequent enough information about their energy consumption in most countries and complain about their energy bills being overly complicated.

Policy options

Improved feedback about energy consumption. Most people would welcome more frequent and more meaningful information regarding their energy consumption.

Awareness-raising, receiving targeted energy-saving advice. In Hungary and Ukraine, getting practical energy-savings tips and targeted advice is appreciated more than getting information about energy consumption.

Community-based solutions. More than half of all respondents (62.5% in Spain) supported community-based solutions. These include refurbishing houses with the help of the local community or organisations involved in construction works at an affordable price. Refurbishing dwellings with the help of an energy service company or an energy supplier in a way that the resulting energy-savings finance the investment also partly falls into this category.

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Information support. People expressed significant interest in getting national energy efficiency grants and assistance with applications. The help of an energy service company would also be appreciated, provided that the resulting savings finance the investment.

Tools for fighting energy poverty. Expanding the energy subsidies programs would help deprived people and would also contribute to phasing out some illegal and harmful heating practices. The highest support was found in Germany and Spain, and the lowest in Hungary.

5.5 General discussion and conclusion

European consumers are diverse in terms of: heating requirements; financial resources that can be allocated towards low-carbon investment; housing conditions including insulation, home size, ownership; their preferences, willingness and motivation to change their habitual behaviour; their motivation for making changes; their beliefs and misunderstandings about low-carbon options. Still, most challenges and policy options identified overlap in several countries and could be grouped into a limited set of themes that may be tackled with similar policy options.

Challenges overlapping in several countries

- technical status and age of the heating system,
- characteristics of the dwelling in terms of age, condition, orientation, location,
- issues of insulation: poor or no insulation decreases the efficiency of heating,
- fuel types used for heating/use of renewable resources for heating,
- fuel price and fuel price differences,
- difference between inside and outside temperature,
- individual heating behaviour,
- sharing bills between blocks of apartments,
- conflicts and difficult dialogue between tenants and landlords connected to issues regarding investment into more efficient heating systems or into insulation,
- differing interests within multi-apartment houses related to investing into renovation: decision making in multi-apartment houses may block investments into house or heating system renovation.

Strategy options that overlap in several countries

- **Information-sharing and communication**. Common ground for policy recommendations in the participating countries can be detected regarding the following issues: (1) provision of easily understandable practical information about energy-saving solutions, metering and behavioural patterns, (2) multichannel communication for reaching various target groups with appropriate messages, and (3) use of independent, trustworthy parties for successfully influencing the energy-related behaviour of the society.
- **Awareness raising**. Raising awareness regarding (1) energy-efficient behaviour, (2) the interrelationship between energy consumption and its impacts on the environment, on our health, and on the costs of the household, and (3) good examples and the easy ways (and benefits) of behaviour change are crucial in policy making.
- **Technology-related**. Similar strategies include (1) supporting the availability, the cost efficiency and the affordability of new, more sustainable technological solutions for heating. In addition, (2) promoting the modernisation of buildings for better insulation, thermal conditions and ventilation, (3) promoting individual metering and the use of thermostats, and (4) making use of community-based solutions.

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- **Financial measures** stressed both (1) the need to provide more financial incentives for using more renewable energy, switching to more energy-efficient solutions, solving conflict situations (e.g. between landlords and tenants), and (2) the need to penalise the overconsumption of energy and polluting ways of heating.
- **Fighting energy poverty,** policy recommendations commonly focused on (1) the need for social support for higher-scale investment into improving the energy efficiency of the houses of vulnerable families, and (2) the need for various social schemes.

Triple dividend options

The project identified triple dividend policy options that create added value.

Creation of environmental, economic and health dividends. Providing information through different communication channels about the required temperature results in less energy consumption, creating less environmental load, savings on energy costs, and a healthier lifestyle. Different (trusted) communication channels are important here, as different target groups have to be approached in different ways. A properly designed insulation programme also appears to be a triple-dividend solution: less energy is consumed, making significant savings for households, along with less emissions and a healthier lifestyle.

Creation of economic, environmental and community-based dividends. Community-based projects can generate the economic benefits of saving energy costs and the environmental benefits of less pollution, but also result in a better community life and inclusion. Shared practices can have a reinforcing impact on members of the community, encouraging them to find energy saving measures reasonable and to better recognize their benefits. Fair individual billing may also contribute to the triple dividend by reducing suspicion and finger-pointing among neighbours, while creating a common interest in making energy saving investments.

Creation of a health-related, social and environmental dividend. Managing the challenge of heating with waste will also result in a triple dividend. Informing people about how dangerous and detrimental this practice is to their own health may change this behaviour, resulting in better individual and settlement-level health conditions, less social tension and a cleaner environment.

Creation of an economic, social and environmental dividend. Helping low-income bracket households through financial support to invest into refurbishment of more efficient-energy heating systems empowers those households economically. They will be able to pay back loans from the savings they make because of more efficient resource use and hence, less energy costs, while lessening energy consumption is beneficial to the environment as well. Social investment at the EU level should be considered as a form of economic investment - for example, for thermal renovation which creates a triple dividend benefit – reducing the energy consumption of dwellings, lowering energy expenses, and perhaps even lifting households out of energy poverty and making the dwelling an asset that is more environmentally friendly.

Limitations and directions of future research. Most challenges and policy options overlap across several countries. Still, generalization to all European countries cannot be made on the grounds of the present research and further research is needed. In addition, due to the limited length of the survey tool and timing of different tasks we could only add a very limited number of heating-related questions to the survey, thus the major part of our findings still remain qualitative and explorative. Furthermore, the various issues raised in the focus group discussions and the Q-methodology (see results in Hungary) are worth further investigation.

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European energy policy may involve diverse approaches that fit the circumstances of various social groups. Identifying affordable and low-carbon options for vulnerable groups may create a triple-dividend in terms of reducing carbon footprint, maintenance costs, and energy dependence. These policy recommendations could thus be considered by policy-makers to benefit all European citizens while at the same time contributing to improving energy efficiency and reducing CO2 emissions.

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6 A regression analysis of the factors influencing mobility decisions

6.1 Introduction

The understanding of travel behaviour, and in particular citizens' choices on how to perform their routinely trips, is a fundamental step towards the decarbonisation of the transport sector. Travel mode choice affects the level of greenhouse gases emissions, as well as the local air pollution, the noise and the congestion produced by passenger cars. Being able to quantify how different social and economic factors, as well as cultural and trip related ones, affect this choice is a fundamental step in the transition to low-carbon mobility.

Hence, the specific aim of this section is to understand different users' profiles through the analysis of how different factors affect the probability of using one travel mode or another.

The study relies on the data collected through the ENABLE.EU household survey and in particular its Mobility section, which has been conducted in Hungary, Italy, Norway, Poland and Spain in the beginning of 2018.

The survey collected data about the weekly travel routine of households with a particular attention to the specific modes used to reach a predetermined list of destinations. Moreover, it collected information about preferences affecting travel related choices and satisfaction with transport infrastructure. The total sample of the five countries sum up to 5028 households and it is representative in each country of the national population (for further details about the Household survey see *ENABLE.EU Deliverables 4.1 and 4.2*).

6.2 Methodology

For the analysis of the mode use, we focused on the two trips performed by the highest share of the surveyed population: the trip to the Workplace (or University) and the trip to Grocery shopping.

The trips performed by each household were grouped in three categories based on the main mode used: Private vehicle (PV); Public transport (PT); and Active modes (AM) for bicycle and walking. The derived mode was then analysed through a discrete choice model, as a function of different socio-cultural, attitudinal and demographic factors to estimate how these affect the travel mode choice. In particular, the selected discrete choice model is a multinomial regression model which allows to estimate how different factors affect the probability of using a mode with respect to the others.

6.3 Results

Figure 1 and Figure 2 show the normalised distributions by country of the modes used to perform respectively the Workplace/University and the Grocery/Shopping trips. For each transport mode, a bar represents the share of users of a specific country compared to the other countries, so that shares within a single mode sum up to 100%. As the data shows, Italy has the highest share of trips performed by private vehicle for both destinations, while Spain presents the lowest values; with respect to Public transport, Norway has the highest share of trips to work, while Hungary has, by far, the highest share of trips to grocery shopping. In this case, the lowest shares are found for Italy for the Workplace trip and Spain for the grocery shopping trip. Finally, Spain presents the highest shares of trips using bicycle and/or walking for both the destinations, while Italy presents the lowest values.

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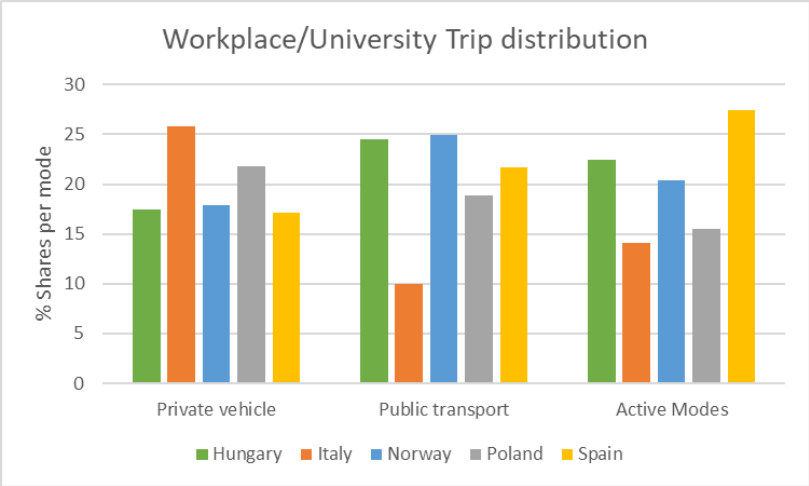

Figure 1: Normalised percentage distribution of mode use in the countries for the Workplace/University trip

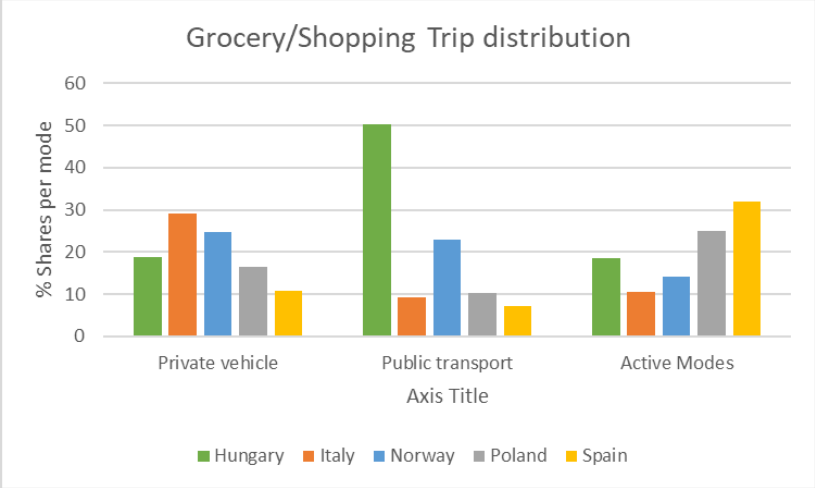

Figure 2: Normalised percentage distribution of mode use in the countries for the Grocery/Shopping trip

Table 2 reports the descriptive statistics used in the multinomial regression model[4]. The explanatory variables included in the model were classified under 5 main groups: The *Country Effects*, the *Trip Characteristics*, which include the information whether the trip starts from the interviewee house, the distance in kilometres and the frequency of the trip for each particular destination, *Attributes of the trip choice* which estimate the effect of considering determined factors, such as Cost, Comfort, Flexibility, etc., as very important when deciding which mode to use. These attributes are common to both destinations as they represent overall preferences of the interviewees. Fourth, there are two variables assessing the *level of satisfaction* with the infrastructure. In particular, the satisfaction with the presence of parking spaces and public transport in the area where the household live pertain to this category. Fifth, several *Socio-demographic characteristics* collected in the household survey have been included. These comprise education, age, being a full-time worker, gender, living in a city and an assessment of the level of comfort provided by the present income.

[4] The list of variables used represent the model which best fitted our data. Some variables collected during the survey have been excluded as these were not significant explicators of the mode choice. These include the factors Travel time, Security, Availability and Reputation.

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Table 2 Descriptive statistics of the variables considered in the analysis

Variable	Description	Stat
Workplace/University Mode	Categorical variable indicating the main mode used for the workplace /university trip. Categories: Private Vehicle, Public Transport, Active modes.	PV = 58% PT = 25% AM = 17%
Grocery/Shopping Mode	Categorical variable indicating the main mode used for the grocery/shopping trip. Categories: Private Vehicle, Public Transport, Active modes.	PV = 52% PT = 4% AM = 44%
Country Effects)	Dummy variables indicating the country where the interviewee resides, Norway, Hungary, Italy, Poland or Spain.	
Trip Characteristics		
Leaving from Home	Dummy variable indicating if the starting point of the trip is the house of the interviewee	Work. = 95% Shop. = 85%
Frequency	Frequency of the trip in terms of days in a week, from 1 to 7	Work. = 4,9 Shop. = 3,2
Distance	Distance in kilometres from the starting point to the destination	Work. = 11,3 Shop. = 3,6
Attributes (stated as Very important in the Likert scale)	Dummy variables indicating the importance[5] of the specific attribute in the decision of the mode to take.	*Percentage variable =1*
Cost	Cost of the trip	36,4%
Comfort	Comfort provided by the travel mode	34,2%
Flexibility	Flexibility provided by the travel mode	38,0%
Privacy	Privacy feeling provided by the travel mode	26,0%
Air Quality Impact	Concerns about the travel mode's impact on air quality	24,7%
CO2 Emissions Impact	Concerns about the travel mode's impact on CO2 emissions	24,7%
Reliability	Perceived reliability of the mode	47,7%
Infrastructure satisfaction	Dummy Variables indicating a high or very high satisfaction level with respect of different transport related infrastructures[6]	*Percentage variable =1*
Parking presence	Level of satisfaction with the presence of parking space in the household's area	39%
PT satisfaction	Average value between satisfaction with the public transport timetables and coverage	34,6%
Socio-economic factors		*Percentage variable =1*
Highly Educated	Dummy variable which takes value 1 for university or higher education level	29,7%
Age	Age of the interviewee	48,8(Mean)
Fulltime Worker	Dummy variable which takes value 1 if the interviewee is a fulltime worker	49,3%
Female	Dummy variable taking value 1 if the interviewee is female	54,6%
Children	3-level categorical variable indicating if the household has 0, 1 or more than 1 underage children	0= 60,9% 1= 20,4% >1= 18,7%
Living in City	Dummy variable taking value 1 if the household resides in a small or big city, compared to a village or rural area	73,6%
Comfortable Living	Dummy variable taking value 1 if the household state their present income allows to live in a sufficiently comfortable manner.	71,8%

6.3.1 Trip to the Workplace/University

The final sample used to analyse the trip to the workplace or university counts 2183 households. Of these, 69% travels 5 times per week, 17% more than 5 times and 14% less than 5 times. Table 3 reports the results of the multinomial logistic regression for this trip.

[5] Variables take value 1 if the interviewee answered "Very important" out of a 5 level Likert-scale from "Not at all important" to "Very important".

[6] Values based on a 5 Likert scale from "Very low" to "Very high"

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727524.

Country effects

Italy and **Spain** have a significantly higher probability of using private vehicles for going to work with respect to **Norway**. In particular, a household in Italy has a 20% higher probability compared to a household with similar characteristics in Norway to use a private vehicle, while in Spain this is 14% higher. The effect for **Hungary** and **Poland** is not statistically significant.

Trip characteristic.

Households **leaving from home** (not from other previous destinations) have a 16% higher probability of using public transport and an equivalent lower one of using their private vehicle. In addition, an increase of 1 kilometre in **distance** significantly increase the probability of using public transport for a 0,4%. The **frequency** of trip does not affect the probability of using any of the modes significantly. The distance decreases the probability of choosing an active mode transport.

Attributes of the choice.

Users stating that **cost** play a *very important* role in shaping their decision have a 14 percentage points higher probability of going to work by public transport. Those who seek **comfort** or **flexibility** instead have respectively a 11 and 12% higher probability of using their private vehicle. Those considering **privacy** a very important factor, have a 7% higher probability of going by private vehicle. Interestingly, a significant effect is found for the importance of the **impact of CO2 emissions,** which increases the probability of using Public transport by 12%. No significant effect is found for **reliability** and the impact on **air quality**[7].

Infrastructure Satisfaction.

It seems to play an important role in the choice of the mode to use to go to work. Households that stated to be *highly or very highly satisfied* with the **presence of parking space** in the area where they live have an 8% higher probability of going to work by car. The **satisfaction with the public transport** infrastructure leads to a 24% higher probability to use this mode.

Socio-economic factors.

Age increases the probability of using a private vehicle by half of a percentage point for each additional year. Being a **fulltime worker** increases this same probability by 12%. Gender also seems to play a role in this context with **women** having a 13% higher probability than men of going to work by public transport. Having more than one **child** increases by a 5% the probability of going to work by car. People **living in cities** have a 13% higher probability of going to work by public transport. Households stating that their present income allows them to **live comfortably** have about a 10% higher probability of going to work with their private vehicle.

[7] in this case, the high correlation with the importance of impact of CO2 emissions (0,82) might have affected the significance level of the variable

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Table 3 Marginal Effects of the Multinomial logistic regression for the trip to Workplace/University

	Private Vehicle		Public Transport		Active mode	
Country Effect (Compared to Norway)						
Norway	(Reference)		(Reference)		(Reference)	
Hungary	0.00380	(0.0391)	-0.00679	(0.0389)	0.00299	(0.00229)
Italy	0.204***	(0.0275)	-0.202***	(0.0274)	-0.00255	(0.00171)
Poland	0.0426	(0.0392)	-0.0436	(0.0390)	0.000987	(0.00137)
Spain	0.138***	(0.0284)	-0.137***	(0.0282)	-0.000410	(0.00102)
Trip Characteristics						
Leaving from Home	-0.162**	(0.0723)	0.158**	(0.0721)	0.00341	(0.00289)
Frequency	0.00144	(0.0168)	-0.00183	(0.0167)	0.000387	(0.000478)
Distance	-0.00188*	(0.00111)	0.00374***	(0.000863)	-0.00186**	(0.000939)
Attributes (stated as Very Important in the Likert scale)						
Cost	-0.141***	(0.0319)	0.140***	(0.0319)	0.00139	(0.00117)
Comfort	0.106***	(0.0283)	-0.104***	(0.0282)	-0.00176	(0.00138)
Flexibility	0.117***	(0.0294)	-0.115***	(0.0293)	-0.00242	(0.00168)
Privacy	0.0725**	(0.0296)	-0.0708**	(0.0295)	-0.00166	(0.00130)
Air Quality Impact	-0.0683	(0.0443)	0.0663	(0.0440)	0.00196	(0.00181)
CO2 Em. Impact	-0.123***	(0.0447)	0.121***	(0.0446)	0.00207	(0.00182)
Reliability	0.0303	(0.0298)	-0.0302	(0.0297)	-0.000156	(0.000835)
Infrastructure Satisfaction						
Parking presence	0.0811***	(0.0256)	-0.0805***	(0.0256)	-0.000593	(0.000760)
PT Satisfaction	-0.243***	(0.0316)	0.243***	(0.0315)	-9.13e-05	(0.000694)
Socio-economic factors						
Highly Educated	0.0186	(0.0271)	-0.0181	(0.0270)	-0.000510	(0.000774)
Age	0.00504***	(0.00107)	-0.00500***	(0.00106)	-3.62e-05	(3.49e-05)
Fulltime Worker	0.119***	(0.0428)	-0.118***	(0.0428)	-0.00101	(0.00120)
Female	-0.133***	(0.0260)	0.133***	(0.0259)	-6.52e-05	(0.000658)
Children						
No Children	(Reference)		(Reference)		(Reference)	
1 Child	0.0217	(0.0329)	-0.0212	(0.0328)	-0.000474	(0.000899)
>1 Children	0.0567*	(0.0325)	-0.0565*	(0.0324)	-0.000135	(0.000873)
Living in City	-0.124***	(0.0251)	0.125***	(0.0250)	-0.000510	(0.00104)
Comfortable living	0.0964***	(0.0366)	-0.0939**	(0.0365)	-0.00249	(0.00183)
Pseudo R^2	0.3020					
Observations	2,183					

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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6.3.2 Trip to the Grocery/Shopping

The same model specification of the trip to work has been used for analysing the trip to grocery shopping. Here, 4425 out of 5028 household stated to perform this trip at least once a week. 51% of them travels either 2 or 3 times per week, 36% more than 3 times and 13% only once a week. Due to missing values in the completion of the survey, the final sample use counts 2960 households. Table 4 reports the results of the multinomial logistic regression for this type of trip.

Country effects.

Households of all countries but **Italy** have a statistically significant difference with Norway with respect to the modes used. Households in **Hungary** have a 21% lower probability of going shopping by car, compensated by a 5% higher probability of going by Public transport and a 15% higher probability of going by foot. In **Poland** and **Spain**, households have a 25, and 27% respectively, lower probability of going by car and a 23 and 27% higher probability of going by foot instead. In both these countries the effect on Public transport use is not significant for shopping destinations.

Trip characteristics.

Leaving from home (not from other previous destinations) translates into a 12% higher probability of going by foot or bike to the grocery, while implies a 4% lower probability of going by public transport and 8% lower probability of going by car. Going more **frequently** to shopping increases by 3% the probability of going by foot for each extra day in which the trip is performed. This reduces the probability of going by car while has no significant effect on the use of public transport. One additional kilometre in **distance** of the trip heightens by 8% the probability of going by private vehicle and by 0,5% the probability of going by public transport, while reduces the one of going by foot or bicycle by more than 8%.

Attributes.

Considering **cost** as a very important factor increases the probability of using active modes by 5% and decreases the probability of going by car by 6%, while it has no effect on public transport. Those households who consider **comfort** as a *very important* factor have a 14% higher probability of going by car, compensated by a 2 percentage points lower one of going by public transport and a 12% lower for active modes. Both concerns towards the **impact** of transport on **air quality** and the one on **CO2 emissions** have an 8% and 6% respectively significant lower probability of using their private car to go shopping. However, only the first of them increases the probability of going by foot or bicycle significantly. Households considering the **reliability** of a mode to be very important have a 5% higher probability of going by car and an equivalent lower probability of going by foot. No significant effect in this case has been found for **flexibility** and **privacy**.

Satisfaction with infrastructure.

Being satisfied with the **parking availability** in the area where living heightens the probability of going by car by almost 6%, reducing the one of going by public transport by 2% and by active modes by 4. Surprisingly, being satisfied with public transport infrastructure significantly increases the probability of going by foot or bicycle by almost 7%, more than the 3% increase for public transport itself.

Socio-economic factors.

Being **highly educated** reduces by almost 4% the probability of going shopping by foot or bike. Being 1 year **older** slightly heightens the probability of going by car by a 0,1%. **Working fulltime**, significantly increases the probability of going shopping by car by 9 percentage points and at the same times lowers by 2 the probability of using public transport and by 7 the one of using active modes. Having **children** significantly increases the probability of going shopping by car, by 9% for households having 1 child and by 12 for those having more than one. This reduces the probability of going by public transport of respectively, a 2 and 3%, while for active modes the percentage reduction is of 7 and 9%. **Living in a city** increases the probability of going by public transport to the grocery by 2%. Finally, households considering that present income is sufficient to **live comfortably** have a 13% higher probability of going shopping by car.

Table 4 Marginal Effects of the Multinomial logistic regression for the trip to Grocery shopping.

	Private Vehicle	Public Transport	Active mode

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Country Effect						
Norway	(Reference)		(Reference)		(Reference)	
Hungary	-0.207***	(0.0382)	0.0532***	(0.0189)	0.154***	(0.0362)
Italy	0.0362	(0.0343)	-0.0164	(0.0110)	-0.0198	(0.0325)
Poland	-0.250***	(0.0451)	0.0170	(0.0167)	0.233***	(0.0456)
Spain	-0.273***	(0.0453)	-0.00154	(0.0141)	0.274***	(0.0450)
Trip Characteristics						
Leaving from Home	-0.0798**	(0.0338)	-0.0435***	(0.00873)	0.123***	(0.0323)
Frequency	-0.0353***	(0.00732)	0.00278	(0.00206)	0.0325***	(0.00712)
Distance	0.0812***	(0.00542)	0.00453***	(0.000687)	-0.0858***	(0.00564)
Attributes (stated as Very Important in the Likert scale)						
Cost	-0.0613**	(0.0241)	0.00778	(0.00896)	0.0536**	(0.0224)
Comfort	0.139***	(0.0261)	-0.0238***	(0.00784)	-0.115***	(0.0257)
Flexibility	0.0215	(0.0237)	0.000246	(0.00817)	-0.0217	(0.0222)
Privacy	0.0344	(0.0262)	-0.0104	(0.00911)	-0.0240	(0.0246)
Air Quality Impact	-0.0754**	(0.0361)	-0.00185	(0.0118)	0.0772**	(0.0341)
CO2 Em. Impact	-0.0598*	(0.0348)	0.00909	(0.0136)	0.0507	(0.0331)
Reliability	0.0531**	(0.0234)	-0.000120	(0.00738)	-0.0529**	(0.0220)
Infrastructure Satisfaction						
Parking presence	0.0566***	(0.0196)	-0.0177**	(0.00719)	-0.0389**	(0.0186)
PT Satisfaction	-0.0956***	(0.0238)	0.0298***	(0.0103)	0.0658***	(0.0229)
Socio-economic factors						
Highly Educated	0.0377	(0.0231)	0.000158	(0.00868)	-0.0379*	(0.0212)
Age	0.00143*	(0.000813)	-0.000113	(0.000263)	-0.00132*	(0.000770)
Fulltime Worker	0.0900***	(0.0249)	-0.0213**	(0.00985)	-0.0687***	(0.0233)
Female	-0.0305	(0.0192)	0.00503	(0.00678)	0.0255	(0.0179)
Children						
No Children	(Reference)		(Reference)		(Reference)	
1 Child	0.0880***	(0.0264)	-0.0176*	(0.00978)	-0.0704***	(0.0252)
>1 Children	0.121***	(0.0276)	-0.0344***	(0.00873)	-0.0867***	(0.0273)
Living in City	-0.00859	(0.0236)	0.0207***	(0.00697)	-0.0121	(0.0229)
Income description	0.129***	(0.0273)	-0.0161	(0.0106)	-0.113***	(0.0261)
Pseudo R^2	0.2939					
Observations	2,960					

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6.4 Conclusion

In this section, we analysed how different factors affect the probability of using different modes for two specific recurrent destinations: the trip to the workplace or University and the trip to grocery shopping.

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As the results show, several socio-demographic and behavioural factors affect the decision of mobility. Overall, the impact of these factors on the two destinations is quite different. For the trip to the workplace, they mainly describe significantly only the choice between public transport and private vehicles, while for the trip to shopping they impact on all the three modes.

The factors have been grouped under 5 main categories. The first one is represented by specific *country effects* and has been useful to isolate effects of being living in a specific country. These effects are significant for some of the countries and also in this case, it changes significantly from one destination or the other. For instance, **Norway** which is the country with the lowest probability of going to work by car is the country with the highest in the case of the trip to grocery shopping. Also, while for work destination **Hungary** and **Poland** are not significantly different from Norway, it is more likely that people use less private cars for shopping trips. In **Italy,** it is more likely to find people using private car for work trips and in **Spain** it is more likely than in Norway to find people using active mode for shopping and less private car but also more private car for work trips.

Trip characteristics. **Leaving from home** in both cases reduces the probability of going by private vehicles. This suggests that people who instead connect these trips to other previous destinations have a higher probability of deciding to move by car. The more **frequently** people goes shopping the more likely they are to go by foot, while the same does not stands for the workplace destination. This might represent household preferring neighbourhood shops since it has been found that distance has a negative impact on active mode choices. **Distance** is the only variable that assumes statistically significant values for all the estimations. While on the way to work a longer trip increases the probability of choosing public transport, in the trip to grocery it heightens the probability of going by motorised transport modes, mainly private ones.

Attributes of the trip. Households who consider the **cost** of the trip as a very important factor tend to use less the private vehicle and have higher probability of going by public transport to work or by active modes to the grocery. On the contrary, those households seeking **comfort** of the travel mode tend to prefer their private vehicle for both destinations. The same stands for those valuing importantly the **flexibility** and the **privacy** guaranteed by the travel mode, although this is significant only for the workplace destination. In addition, people seeking a **reliable** travel mode have a 5% higher probability of choosing the private vehicle for their trip to the grocery. Interestingly, people's concerns towards the environment also translate into a lower propensity of using private vehicles in favour of public transport and active modes. In particular, for both destinations, households stating to have a high concern towards transport-related **CO2 emissions** have a lower probability of using private vehicles. Concerns on the impacts on **air quality** have also been found to be significantly affecting this propensity for the grocery shopping.

S*atisfaction with the infrastructure.* Those households that are satisfied with the **availability of parking** are more inclined towards using their private vehicles, and those satisfied with the **condition of the public transport** tend to use more this mode. Even though, for grocery shopping, this last satisfaction impacts even more on the use of active modes.

Moreover, several *socio-economic factors* are found to affect the probability of choosing a specific transport mode. Although, surprisingly, being **highly educated** is found to have almost no effect, being **older** and **working fulltime** increases the probability of using the private car instead of other modes. **Women** tend to use less the car with respect to men for going to work, although no effect was found for the trip to the grocery. Having **children** is a significant factor for the trip to the grocery shopping, where it increases the probability of using private car, while to some extent it also affects the trip to work for those households having more than 1 child. Finally, households **living in cities** have a higher probability of moving by public

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transport to both destinations, while those **living more comfortably** with their current income have a higher probability of using their private car.

In conclusion, some remarks can be drawn upon these results. A first aspect to note is that households have been found to act consistently with their preferences. In particular, seekers of comfort, flexibility, privacy and reliability seem to prefer the private vehicle to other modes. But also those households concerned about the environment act consistently with their beliefs preferring active modes or public transport. Infrastructure, and in particular how its quality is perceived, is by far the most important factor explaining the use of a mode or the other, particularly for workplace destinations. Also the impacts found based on socio-economic factors can highlight which are the groups where some effort should be done to increase their propensity to reduce private car use in favour of more sustainable transport modes. Families with children and fulltime workers for instance, might be target of interest. Finally, the policies to promote this transition should also be careful to account for the country specific context, since this is also a significant determinant of households' travel behaviour.

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7 A regression analysis of the factors influencing heating energy costs

7.1 Introduction

The heating and cooling case study carried out in the frame of ENABLE.EU research project intended to explore the main factors affecting households' heating energy use, one of the main contributors to energy consumption accounting for approximately 20% of final energy use in the EU[8], while still having a huge potential for energy-efficiency improvements[9]. A wide range of studies focus on the factors that influence heating and cooling energy use of households and the possibility of energy conservation, focusing on several aspects and drawing on several disciplines. Besides the economic and technological factors, they analyse socio-cultural and demographic characteristics, attitudes, values, beliefs, as well as the habits and daily practices of households. The literature review of the ENABLE.EU project[10] provides a review of the main findings of the related literature, which, in general reveal the importance of economic and technological, as well as the social and demographic factors, while show quite mixed results regarding attitudes, values, habits and daily practices. However, it is agreed that these factors might be very important drivers of energy-efficiency investments, and the benefits of energy-conservation measures are highly dependent on the energy-using behaviour of households (EEA 2013), given that the preference for comfort and the so called 'rebound effect' might counterbalance the savings achieved.

Our quantitative analysis is based on the dataset of the ENABLE.EU household survey, which included a special section on heating and cooling for five European countries: France, Germany, Hungary, Spain and Ukraine, designed to provide additional information for the Heating and Cooling Case Study of the project. The case study aimed at eliciting information from households about the possibilities and obstacles they face when trying to implement energy conservation measures, including energy efficiency investments and everyday consumption practices. Because the amount of heating energy used by households might be very difficult to quantify in some cases, especially when wood or mixed energy sources are used for heating, the amount of heating bill was used as a proxy for measuring the level of energy use. Besides energy cost, the questionnaire included a wide range of questions related to respondents' dwellings and household characteristics, their energy-saving opportunities and obstacles, attitude and consumption practices, providing an opportunity to explore relationships in the level of energy costs and the possible influencing factors.

Our present analysis is an initial step in investigating these relationships. We categorized the factors of our main interest into five groups: 1) variables related to household income, 2) external influencing factors, 3) knowledge and availability of information, 4) environmental awareness and 5) energy using practices. We are interested in the effects of these broadly defined factors on households' spending related to heating in the five countries. Income is distinct from the other four categories being a generally used control variable included in many traditional quantitative analyses. However, in our research we had the opportunity to explore the effect of subjective income situation besides the objective income level of households,

[8] Including water heating, based on 2016 data. Source: Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_consumption_in_households

[9] COM(2016) 51 final on An EU Strategy on Heating and Cooling, https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v14.pdf

[10] See deliverable D2.2 available on the project's website.

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investigating whether the subjective financial well-being of a family influence their actual spending. Our hypothesis is that households which are less satisfied with their monetary situation, spend less money on the modernisation of the house and heating system, so they spend more on heating compared to people who have a similar income level but have no problem with their financial well-being.

The external social attributes refer to social factors that are mostly beyond the control of the households. These include variables describing whether the owner and the tenant of the dwelling are different, to what extent the behaviour of the neighbours influences own energy consumption, or whether the given individual spends most of his time at home or not. Limited availability of information can distort optimal decisions due to actual information shortage or because of the lack of ability to use the information available (i.e: if somebody is not able to understand her/his energy bill) or the two factors combined. We suppose that people facing such social or informational barriers tend to pay higher heating bills as they are not fully aware of their actual consumption and the possible level of savings.

Environmental awareness refers to the attitude of the given person toward environmental issues. We assume that people who are more environment friendly tend to use less energy due to energy saving practices and by investing in efficient technologies. Finally, we assume that daily energy consumption practices and routines can also affect the energy bill: people who often forget to turn down the temperature at night (albeit they agree that it would be the correct thing to do) or postpone energy-saving measures pay higher heating bills.

In the following sections we present the most important insights from the descriptive statistics of the variables used, as well as the results of the regression estimates for the five countries. After providing a brief overview of the variables used based on their descriptive statistics, we present the estimation method and then summarise the estimation results and the main conclusions of the analysis.

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Description of the data

Tables Table A 1 to Table A 8 in the Appendix include the descriptive statistics of variables involved in the analysis. Our main variable of interest, the heating cost, differs substantially across countries mainly due to variations in the types of heating sources used and household fuel prices, influenced by national regulation, taxes, levies and system-related tariffs (e.g. in case of heating based on natural gas, district heating or electricity). As can be seen from Table A 1, the mean value of monthly heat cost in German households is more than three times higher than the average of Ukrainian bills. The highest variation among monthly bills is observable in Hungary, albeit cost variations are present for the most part due to differences in household size and dwelling characteristics.

TablesTable A 2 and Table A 3 show the statistics of control variables used in our analysis. Single detached family houses represent the highest share according to dwelling type in France, Germany and Hungary, while in Spain most of the respondents live in apartment buildings. The Ukrainian respondents live mainly in single detached houses and larger apartment buildings. The share of buildings constructed after 2000 is the smallest in Hungary and Ukraine, and the share of the oldest buildings is also higher in these countries. People living in large cities compared to settlements in the countryside are highly represented in Germany compared to the other four countries. As regards insulation, the majority of the dwellings have at least one type of insulation (attic and/or roof, cavity wall and external wall insulation) in France and Germany. However, more than half of the dwellings lack insulation in the other 3 countries. The proportion of dwellings having all 3 types of insulation is quite small in the sample, ranging from 0,7% in Ukraine to 3,5% in France, while in Germany more than 14% of dwellings are fully insulated. The dominant heating source is mostly electricity (31% of observations) and natural gas (29%) in France, in Germany natural gas heating dominates (53%), but heating oil is also widely used, unlike in other countries (27%). Gas-heating is the most important heating method in Hungary (54% of households), followed by wood-burning (26%). In Spain, most households heat with electricity (51%) and wood (24%). In the Ukraine, district heating and natural gas represent a similarly high share among heating sources (36 and 37%, respectively), and wood is also highly used by the respondents (14%). French and German households are way ahead of the other 3 countries in terms of temperature controllability: while the share of homes with controlling device is 85% and 92% in these countries, more than a quarter of the households cannot yet regulate the temperature in Hungary and Spain, while in the Ukraine less than half of the households has controlling device.

The variables representing income brackets and subjective perception of household income are interrelated in the sense that above the 3rd income quintile, a smaller share of people states having financial difficulties compared to the lower quintiles, albeit 25% of households feel this way even in the highest income group.

As Table A 3 shows, households are composed of 2 or 3 members on average in the sample. Females were more likely to be respondents in all surveyed countries. Countries vary in terms of the education level of respondents, while the distribution by employment status is quite similar, with around or over 50% being employed and over 30% pensioner and other inactive persons.

Among the external factors that might influence energy-saving behaviour (Table A 5), the fact that the energy bill depends also on other households' consumption seems to be an important factor in Germany, while the necessity to obtain the consent of other tenants in apartment buildings is determinant mainly in Spain and Ukraine, and also in Germany for the cases where the question is applicable (mainly in case of non-detached houses). Although we could not precisely identify owners and tenants in the survey, relatively more German and French respondents compared to the other 3 countries claimed that being a tenant and not an owner

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means a challenge for them in trying to decrease their energy bills, probably due to the higher share of rented versus owned dwellings in these countries. Staying at home during the day does not show high variability among the households in the different countries, around one third of the respondents spend much time at home, including both pensioners and non-pensioners. Monument protection problems affect less than 20% of the dwellings in the sample. According to Table A 6, lack of information on actual energy consumption is regarded as a problem by almost half of the respondents in Germany, and more than a third of the households in France and Spain, while Hungarian and Ukrainian respondents consider it to be relatively less important. Except for France and Hungary, the problem that households cannot calculate the payback on their energy efficiency investments is thought to be an important obstacle by the majority of people. The difficulty of interpreting complicated energy bills is mostly claimed as a problem by German households, causing concern for at least a quarter of households in the other countries as well.

Table A 7 includes frequencies for some selected variables on environmental awareness. The responses to general questions related to environmental issues reflect a generally high pro-environmental attitude in case of the first 3 questions included in Table A 7. Nevertheless, the majority of people think that environmental policies should not cost them extra money. The statistics underline previous research results related to the gap observed between claimed energy awareness and actual pro-environmental behaviour (e.g. Kollmuss, Agyeman 2002, Gadenne et al. 2011). We also included the variable 'I have already done what I could do to reduce my energy bill' as a possible – although still subjective - measure of environmental awareness. It is interesting to see that more than half of the respondents – except for Hungarian households – feel that they have already done everything to reduce their energy costs.

Table A 8 includes variables describing energy using practices and the attitude towards implementing energy saving plans. Forgetting to turn down the heating is not so much cited as a reason for not being able to reduce energy bills, however postponing energy saving plans was mentioned by almost a third of German and Ukrainian households as a problem. A quite high proportion of households heats only the rooms in use, mostly in France and Spain, although in the territories of these countries high variations exist in heating degree days, so probably in many homes temperature differences are not so substantial between heated and unheated rooms. Nevertheless, the share is also high in other countries, over a quarter of households try to save energy and reduce costs this way.

7.2 Methodology

As the analysis covers data of five separate countries, it is an important question whether to estimate a pooled-regression or run the same model for all countries separately. We are mainly interested in the differences between the five countries with respect to the variables of interest, and it is highly likely that the coefficients would be not similar. Because of this fact a good pooled model should include country fixed effects and the interaction of these fixed effects with the explanatory variables. However, that would make our model unnecessarily complex and difficult to interpret, so we decided to estimate the regression model for all five countries separately and compare the results.

As we already highlighted in the data description section, our planned dependent variable, the monthly heating bill varies substantially across countries. In case of Hungary and Ukraine the average Euro exchange rates for 2018 January were used to calculate the heating costs in Euros. It is, however, a problem that the household heating market and purchasing power is very different in all five countries. This result in the fact that a 3 EUR coefficient received from the estimation in Hungary for example can have a very different meaning than a 3 EUR coefficient in Germany.

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In order to be able to compare our regression results between the different countries we standardized the heating bill variable using the formula (1):

$$(1)\ shbill_{c,i} = \frac{hbill_{c,i} - \frac{\sum_1^n hbill_{c,i}}{n_c}}{\sqrt{\sum_1^n (hbill_{c,i} - \frac{\sum_1^n hbill_{c,i}}{n_c})^2}} = \frac{hbill_{c,i} - \overline{hbill_c}}{std(hbill)_c}$$

Where c is the country in which the corresponding responder resides, i stands for the different individuals, and n shows the total number of respondents. $shbill$ is the standardized heating bill variable with mean 0 and standard deviation 1 and $hbill$ is the raw monthly heating cost variable in EUR. So, the variable is created by subtracting the mean of heating costs from the value for given observation and then dividing it by the sample's standard deviation by country.

Using the standardized monthly electricity bill variable, we define our main regression according to equation (2):

$$(2)\ shbill_{c,i} = \alpha + \beta_1 * housechar_{i,c} + \beta_2 * individchar_{i,c} + \beta_3 * incomevar_{i,c} + \beta_4 * outsidevar_{i,c} + \beta_5 * informationvar_{i,c} + \beta_6 * enviromentalvar_{i,c} + \beta_7 * routinevar_{i,c}$$

where $housechar$ and $individchar$ represent the main characteristics of the household (size, age, etc.), and the socioeconomic characteristics of the respondents (age, education, etc). The other sets of variables represent the main variables of interest belonging to the five groups which defined earlier. $incomevar$ denotes the variables related to objective and subjective income, $outsidevar$ involves the factors that are beyond the control of households but may affect their heating bill significantly. $informationvar$ includes variables representing information processing and gathering constraints, $enviromentalvar$ stands for variables related to environmental awareness, while $routinevar$ collects factors which describe energy-related behaviour and daily routines. The complete list of variables included in our regression and their descriptive statistics can be found in the Appendix. We used sample weights in the regression estimation to obtain representative results and robust standard errors.

7.3 Results

This section provides a summary of the regression results focusing on the variables of interest categorised into the five pre-specified groups. As our regression equation revealed, dwelling attributes and socioeconomic control variables were also included in the estimation. However, as these variables were not in focus, we only briefly mention here that dwelling attributes and households' characteristics generally show significant relationship with heating costs in all countries, while socioeconomic factors do not seem to influence the level of standardised heating costs. Detailed results related to these two categories can be found in the Appendix.

Table 5 summarizes the main characteristics of the estimated regression. It is visible that the variation in heating costs is explained to a quite different extent in the five countries. In Hungary the R^2 of the regression was only 0.13, while in Spain it reached 0.57.

Table 5: Main descriptive statistics of the estimated regression, source: Authors' own calculations

	(1) France	(2) Germany	(3) Hungary	(4) Spain	(5) Ukraine
Observations	1,054	597	990	580	850
R-squared	0.304	0.595	0.132	0.567	0.214

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In this section we will present the results of the regression based on the five variable categories presented earlier.

Income-related variables

We included two variables in this group. The first variable denotes the national income quintile in which the household's earnings fall based on the income distribution of the specific country. Subjective income is a binary variable showing whether the respondent finds it difficult to live on the household's current income level or not. Table 6 presents the regression results for the income related variables. In case of the categorical variables for income brackets, the reference category is the 1st (lowest) quintile, while in case of subjective income the reference category is when the respondent thinks it is not difficult to live on the current income of the household.

Table 6: Regression coefficients of income group, source: Authors' own calculations

	(1)	(2)	(3)	(4)	(5)
	France	Germany	Hungary	Spain	Ukraine
2nd income quintile	**0.0901**	**-0.00793**	**-0.0137**	**-0.294****	**0.0439**
	(0.0881)	(0.166)	(0.0881)	(0.140)	(0.110)
3rd income quintile	**0.141**	**0.0453**	**-0.138**	**-0.346****	**-0.184***
	(0.101)	(0.134)	(0.100)	(0.154)	(0.111)
4th income quintile	**0.0627**	**-0.0742**	**-0.0474**	**-0.254**	**0.0718**
	(0.104)	(0.139)	(0.128)	(0.181)	(0.136)
5th income quintile	**0.0254**	**-0.0744**	**-0.0703**	**1.440*****	**0.00627**
	(0.136)	(0.128)	(0.109)	(0.322)	(0.148)
Difficult to live with current income level	**0.127***	**-0.00509**	**-0.150**	**-0.181****	**-0.126**
	(0.0701)	(0.0795)	(0.117)	(0.0745)	(0.0879)

According to the results, the objective income level does not affect the heating bill of the households. In France, Germany and Hungary, no differences can be identified between the different income groups. In Ukraine, the middle-income quintile's heating bill is smaller by approximately 0.2 standard deviations than that of all the other groups, however this result is only marginally significant at the 10% level. The only exemption is Spain where significant differences can be observed. The first interesting finding is that households belonging to the 2nd and 3rd income quintiles spend 0.3-0.35 standard deviations less on heating than the 1st quintile. Additionally, households of the richest quintile spend 1.4 standard deviations more on heating than the 1st quintile, which is a massive difference. This shows that in Spain wealthy people ceteris paribus tend to spend more on heating, while this is not the case in other countries.

It is interesting to see that the other income related variable is significant only in Spain as well. According to the results, after controlling for the objective income, those people who find it difficult to live on their current income tend to spend almost 0.2 standard deviations less on heating compared to respondents with similar income but higher subjective evaluation.

External attributes

The external attributes category includes variables representing external barriers to energy efficiency improvements. The group consists of five variables. The first one shows whether the heating bill is affected by neighbours' behaviour. The second one denotes households for which the consent of the neighbours is needed to do refurbishments. We also included a variable that indirectly tries to capture whether the owner of the house is different from the people who live in it (tenant). The fourth variable captures whether the

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respondent needs to spend a lot of time at home during the day, while the fifth variable shows whether the dwelling is located in a monument building with constrained refurbishment possibilities.

Table 7 includes the regression results related explanatory variables of the external attributes category. The problem that the energy bill also depends on the consumption of other tenants, does not influence the level of energy costs in any of the countries. According to the results, individuals who spend a lot of time at home face higher heating costs only in Hungary, but this result is only significant at the 10% level.

Table 7: Regression coefficients of external attributes group, source: Authors' own calculations

	(1) France	(2) Germany	(3) Hungary	(4) Spain	(5) Ukraine
Energy bill dependent on others	**-0.0182**	**-0.106**	**-0.0198**	**-0.0395**	**0.131**
	(0.107)	(0.0875)	(0.132)	(0.0725)	(0.110)
Spend a lot of time at home	**0.0390**	**0.0426**	**0.223***	**0.00504**	**-0.0461**
	(0.0595)	(0.0814)	(0.128)	(0.0847)	(0.0760)
Person is the owner of the house	**0.176****	**0.109***	**-0.0572**	**-0.0753**	**0.0756**
	(0.0697)	(0.0616)	(0.0796)	(0.0782)	(0.0951)
Neighbours' consent is needed for refurbishment	**0.0613**	**0.0691**	**-0.0388**	**-0.175****	**-0.278*****
	(0.0974)	(0.0998)	(0.130)	(0.0794)	(0.105)
Building is a monument building	**-0.167***	**0.348****	**-0.0828**	**0.233****	**0.0956**
	(0.0963)	(0.152)	(0.120)	(0.106)	(0.110)

We received counterintuitive results for the owner-tenant and the neighbour consent for refurbishment variables. The owner-tenant variable is significant at the 5% level for France and at the 10% level for Germany with positive coefficients between 0.1 and 0.2 standard deviations. This suggests that in Germany and France the heating bill is higher in dwellings owned by the households, contrary to the expectation of owners investing more in the energy efficiency of their own flats compared to rented flats. It is also unexpected that in Spain and Ukraine the heating cost is significantly lower in case of flats claiming that the neighbours' consent is needed for the refurbishment of their homes. Finally, the most diverse results occur related to the monument building protection. According to the results the monument status of the building does not have any effect on the heating bills in Hungary and Ukraine. On the other hand, heating costs are much higher in those old buildings which cannot be refurbished easily in Germany and Spain (0.25-0.35 standard deviations more). However, we received a negative coefficient in France (-0.17), which is marginally significant at a 10% level.

Information problems

This group consists of three different variables trying to capture barriers related to information gathering and processing. The three variables are answers to the questions of whether the respondent feel that he receives enough information about his consumption, whether the respondents have difficulties understanding the information presented on their heating bills, and whether the respondent is able to calculate the associated costs and benefits of a potential refurbishing investment.

Table 8 presents the results related to information barriers, according to which variables either have the expected effects or do not affect heating bill at all. Based on the regression coefficients, information and feedback on energy consumption acts as a barrier only in Spain. Those persons who feel they do not receive enough feedback tend to spend 0.16 standard deviation more on heating compared to those who feel to have all the necessary information. The variable for Hungary has a relatively large (0.25) coefficient as well, but because of the large standard error this effect is not significant at any conventional level.

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Table 8: Regression coefficients of information problems group, source: Authors' own calculations

	(1) France	(2) Germany	(3) Hungary	(4) Spain	(5) Ukraine
Not enough feedback about energy consumption	**0.0142**	**-0.105**	**0.246**	**0.159****	**-0.0761**
	(0.0660)	(0.0708)	(0.158)	(0.0803)	(0.0789)
Cannot calculate the payback of investment	**0.101**	**0.166***	**0.190***	**-0.0315**	**-0.0406**
	(0.0834)	(0.0984)	(0.0991)	(0.0726)	(0.0798)
Cannot interpret energy bill	**-0.00338**	**0.122**	**-0.0992**	**0.168****	**-0.0836**
	(0.0783)	(0.0849)	(0.0902)	(0.0783)	(0.0784)

Inability to calculate the payback of investments in energy-efficiency seems to be a barrier in Germany and Hungary. In both countries people having problems with the calculation tend to spend 0.17-0.19 standard deviations more on heating. The difference is significant at the 10% level. Finally, the complexity of information on the electricity bill seems to hinder cost savings in Spain. In Spain those respondents who have problems interpreting their energy bill pay 0.17 standard deviations more. In other countries this variable shows no significant relationship with the dependent variable.

Environmental awareness

Variables belonging to this group measure environmental awareness. People who take environmental issues in consideration in their decisions are assumed to consume less energy, resulting in lower heating bills. The category consists of four variables. The first one shows whether the respondent is willing to make personal sacrifice for environmental reasons, the second shows whether the respondent agrees with the statement that environmental measures taken by the government should not cost extra money for the households. The third variable shows whether the given person agrees or disagrees with the statement that environmental problems are overstated, while the fourth variable captures those people who state they have already done everything they could do to reduce their energy bills.

Concerning the environmental awareness variables, it is a relevant question whether the estimation should include all the presented variables simultaneously, as the presented variables might be highly interlinked, resulting in multicollinearity, distorting the regression results. However, we found no significant correlations among them when testing their correlations on a country by country basis, so we included all variables in the regression simultaneously. Table 9 summarizes the results related to the environmental awareness variables.

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Table 9: Regression coefficients of environmental awareness group, source: Authors' own calculations

	(1) France	(2) Germany	(3) Hungary	(4) Spain	(5) Ukraine
Willing to make compromise	**-0.137**	**0.375***	**-0.113**	**0.388**	**-0.0959**
	(0.164)	(0.225)	(0.126)	(0.267)	(0.129)
Policies by government should not cost money	**-0.143****	**0.0164**	**-0.00147**	**-0.154**	**0.314*****
	(0.0687)	(0.0692)	(0.137)	(0.102)	(0.110)
Environmental impacts are overstated	**0.259*****	**0.00697**	**-0.0409**	**-0.0860**	**-0.0183**
	(0.0749)	(0.0831)	(0.0534)	(0.0873)	(0.0825)
Done everything to reduce energy bill	**-0.154****	**-0.151****	**-0.00109**	**-0.0838**	**-0.0539**
	(0.0617)	(0.0735)	(0.0768)	(0.0654)	(0.0810)

The results show that environmental factors play an important role mostly in France and in Germany. In Ukraine only one variable is showed significant relationship with the dependent variable, while environmental awareness does not seem to have any role based on our results in Hungary and Spain. As it was shown in the section of descriptive statistics, the vast majority of respondents claimed to be willing to make a compromise for the environment. This can be the reason that for receiving insignificant results for this variable with the exception of Germany where more conscious people have 0.4 standard deviations higher heating bills (the result is significant at the 10% level). It is not wise to draw important conclusions form this result however, because it is likely that people state they are willing to make a sacrifice even if in reality it might not be true.

The variable including answers to the question of whether people agree with the statement that government measures related to saving the environment should not cost them extra money showed significant relationship with heating costs only significant in France and the Ukraine, but with a different sign. Ukrainian results are in line with our hypothesis as those people who agree with the statement tend to care less about their consumption and spend more on heating (by 0.31 standard deviations) than those who disagree. In France, however, the effect is negative -0.14, which is difficult to explain, perhaps thriftier consumers agreed mostly.

The last two variables show results having the expected sign. In France, those people who think that environmental issues are overstated tend to spend 0.26 standard deviations more on heating than others, while in France and in Germany those households which state that they did everything to reduce their energy bills have heating costs 0.15 standard deviations lower compared to the other group. For the other countries these variables did not show significant association.

Variables related to behaviour and consumer practice

In the final category we included three variables. The first two were based on questions asking respondents 1) whether they often forget to turn off the heating for the night, and 2) whether they tend to postpone realizing energy efficiency improvement measures. The third variable corresponds to whether the family heats all rooms in the dwelling, or only those rooms that are in use. This third variable was somewhat difficult to categorize as the decision on not to heat all rooms might have several motivations: financial, environmental and behavioural as well. We decided to include it in the behavioural category, as it might go together with a decrease in comfort level. The corresponding regression coefficients are summarized in Table 10.

Table 10: Regression coefficients of routine variables group, source: Authors' own calculations

	(1)	(2)	(3)	(4)	(5)

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	France	Germany	Hungary	Spain	Ukraine
Forget to turn down heating	**-0.121**	**-0.0876**	**-0.0625**	**0.277****	**0.0935**
	(0.0998)	(0.0731)	(0.0847)	(0.108)	(0.111)
Tend to postpone investments	**-0.0670**	**-0.0690**	**0.0519**	**0.0269**	**0.0128**
	(0.0782)	(0.0666)	(0.119)	(0.105)	(0.0922)
Heat only those rooms they use	**0.0109**	**0.0407**	**0.00166**	**-0.229*****	**0.0913**
	(0.0621)	(0.0660)	(0.0887)	(0.0769)	(0.0837)

The regression coefficients show that routine variables generally do not have effect on the heating bill. We were able to identify only two significant coefficients for all countries. In Spain, those people who tend to forget to turn down the heating system spend 0.28 standard deviations more on heating than those who do not forget it. Heating only the rooms that are in use also results in lower heating bill for Spanish families, which pay 0.23 standard deviations less compared to those constantly heating all rooms. For the other countries these two variables do not show any significant relationship with the dependent variable.

7.4 Conclusion

In this quantitative analysis our aim was to identify relationships between heating expenses and variables measuring household income, external conditions that hinder energy-efficiency measures, accessing and ability to use information, environmental attitude and behaviour related to heating energy use, controlling for technical and socio-economic characteristics.

Our research results show similar results to earlier analysis, revealing that the variables we focused on in our regression seem to have smaller effect on heating bills than the technical and socio-economic variables that describe dwelling and household characteristics. House type, house size or house age tend to have an effect of 0.4-0.5 standard deviations magnitude on standardised heating bill (sometimes even more than 1 standard deviation), while the investigated explanatory variables were associated with the dependent variable having coefficients of only around 0.15-0.25 standard deviations. Also, while general household characteristics showed significant relationship with heating bills in most countries, only some of the investigated behavioural factors had a significant effect in one or two countries, sometimes with a direction that is difficult to explain.

According to our results neither objective nor subjective income (i.e. whether one finds it difficult to live with their income) plays an important role as a determinant of heating bills. The only exception is Spain, where rich people tend to spend significantly more on heating, and subjective income also influences heating consumption even among people having similar income level.

We also investigated whether external barriers, such as dependency on the energy consumption of neighbours affect heating bill. We identified several variables measuring external barriers, but received diverse results. We were not able to identify any general patterns based on them in the five countries analysed.

As regards access to information and the ability to use information, our results show that information barriers play an important role in Spain but also have some effect in Hungary and Germany. We found no proof that these barriers would affect consumption and energy bills in France or in Ukraine.

We assumed that people who care more for the environment tend to reduce their energy consumption resulting in lower heating bills. This hypothesis was partly validated as we identified such a pattern in

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Germany, France and to some extent in the Ukraine. However, no such relationship was identified in Spain and Hungary.

Finally, we investigated whether daily routines can affect heating costs. The results suggest that in general these routines do not influence energy consumption significantly, only a slight effect could be detected in Spain, showing that bad routines can have a negative effect on energy cost savings.

To conclude, we found evidence that factors other than classical household characteristics and basic socioeconomic variables can influence heating costs to some extent, but the magnitude of their effects seems to be much smaller and the impacts are very diverse in the different countries, while in some cases do not result in the expected outcomes. These ambiguous results need further investigation. It is also important to interpret the results with caution in Spain and France, as the heating degree days in these countries can vary substantially, while we could not account for the territorial distribution of households, so that we miss an important variable that could explain variations in the level of heating bills.

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Appendices of the household heating energy costs analysis

Table A 1:Dependent variable

		Country				
		France	**Germany**	**Hungary**	**Spain**	**Ukraine**
Monthly heat cost	Mean	97,81	114,92	87,99	63,04	35,94
	Minimum	,36	12,50	4,30	2,00	,20
	Maximum	711,32	428,57	1611,19	500,00	231,23
	Std Dev	72,19	61,42	94,09	64,97	25,78
	Count	1500	711	1022	760	1013
Standardized heat cost	Mean	-,01	,00	-,01	,00	,00
	Minimum	-1,34	-1,66	-,88	-,94	-1,35
	Maximum	8,38	5,10	15,75	6,73	7,33
	Std Dev	,99	1,00	,97	1,00	,97
	Count	1500	711	1022	760	1013

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Table A 2: Control variables: dwelling characteristics

		Country									
		France		Germany		Hungary		Spain		Ukraine	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Which best describes your home?	Single detached family house	641	42,7%	304	42,8%	755	73,9%	73	9,6%	447	44,2%
	Family house attached	302	20,1%	117	16,5%	29	2,8%	132	17,4%	47	4,6%
	Apartment building with 2 to 5 flats	160	10,7%	112	15,8%	20	2,0%	355	46,7%	41	4,1%
	Apartment building with above 6 flats	397	26,5%	153	21,5%	217	21,2%	200	26,3%	465	46,0%
	NA	0	0,0%	25	3,5%	1	0,1%	0	0,0%	11	1,1%
Construction year of building	before 1959	342	22,8%	130	18,3%	317	31,0%	83	10,9%	210	20,8%
	1960-1979	374	24,9%	205	28,8%	381	37,3%	253	33,3%	386	38,2%
	1980–1999	335	22,3%	195	27,4%	228	22,3%	222	29,2%	291	28,8%
	after 2000	339	22,6%	136	19,1%	37	3,6%	113	14,9%	47	4,6%
	NA	110	7,3%	45	6,3%	59	5,8%	89	11,7%	77	7,6%
Size of dwelling	below 65 m2	339	22,6%	148	20,8%	245	24,0%	125	16,4%	598	59,1%
	66-90 m2	393	26,2%	190	26,7%	355	34,7%	327	43,0%	253	25,0%
	91–120m2	423	28,2%	180	25,3%	352	34,4%	184	24,2%	102	10,1%
	above 120 m2	328	21,9%	168	23,6%	65	6,4%	108	14,2%	37	3,7%
	NA	17	1,1%	25	3,5%	5	0,5%	16	2,1%	21	2,1%
Settlement type	big city	516	34,4%	360	50,6%	244	23,9%	287	37,8%	299	29,6%
	city	505	33,7%	170	23,9%	464	45,4%	314	41,3%	370	36,6%
	countryside	474	31,6%	117	16,5%	314	30,7%	156	20,5%	331	32,7%
	NA	5	0,3%	64	9,0%	0	0,0%	3	0,4%	11	1,1%
Degree of insulation	Any type of insulation	821	54,7%	431	60,6%	415	40,6%	152	20,0%	252	24,9%
	No insulation	270	18,0%	76	10,7%	555	54,3%	449	59,1%	685	67,8%
	All 3 types of insulation	53	3,5%	104	14,6%	24	2,3%	9	1,2%	7	0,7%
	NA	356	23,7%	100	14,1%	28	2,7%	150	19,7%	67	6,6%
Dominant heating system	electricity	468	31,2%	11	1,5%	7	0,7%	390	51,3%	12	1,2%
	district heating	52	3,5%	94	13,2%	112	11,0%	43	5,7%	365	36,1%
	natural gas	434	28,9%	375	52,7%	554	54,2%	185	24,3%	373	36,9%
	wood	117	7,8%	0	0,0%	263	25,7%	8	1,1%	145	14,3%
	coal	1	0,1%	0	0,0%	14	1,4%	2	0,3%	27	2,7%
	pellet	40	2,7%	0	0,0%	1	0,1%	1	0,1%	0	0,0%
	heating oil	92	6,1%	189	26,6%	0	0,0%	30	3,9%	0	0,0%
	garbage	2	0,1%	0	0,0%	0	0,0%	0	0,0%	0	0,0%
	biomass	3	0,2%	2	0,3%	0	0,0%	0	0,0%	0	0,0%
	geothermal/heat pump	67	4,5%	6	0,8%	0	0,0%	1	0,1%	2	0,2%
	other	3	0,2%	1	0,1%	0	0,0%	2	0,3%	5	0,5%
	mixed	109	7,3%	2	0,3%	64	6,3%	30	3,9%	59	5,8%
	NA	112	7,5%	31	4,4%	7	0,7%	68	8,9%	23	2,3%
Ability to control temp.	no	233	15,5%	4	0,6%	272	26,6%	218	28,7%	546	54,0%
	yes	1267	84,5%	652	91,7%	743	72,7%	501	65,9%	459	45,4%
	NA	0	0,0%	55	7,7%	7	0,7%	41	5,4%	6	0,6%
Total		**1500**	**100,0%**	**711**	**100,0%**	**1022**	**100,0%**	**760**	**100,0%**	**1011**	**100,0%**

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Table A 3:Control variables: household characteristics

		Country														
		France			Germany			Hungary			Spain			Ukraine		
		Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Household size		3	1	37	2	1	9	2	1	8	3	1	14	3	1	10
Number of people older than 65 in hh		1	0	16	0	0	2	0	0	2	0	0	3	0	0	4
Number of people younger than 18 in hh		1	0	14	0	0	4	0	0	5	0	0	8	1	0	5
		France			Germany			Hungary			Spain			Ukraine		
		Count		Column N %	Count		Column N %	Count		Column N %	Count		Column N %	Count		Column N %
Gender	Male	714		47,6%	334		47,0%	415		40,6%	369		48,6%	388		38,4%
	Female	786		52,4%	377		53,0%	607		59,4%	391		51,4%	623		61,6%
Education	Primary or lower	54		3,6%	27		3,8%	233		22,8%	233		30,7%	29		2,9%
	Secondary	674		44,9%	580		81,6%	635		62,1%	310		40,8%	640		63,3%
	University	765		51,0%	74		10,4%	154		15,1%	211		27,8%	328		32,4%
	NA	7		0,5%	30		4,2%	0		0,0%	6		0,8%	14		1,4%
Employ-ment status	employed	855		57,2%	372		55,3%	596		58,4%	395		52,7%	490		49,5%
	unemployed	54		3,6%	39		5,8%	16		1,6%	70		9,3%	81		8,2%
	student	110		7,4%	43		6,4%	6		0,6%	32		4,3%	32		3,2%
	pensioner or inactive	475		31,8%	219		32,5%	403		39,5%	252		33,6%	386		39,0%

Table A 4:Independent variables related to household income

		France		Germany		Hungary		Spain		Ukraine	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Income brackets	1st quintile	306	20,4%	66	9,3%	478	46,8%	36	4,7%	183	18,1%
	2nd quintile	285	19,0%	43	6,0%	202	19,8%	203	26,7%	227	22,5%
	3rd quintile	302	20,1%	72	10,1%	64	6,3%	234	30,8%	154	15,2%
	4th quintile	284	18,9%	169	23,8%	66	6,5%	60	7,9%	107	10,6%
	5th quintile	157	10,5%	178	25,0%	40	3,9%	2	0,3%	122	12,1%
	no answer	125	8,3%	131	18,4%	160	15,7%	198	26,1%	148	14,6%
	NA	41	2,7%	52	7,3%	12	1,2%	27	3,6%	70	6,9%
Subjective perception of household income	live comfortably or cope on income	1011	67,4%	511	71,9%	619	60,6%	552	72,6%	277	27,4%
	finds it difficult on present income	457	30,5%	169	23,8%	393	38,5%	164	21,6%	716	70,8%
	doesn't know	32	2,1%	31	4,4%	10	1,0%	44	5,8%	18	1,8%
Total		**1500**	**100,0%**	**711**	**100,0%**	**1022**	**100,0%**	**760**	**100,0%**	**1011**	**100,0%**

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Table A 5.Independent variables related to external factors

Variables related to external factors		Country									
		France		Germany		Hungary		Spain		Ukraine	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Energy bill also depends on other households' consumption	no	699	46,6%	110	15,5%	758	74,2%	371	48,8%	360	35,6%
	yes	225	15,0%	208	29,3%	148	14,5%	278	36,6%	168	16,6%
	non-applicable	526	35,1%	378	53,2%	112	11,0%	101	13,3%	420	41,5%
	missing	50	3,3%	15	2,1%	4	0,4%	10	1,3%	63	6,2%
Refurbishing our block of flats needs the consent and financial contribution of other tenants	no	476	31,7%	108	15,2%	701	68,6%	228	30,0%	230	22,7%
	yes	277	18,5%	133	18,7%	165	16,1%	237		323	31,9%
	non-applicable	646	43,1%	364	51,2%	144	14,1%	222	29,2%	389	38,5%
	missing	101	6,7%	106	14,9%	12	1,2%	73	9,6%	69	6,8%
The owner and the tenant of the building is not the same person	tenant	521	34,7%	255	35,9%	226	22,1%	163	21,4%	174	17,2%
	owner	879	58,6%	434	61,0%	789	77,2%	584	76,8%	770	76,2%
	missing	100	6,7%	22	3,1%	7	0,7%	13	1,7%	67	6,6%
Spend a lot of time in the dwelling during daytime	no	810	54,0%	334	47,0%	647	63,3%	454	59,7%	403	39,9%
	yes	533	35,5%	224	31,5%	353	34,5%	200	26,3%	371	36,7%
	non-applicable	122	8,1%	147	20,7%	18	1,8%	104	13,7%	198	19,6%
	missing	35	2,3%	6	0,8%	4	0,4%	2	0,3%	39	3,9%
I live in an old building, in which the refurbishment possibilities are limited	no	701	46,7%	216	30,4%	761	74,5%	369	48,6%	319	31,6%
	yes	260	17,3%	62	8,7%	191	18,7%	117	15,4%	171	16,9%
	non-applicable	424	28,3%	406	57,1%	49	4,8%	207	27,2%	434	42,9%
	missing	115	7,7%	27	3,8%	21	2,1%	67	8,8%	87	8,6%

Table A 6:Independent variables related to information

Variables related to information problems		Country									
		France		Germany		Hungary		Spain		Ukraine	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
	Country		Country		Country		Country		Country		Country
I don't get frequent enough feedback on my actual energy consumption.	no	832	55,5%	299	42,1%	836	81,8%	392	51,6%	618	61,1%
	yes	499	33,3%	344	48,4%	153	15,0%	282	37,1%	222	22,0%
	non-applicable	114	7,6%	57	8,0%	21	2,1%	59	7,8%	145	14,3%
	missing	55	3,7%	11	1,5%	12	1,2%	27	3,6%	26	2,6%
I cannot calculate the payback of my investment	no	612	40,8%	127	17,9%	611	59,8%	248	32,6%	325	32,1%
	yes	286	19,1%	323	45,4%	350	34,2%	322	42,4%	434	42,9%
	non-applicable	377	25,1%	225	31,6%	37	3,6%	99	13,0%	143	14,1%
	missing	225	15,0%	36	5,1%	24	2,3%	91	12,0%	109	10,8%
My energy bill is too complicated, I cannot interpret it.	no	979	65,3%	182	25,6%	689	67,4%	421	55,4%	606	59,9%
	yes	363	24,2%	457	64,3%	325	31,8%	247	32,5%	249	24,6%
	non-applicable	115	7,7%	45	6,3%	7	0,7%	68	8,9%	123	12,2%
	missing	43	2,9%	27	3,8%	1	0,1%	24	3,2%	33	3,3%

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Table A 7:Independent variables related to environmental attitude

Variables related to environmental attitude		Country									
		France		Germany		Hungary		Spain		Ukraine	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
I am not willing to do anything for the environment if others don't do the same	disagree	1050	70,0%	600	84,4%	886	86,7%	623	82,0%	755	74,7%
	agree	383	25,5%	98	13,8%	121	11,8%	133	17,5%	158	15,6%
	missing	67	4,5%	13	1,8%	15	1,5%	4	0,5%	98	9,7%
Environmental impacts are frequently overstated	disagree	924	61,6%	568	79,9%	683	66,8%	530	69,7%	655	64,8%
	agree	468	31,2%	138	19,4%	309	30,2%	195	25,7%	230	22,7%
	missing	108	7,2%	5	0,7%	30	2,9%	35	4,6%	126	12,5%
I am willing to make compromises in my current lifestyle for the benefit of the	disagree	165	11,0%	40	5,6%	182	17,8%	104	13,7%	172	17,0%
	agree	1260	84,0%	666	93,7%	812	79,5%	636	83,7%	694	68,6%
	missing	75	5,0%	5	0,7%	28	2,7%	20	2,6%	145	14,3%
Policies introduced by the government to address environmental issues should not cost me extra money	disagree	310	20,7%	160	22,5%	168	16,4%	91	12,0%	117	11,6%
	agree	1068	71,2%	538	75,7%	823	80,5%	655	86,2%	812	80,3%
	missing	122	8,1%	13	1,8%	31	3,0%	14	1,8%	82	8,1%
I have already done what I could do to reduce my energy bill	no	487	32,5%	207	29,1%	582	56,9%	309	40,7%	331	32,7%
	yes	923	61,5%	485	68,2%	427	41,8%	377	49,6%	553	54,7%
	non-applicable	51	3,4%	2	0,3%	5	0,5%	62	8,2%	68	6,7%
	missing	39	2,6%	17	2,4%	8	0,8%	12	1,6%	59	5,8%

Table A 8:Independent variables related to energy consumption behavior

Variables related to behaviour		Country									
		France		Germany		Hungary		Spain		Ukraine	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Often forget to turn down the heating	no	1083	72,2%	321	45,1%	863	84,4%	567	74,6%	463	45,8%
	yes	240	16,0%	166	23,3%	124	12,1%	92	12,1%	228	22,6%
	non-applicable	149	9,9%	207	29,1%	31	3,0%	96	12,6%	269	26,6%
	missing	28	1,9%	17	2,4%	4	0,4%	5	0,7%	51	5,0%
Tend to postpone my saving plans	no	992	66,1%	367	51,6%	823	80,5%	569	74,9%	445	44,0%
	yes	326	21,7%	234	32,9%	162	15,9%	101	13,3%	325	32,1%
	non-applicable	152	10,1%	87	12,2%	26	2,5%	78	10,3%	172	17,0%
	missing	30	2,0%	23	3,2%	11	1,1%	12	1,6%	69	6,8%
Heating rooms	heating all the rooms	785	52,3%	422	59,4%	716	70,1%	368	48,4%	737	72,9%
	heating only the rooms in use	715	47,7%	269	37,8%	306	29,9%	392	51,6%	262	25,9%
	NA	0	0,0%	20	2,8%	0	0,0%	0	0,0%	12	1,2%
Total		**1500**	**100,0%**	**711**	**100,0%**	**1022**	**100,0%**	**760**	**100,0%**	**1011**	**100,0%**

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Table A 9:Regression coefficients of other variables not included in the main text, source: Authors' own calculations

	(1)	(2)	(3)	(4)	(5)
	France	Germany	Hungary	Spain	Ukraine
Attached family house (ref: Single family house)	**-0.111**	**-0.231****	**-0.114**	**-0.0235**	**0.0953**
	(0.0847)	(0.0971)	(0.130)	(0.158)	(0.259)
Apartment 2-5 flats	**-0.348*****	**-0.152**	**0.206**	**-0.0640**	**-0.128**
	(0.105)	(0.120)	(0.303)	(0.147)	(0.173)
Apartment 5+ flats	**-0.367*****	**-0.162**	**-0.0807**	**-0.245**	**-0.0631**
	(0.109)	(0.130)	(0.0999)	(0.153)	(0.137)
Construction 1960-1979 (ref before '60)	**-0.0220**	**0.0285**	**0.0392**	**-0.0144**	**-0.194***
	(0.0860)	(0.109)	(0.0993)	(0.131)	(0.100)
Construction 1980-1999	**-0.212*****	**-0.0289**	**-0.0199**	**-0.0142**	**-0.101**
	(0.0789)	(0.115)	(0.0945)	(0.132)	(0.107)
Construction after 2000	**-0.175****	**-0.183**	**-0.0515**	**0.193**	**-0.280**
	(0.0883)	(0.132)	(0.117)	(0.162)	(0.218)
66-90 m2 (ref: less than 66m2)	**0.166****	**0.368*****	**0.193*****	**-0.169****	**0.269*****
	(0.0789)	(0.0790)	(0.0741)	(0.0831)	(0.0964)
91-120m2	**0.392*****	**0.807*****	**0.352*****	**0.0422**	**0.626*****
	(0.0999)	(0.114)	(0.124)	(0.106)	(0.151)
above 120 m2	**0.670*****	**1.441*****	**0.370*****	**0.456*****	**0.963*****
	(0.130)	(0.150)	(0.122)	(0.154)	(0.360)
No insulation (ref: some insulation)	**0.0243**	**-0.138**	**-0.0544**	**-0.172***	**-0.0918**
	(0.0850)	(0.131)	(0.0877)	(0.0934)	(0.0929)
All 3 types of insulation	**-0.0488**	**-0.130**	**0.0532**	**2.109*****	**-0.0813**
	(0.157)	(0.0950)	(0.152)	(0.639)	(0.217)
household size	**0.0486**	**0.165*****	**0.000251**	**0.0796*****	**0.0340**
	(0.0330)	(0.0546)	(0.0285)	(0.0265)	(0.0244)
no. People older than 65	**0.0556**	**0.0441**	**-0.0609**	**-0.00478**	**-0.0472**
	(0.0773)	(0.0688)	(0.0543)	(0.0593)	(0.0585)
heating system- DC heating (ref:electricity)	**0.0683**	**0.571***	**-0.235**	**0.350****	**0.514**
	(0.187)	(0.328)	(0.290)	(0.151)	(0.319)
heating system- Natural gas	-0.197**	0.383	-0.237	0.709***	0.396
	(0.0775)	(0.312)	(0.272)	(0.0956)	(0.323)
heating system- Wood	**-0.720*****		**-0.140**	**-0.311**	**0.326**
	(0.134)		(0.294)	(0.264)	(0.338)
heating system- Coal	**-2.071*****		**-0.352**	**0.568**	**0.857****
	(0.175)		(0.322)	(0.663)	(0.381)
heating system-Pellet	**-0.832*****		**0.428**	**-0.338**	
	(0.145)		(0.393)	(0.330)	
heating system- Oil	**0.179**	**0.465**		**0.0100**	
	(0.130)	(0.326)		(0.129)	
heating system- Other bio	**-0.510**	**-1.626*****			
	(0.418)	(0.416)			
heating system- Geothermal	**-0.391*****	**0.354**		**-0.00858**	**0.742**
	(0.134)	(0.427)		(0.230)	(0.451)
heating system- Other	**0.0506**	**0.310**		**0.144**	**0.0529**

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	(0.304)	(0.330)		(0.208)	(0.434)
heating system - Mixed	**-0.140**	**-0.271**	**0.266**	**0.291***	**0.373**
	(0.148)	(0.327)	(0.400)	(0.149)	(0.350)
able to control temperature	**0.212***	**1.201****	**-0.186**	**0.143***	**-0.0598**
	(0.113)	(0.472)	(0.154)	(0.0808)	(0.0817)
secondary school (ref:primary)	**0.0406**	**-0.141**	**0.0474**	**0.0483**	**0.0669**
	(0.145)	(0.216)	(0.111)	(0.0911)	(0.172)
university	**-0.0168**	**-0.161**	**-0.0303**	**0.144**	**0.204**
	(0.148)	(0.221)	(0.134)	(0.109)	(0.184)
unemployed (ref: employed)	**-0.106**	**0.0830**	**-0.521****	**-0.109**	**-0.193**
	(0.280)	(0.142)	(0.211)	(0.138)	(0.129)
student	**-0.0672**	**0.0990**	**0.171**	**0.0212**	**-0.260**
	(0.153)	(0.181)	(0.188)	(0.219)	(0.172)
pensioner & other passive	**-0.0382**	**-0.0377**	**-0.150**	**0.0313**	**-0.00452**
	(0.0804)	(0.105)	(0.122)	(0.113)	(0.0937)
female	**-0.0426**	**-0.0310**	**0.0260**	**-0.0709**	**0.0901**
	(0.0579)	(0.0655)	(0.0620)	(0.0664)	(0.0674)
age	**0.00494***	**-0.000428**	**-3.11e-5**	**0.00272**	**-0.00157**
	(0.00260)	(0.00310)	(2.47e-05)	(0.00341)	(0.00288)
city (ref: big city)	**-0.0428**	**0.0231**	**0.0155**	**-0.141**	**0.00465**
	(0.0672)	(0.0749)	(0.0604)	(0.0876)	(0.0945)
countryside	**0.0746**	**0.294*****	**0.101**	**-0.249****	**-0.116**
	(0.0891)	(0.104)	(0.109)	(0.121)	(0.129)

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