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Who saves energy and why? Analysing diverse behaviours in 27 European countries

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ABSTRACT

This paper investigates the decision to undertake a range of energy saving actions using individual survey data. Responses to eleven different energy saving actions are examined. These actions are also grouped together under broader curtailment, efficiency and transport categories for additional insights. The final sample comprises over 20,000 responses from a Eurobarometer survey dataset across 27 European countries. Quantitative multivariate modelling is employed to examine the factors that shape the stated conservation choices. The results highlight the heterogeneity of the underlying socio-demographic and attitudinal effects. Age, gender, household composition, occupation, standard of living, accommodation status and location all influence the energy saving choice, but the effects are varied. For example, there is evidence that age has a non-linear effect which takes different forms for each energy saving action examined. The presence of children has counterbalancing effects, increasing the probability of efficiency actions, but decreasing the probability of curtailment actions. Improvements in standards of living have a positive effect on efficiency actions predominantly. In contrast, having expectations that prices will increase into the future has a positive effect on curtailment actions but a negative effect on efficiency actions. The heterogeneity in the pattern of responses highlight why energy conservation policies need a flexible approach. A one size fits all strategy is unlikely to provide enough scope to incentivise higher levels of engagement across all energy saving profile groups.

1. Introduction

A global focus on the demand side of the energy equation has never been more important. A recent report by the United Nations Environment Programme, forecasted that global greenhouse gas emissions will continue to increase up to 2030 and urged nations to do more than current pledges under the Paris agreement or face global warming of 2.5–2.9 °C [1]. Political instability around the world, such as the ongoing conflict in Ukraine, is heightening key issues surrounding supply uncertainty and high energy prices. For example, recent research has found that concern about the war in Ukraine has significantly and positively influenced energy-saving behaviour [2]. The urgent climate targets and instability caused by ongoing conflicts all point to the increased value that can be realised through the promotion of positive energy efficiency and energy saving behaviours.

The purpose of this paper is to examine the factors which determine the adoption of a range of energy saving actions. The data comes from the European Commission's Flash Eurobarometer 514 survey [3], which was carried out to examine the European Union (EU) response to the energy challenges arising from Russia's invasion of Ukraine in 2022, and the subsequent conflict. As part of the survey, respondents were asked about the actions that they are already taking, or would be ready to take, to cut down on energy consumption and energy bills. The data is based on a representative sample of EU citizens, aged 15 and over, in each of the 27 Member States of the EU.

There has been much research in the area using a wide variety of different data and methodological approaches (a selection of which includes [4–12]). This paper contributes to this existing literature in several ways. Previous studies have tended to examine energy saving behaviours in a wholistic way by constructing a single measure or index and analysing the factors which determine variations in this measure [2,5,6,9,12–18]. This can be limiting especially if there is underlying

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heterogeneity in the factors that are associated with each type of energy saving behaviour. The evidence from other research which has examined specific types of energy saving behaviours has shown this to be the case [6,19,20]. Furthermore, research which has grouped energy saving behaviours into similar categories, such as those based on curtailment, that is, frequent and/or low cost (or free) energy-saving behaviours, and those based more on efficiency which refers to infrequent structural changes and/or those requiring investments or purchases [21], also find significant differences in the underlying determinants of the adoption of these behaviours. This suggests that a disaggregated approach to analysing energy saving behaviours is required. This paper carries out a comprehensive disaggregated analysis and is also one of the first to examine both the factors determining specific energy saving behaviours and categories of energy saving behaviours.

The paper uses a recent survey data set and so provides an up-to-date assessment of the current state of knowledge in this area. In addition, the data was collected during the Ukraine conflict and so will capture how individuals are responding during an energy crisis thus providing a different context for examining energy saving behaviours relative to previous research. A body of work has developed which has examined the effect that the COVID-19 pandemic had on energy saving behaviours [2,20,22]. Some recent work has been carried out on the Ukraine conflict and specifically the effects for energy use [2,23] but given the nature of the event and the significant effects that it had on energy prices, further research is warranted. The role that attitudinal variables play during an energy crisis is of particular interest. In line with previous research, this paper includes a set of attitudinal variables, such as having a sense of responsibility to contribute to solving energy problems [14,20] and the effects perceived energy prices increases have on energy saving behaviours [24–26]. New attitudinal variables to the literature which are included in this paper attempt to capture the key issues that arose during the Ukraine conflict and continue to dominate discussions among policymakers, specifically relating to the concerns over energy security and how expectations of future general price rises (as opposed to just energy price rises) impact existing energy saving behaviours. Finally, this paper uses a large dataset and a cross country analysis, based on EU27 countries providing for an examination of country differences across the range of energy saving behaviours that are presented.

2. Literature review

There is an extensive body of research which examines the determinants of energy saving and/or energy efficiency behaviours at an individual or household level. One clear feature of this literature is the variability in how energy saving and/or energy efficiency behaviours are defined. A number of studies construct a single energy saving behaviour index normally based on aggregating responses across a range of specific measures. Although there are some commonalities across these studies in the specific energy saving measures that are asked of respondents e.g. turning off lights, reducing room temperatures, much variation exists in the different measures used to construct the various indices. This can be because the authors are using a secondary data set where the energy saving measures are predetermined by the underlying questionnaire. In other cases, the differences are based on the scope to which energy saving is defined by the authors. Van den Broek et al. [17] for example, construct a scale based on energy behaviours that the respondents engage in on a daily basis only and thus exclude efficiency investments.

Most of these studies cited above use socio-economic and socio-demographic variables, such as gender, age, level of education and income, to examine variation in some measure of energy saving across households. Certain stylised facts have emerged from the research particularly with regard to gender and education. Generally speaking, females [5,6,9,13,27,28] and those on higher levels of education [9,13] have a positive influence on the probability of adopting and/or the level of energy saving behaviours. The effect of age is mixed depending on how age is specified. Some studies assume a linear relationship, that is, include age as a continuous variable, and find positive effects [6,18,25,28]. Other studies investigate the presence of non-linear relationships with some reporting an inverted U-Shape relationship [5,13]. This is reasoned as reflecting a life-cycle effect [5] with the presence of children increasing the propensity to engage in energy saving behaviours [13]. Other variables such as household size and income related measures also provide mixed results. Liobikienė and Minelgaitė [6] and Umit et al. [25] both found positive effects on energy saving actions for household size, while in contrast Belaïd and Joumni [13] did not find this variable to be statistically significant. Income is generally found to have a positive effect [4,12,14,15,29]. In contrast, Belaïd and Garcia [5] and Belaïd and Joumni [13] found no statistically significant effect surmising that households with good energy behaviours will not change their habits due to a higher income.

Other studies incorporate variables which capture the individual or households attitudes to the environment [6,15], their concerns over the climate crisis and other global crises [2,14,19,25], or other psychological variables [13,17]. In the case of the first two sets of variables, environmental concerns and global crisis such as the Covid-19 pandemic and the war in Ukraine were generally found to have positive effects on energy saving behaviours. Psychological variables have been incorporated into studies in a variety of different ways. Belaïd and Joumni [13] include ideological and situational factors, such as whether the individual is involved in a civil society organization or has lived in a rural area previously and found these variables to positively influence energy saving behaviours. Van den Broek et al. [17] apply a Comprehensive Action Determination Model (CADM) to investigate the relative influence of intentional, normative, situational and habitual processes on energy saving behaviour. A series of Likert scale questions were used to create these constructs using questions which measure aspects of the respondent such as personal norms and social norms, how strong the intention is to reduce energy in the next seven days, perceived behavioural control and the extent to which habits play a role in energy use. The authors found that situational and habitual processes were best able to account for energy saving behaviour while normative and intentional processes had little predictive power. As a result, they recommend that policy should focus more on changing energy habits and creating environments that facilitate energy saving behaviour.

While research has tended to focus on aggregate energy saving measures, other research has examined the determinants of specific energy saving behaviours. Liobikienė and Minelgaitė [6], Jakučionytė-Skodienė and Liobikienė [19] and Matiiuk et al. [20] examine nine separate energy and resource-saving behaviours actions, thirteen separate climate change mitigation actions and six resource-saving behaviours respectively. One pertinent conclusion arising from their research is the fact that respondents who performed one action did not necessarily perform other actions because of the different costs and guiding goals. This argument is further supported by Botetzagias et al. [30] who found the factors determining a set of seven curtailment behaviours to be distinct, thus emphasising that they should be analysed separately. Lundberg et al. [8] narrow the focus further by examining the reasons why turning off the lights is often the most common response when respondents are asked about current energy saving actions. Self-reported explanations include the fact that it is easy to do and that it is taught to them as a child. However, the authors found that when presented with alternative options such as replacing incandescent bulbs with CFLs or LEDs, a large percentage switched to this option. This, according to the authors, suggested that participants are aware of complementary effective actions that are available, and which could achieve more significant household-level responses to climate change.

A body of research also exists which specifically examines the retrofitting of energy efficient heating technologies and/or purchasing of climate friendly household appliances [4,29,31–34]. For this type of energy saving behaviour, household income tends to play a more important role, which is not surprising given the high initial costs that are usually involved in these investments. Home ownership and higher levels of education are also positive predictors. The effect that pro environmental attitudes and beliefs have is more nuanced with some studies finding positive effects [4,31] while others have found environmental concerns to be less of a motivator to engage in these energy saving behaviours [29,32].

The research previously outlined provides a useful overview of the current state of knowledge in the area. For some aspects, there are still gaps in understanding and questions that require further investigation. Much of the research cited above examines an overall or aggregate measure of energy efficiency and/or energy saving behaviours. Other research has sought to group different types of energy saving behaviours into specific categories. The most popular approach in the literature is to use curtailment versus efficiency dimensions (see [21], for an overview of these dimensions). Examples of the former include turning off lights, unplugging appliances, or reducing appliance usage, while examples of the latter include purchasing energy-efficient equipment/products or investing in structural changes to the home.

Several researchers have used this approach when examining energy saving behaviours [10,11,25,28,35–37]. This research has highlighted differences in the factors that determine each type of energy saving behaviours. Trotta [11] found the effects that income and dwelling type variables had on curtailment behaviours versus retrofit investments significantly diverged while Umit et al. [25], Urban and Ščasný [28], Kumar et al. [36] and Kumar et al. [37] also found differing effects for income. Moreover, Nauges and Wheeler [10] identified a more complex relationship between households' climate change concerns and energy mitigation practices if the behaviour is characterised as curtailment or as efficiency. More research is needed to establish the nature of these heterogeneous effects particularly as the implications are important for the design of policy in this area. Testa et al. [35] found age and gender to have no significant effect on curtailment energy saving and purchase energy saving actions, but Umit et al. [25] found positive and significant effects for both variables in their study. This paper thus supports various researchers [25,36,37] call to action on the understanding of energy saving behaviour which cannot be complete without evidence that includes both types of behaviour as well as that crosses the national borders.

In summary, although the role that certain socio-economic and socio-demographic variables such as gender, education and income appear to be well established when considering energy saving behaviours in a holistic sense, there may be less certainty when specific or categories of energy saving behaviours are under investigation. Even seemingly established energy saving behaviours can require further scrutiny. Gender is an example. Grünewald and Diakonova [27] found that females have higher electricity use for certain household activities, although overall, they do use less electricity than males. Rainisio et al. [16] also found evidence to suggest that gender differences are not uniformly spread across energy saving behaviours, suggesting cultural practices as a stronger underlying determinant. Tjørring et al. [38] examine flexibility in energy saving behaviours and found that females are more willing to shift electricity consumption to a different part of the day than their male counterparts. More information about such gendered practices could, the authors say, help the design and targeting of energy saving policies.

3. Data and methods

The data comes from a European Commission's Eurobarometer survey. The Eurobarometer "*is the polling instrument used by the European Commission, the European Parliament and other EU institutions and agencies to monitor regularly the state of public opinion in Europe on issues related to the European Union as well as attitudes on subjects of political or social nature*".[1] Eurobarometer surveys come in three types, Standard Eurobarometer which monitor key trends relevant to the European Union, Special Eurobarometer which examine in-depth thematic studies relevant to the activities of the European institutions and Flash Eurobarometer which are more ad-hoc thematic surveys. Data from European Eurobarometer surveys has been used extensively in energy related academic literature [6,9,19,20,39,40].

The dataset used in this study is the European Commission's Flash Eurobarometer 514 survey. The survey was carried out to examine the EU's response to the energy challenges arising from Russia's invasion of Ukraine in 2022, and subsequent conflict. Fieldwork was undertaken by Ipsos European Public Affairs on a representative sample of EU citizens, aged 15 and over, in each of the 27 Member States of the EU. Interviews were conducted via computer-assisted web interviewing (CAWI) in November 2022. Sampling quotas were set based on age, gender and geographic region and a total of 26,325 individuals were sampled. A clear majority of respondents were prepared to take at least one action listed to cut down on their energy consumption and bills (95 %). 85 % of those surveyed agreed that rising energy prices have had a significant impact on their purchasing power while 82 % agreed the EU should continue taking actions to reduce its dependency on Russian gas and oil as soon as possible.[2]

3.1. Dependent variable, energy saving actions

The main variable of interest in this study, the dependent variable, is based on the following question asked in the Flash Eurobarometer 514 survey (Question 9). "And you, personally, what kind of action(s) are you already taking, or would you be ready to take to cut down on your energy consumption and your energy bills?". The exact wording of the 11 possible responses is as follows (respondents could provide multiple answers):

- Unplug your electronic appliances when not in use.
- Use alternatives to your car/motorbike, such as walking, cycling, taking public transport, car sharing.
- Opt for renewable forms of energy in your home (e.g. solar panels, etc.)
- Install equipment at home to control and reduce your energy consumption (e.g. a programmable thermostat).
- Add better insulation at your home.
- Buy energy efficient equipment (with a good energy rating).
- Reduce room temperature at home or at work.
- Take the train rather than a plane for your journeys.
- Turn off lights when you leave a room for a while, at home or at work.
- Other.
- None.

As can be seen, the dependent variable is based on actions already taken but also actions that respondents are ready to take. It is not possible to distinguish between these two types of actions within the data set. It is generally more common in the literature to focus on energy saving actions that have been undertaken or currently undertaken. But energy saving readiness or intentions has also been of interest to researchers with several studies on this topic [24,41]. It could be argued that including energy saving readiness captures certain energy saving behaviours which are otherwise overlooked. These specifically relate to efficiency investments, which require more planning, effort and high costs, and are therefore in a state of readiness rather than necessarily complete. Umit et al. [25] for example, asked a question related to

[1] https://europa.eu/eurobarometer/about/eurobarometer.

[2] For more detail and survey questionnaire see report at https://europa.eu/eurobarometer/surveys/detail/2912.

efficiency investments on the basis of how likely the respondent was to buy an energy efficient appliance, whereas their question on curtailment behaviours focussed on things that were done to reduce energy use. Framing a question which allows more scope in the energy action undertaken, is especially relevant in this study as the questionnaire was administered during an energy crisis and therefore it may be important to examine decisions to save energy based on actions already undertaken, but also actions which are ready to be undertaken in response to the energy crisis. To further support this point, a recent study which examined energy behaviours in Polish households following the increase in energy prices after Russia's invasion on Ukraine, used a question which was based on actions related to daily energy practices and/or actions that were *planned* to be taken [23].

Another issue, previously referred to in the literature, is the fact that the data in this study is based on self-reported behaviours rather than actual observed behaviours. Although this is a limitation, in that observing actual behaviours is normally more ideal, using self-reported stated data is still one of the most common approaches within the literature, producing consistent and significant results [5,8,18,25,30,37]. Furthermore, a number of researchers have suggested that evidence of differences between stated behaviours and actual behaviours is not in fact apparent in the existing literature [18,25]. A final question surrounding the data is the use of individual level respondent data to make inferences for a household. Again, this is somewhat limiting, in so far as some studies that use individual level respondent data, take the information from the household responsible person or person responsible for the household budget [13,23,31]. It is not uncommon however for studies to use individual level respondent data and not state their role within the household, thereby implicitly assuming that they are representative of the energy saving behaviours within their households [8,10,11,15,18].

Table 1 below provides descriptive statistics for each of the energy saving actions. The actions undertaken (or ready to be undertaken) the most by respondents include '*Turn off lights when you leave a room for a while, at home or at work*', '*Unplug your electronic appliances when not in use*' and '*Reduce room temperature at home or at work*'. The actions undertaken (or ready to be undertaken) the least by respondents include '*Install equipment at home to control and reduce your energy consumption* (*e.g. a programmable thermostat*)' and '*Take the train rather than a plane for your journeys*'. Only a small percentage of the sample (3.7 %) did not undertake (or are not ready to undertake) any of the energy actions listed.

3.2. Dependent variable, energy saving actions categorised

The energy saving actions listed in Table 1, can also be grouped into specific categories, namely curtailment, efficiency and transport. Under curtailment the actions, '*Turn off lights when you leave a room for a while, at home or at work*', '*Unplug your electronic appliances when not in use*' and '*Reduce room temperature at home or at work*', are grouped together and thus the dependent variable in this model ranges from 0 to 3. Under efficiency the actions '*Opt for renewable forms of energy in your home* (*e.g. solar panels, etc.*)', '*Install equipment at home to control and reduce your energy consumption* (*e.g. a programmable thermostat*), '*Add better insulation at your home*' and '*Buy energy efficient equipment (with a good energy rating*)' are grouped together and thus the dependent variable in this model ranges from 0 to 4. A final model is estimated which groups the two transport related energy actions together, '*Use alternatives to your car/motorbike, such as walking, cycling, taking public transport, car sharing*' and '*Take the train rather than a plane for your journeys*'. The dependent variable in this model therefore ranges from 0 to 2. The results from this final model may be of particular interest given the relative lack of research into the factors that determine energy saving actions within the transport area.

Table 1
Descriptive statistics for energy saving actions selected.

	No. of Observations (n)	Mean
Unplug electronic appliances	26,325	0.6052
Alternatives to car/motorbike	26,325	0.3649
Renewable energy in home	26,325	0.2765
Equipment to reduce energy consumption	26,325	0.2350
Add insulation in home	26,325	0.3019
Buy energy efficient equipment	26,325	0.4022
Reduce room temperature, home or work	26,325	0.5197
Take the train rather than a plane	26,325	0.1903
Turn off lights, home or work	26,325	0.7665
Other	26,325	0.0492
No energy actions taken	26,325	0.0374

A small proportion of respondents (0.018 or 1.8 %) answered 'don't know' to Question 9.

3.3. EU27 analysis of the dependent variable categories

It is instructive to examine whether any differences exist across countries in these groups of energy saving actions.[3] Table 2 presents mean and median share values for each of the EU27 countries in the sample by the aforementioned categorised energy saving actions. What is initially evident from the tables is the fact that there is a large degree of homogeneity between countries for each of the categories. Most countries, on average, undertake 3 to 4 energy saving actions out of the 10 in total, 2 out of the 3 curtailment actions, 1 out of the 4 efficiency actions and 0 to 1 out of the 2 transport actions. Each of the mean share values for each country lies within one half of a standard deviation of the EU27 mean share. Curtailment actions are the most popular across all countries, with efficiency actions having a higher share relative to transport actions in 18 out of 27 countries. Interestingly, there are a number of examples of countries which are in the top 5 in one category but in the bottom 5 in another category. Germany and Denmark for example rank high (top 5) on curtailment actions but low (bottom 5) on efficiency actions. Conversely, Hungary and Slovenia rank high on efficiency but low on curtailment. Cyprus has the high share of efficiency energy saving actions but one of the lowest shares of transport energy saving actions. Malta has a similar profile. It is possible that Germany and Denmark's low efficiency scores reflect the fact that these countries already have high levels of energy efficiency in their homes and appliances and therefore require less of these actions to be undertaken currently. The opposite might be the case therefore with Hungary and Slovenia reflecting current practices to invest in efficiency improvements among their residents. Both Cyprus and Malta are islands which may explain their low transport scores, particularly in relation to taking the train rather than a plane.

The similarity in share values across the EU27 countries and within each energy action category may indicate a positive outcome from having a consistent approach in EU policies on the overall level of energy saving actions. However, while the variation within each energy action category is not large, there are still variations between each energy action category, that is, some countries are good at one type of energy saving action and not as good at another. Umit et al. [25] found similar differences in curtailment versus efficiency energy saving behaviours across European countries while Liobikienė and Minelgaitė [6] and Jakučionytė-Skodienė and Liobikienė [19] also noted differences in energy saving behaviours across European countries based on more specific actions. This suggests that cultural and normative differences and/or national energy policies still play a significant role.

[3] A summary of the differences across countries between the individual energy saving actions can be found in the online report at https://europa.eu/eurobarometer/surveys/detail/2912.

Table 2
Categorised energy saving actions by EU27 countries, mean and median share values.

	All energy saving actions		Energy saving actions – curtailment		Energy saving actions – efficiency		Energy saving actions – transport		n
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	
FR - France	0.38	*0.40*	0.69[t]	*0.67*	0.28	*0.25*	0.29	*0.00*	1,034
BE - Belgium	0.37[*]	*0.40*	0.68[t]	*0.67*	0.30[*]	*0.25*	0.23	*0.00*	1,046
NL - The Netherlands	0.41[t]	*0.40*	0.67	*0.67*	0.35	*0.25*	0.31	*0.00*	1,007
DE - Germany	0.37[*]	*0.40*	0.68[t]	*0.67*	0.22[b]	*0.25*	0.35[t]	*0.50*	1,026
IT - Italy	0.37	*0.30*	0.66	*0.67*	0.29[*]	*0.25*	0.25	*0.00*	1,019
LU - Luxembourg	0.39	*0.40*	0.70[t]	*0.67*	0.28	*0.25*	0.28[*]	*0.00*	501
DK - Denmark	0.35	*0.30*	0.70[t]	*0.67*	0.21[b]	*0.25*	0.25	*0.00*	1,036
IE - Ireland	0.38	*0.40*	0.67	*0.67*	0.33	*0.25*	0.23[b]	*0.00*	1,091
GR - Greece	0.35	*0.30*	0.56[b]	*0.67*	0.32	*0.25*	0.27	*0.00*	1,011
ES -Spain	0.37	*0.30*	0.63[*]	*0.67*	0.25	*0.25*	0.35[t]	*0.50*	1,005
PT - Portugal	0.43[t]	*0.40*	0.68	*0.67*	0.39[t]	*0.25*	0.32	*0.00*	1,047
FI - Finland	0.35	*0.30*	0.65	*0.67*	0.22[b]	*0.25*	0.28[*]	*0.00*	1,052
SE - Sweden	0.40	*0.40*	0.63[*]	*0.67*	0.32	*0.25*	0.39[t]	*0.50*	1,001
AT - Austria	0.38	*0.40*	0.66	*0.67*	0.27	*0.25*	0.36[t]	*0.50*	1,022
CY - Cyprus (Republic)	0.41[t]	*0.40*	0.62	*0.67*	0.46[t]	*0.50*	0.17[b]	*0.00*	502
CZ - Czech Republic	0.33[b]	*0.30*	0.59	*0.67*	0.25	*0.25*	0.24	*0.00*	1,049
EE - Estonia	0.38	*0.40*	0.63[*]	*0.67*	0.34	*0.25*	0.26	*0.00*	1,061
HU - Hungary	0.42[t]	*0.40*	0.57[b]	*0.67*	0.43[t]	*0.50*	0.35[t]	*0.00*	1,035
LV - Latvia	0.30[b]	*0.30*	0.57	*0.67*	0.24[b]	*0.25*	0.16[b]	*0.00*	1,050
LT - Lithuania	0.32[b]	*0.30*	0.63[*]	*0.67*	0.23[b]	*0.25*	0.17[b]	*0.00*	1,035
MT - Malta	0.41[t]	*0.40*	0.63[*]	*0.67*	0.41[t]	*0.25*	0.21[b]	*0.00*	549
PL - Poland	0.36	*0.30*	0.64[*]	*0.67*	0.26	*0.25*	0.32	*0.00*	1,017
SK - Slovakia	0.33[b]	*0.30*	0.57[b]	*0.67*	0.25	*0.25*	0.28[*]	*0.00*	1,004
SI - Slovenia	0.40	*0.40*	0.56[b]	*0.67*	0.41[t]	*0.25*	0.31	*0.00*	1,039
BG - Bulgaria	0.35[b]	*0.30*	0.52[b]	*0.67*	0.35	*0.25*	0.25	*0.00*	1,009
RO - Romania	0.40	*0.40*	0.62	*0.67*	0.38	*0.25*	0.28[*]	*0.00*	1,035
HR - Croatia	0.37[*]	*0.40*	0.66	*0.67*	0.29	*0.25*	0.27	*0.00*	1,042
EU 27	0.37	*0.40*	0.63	*0.67*	0.30	*0.25*	0.28	*0.00*	26,325

t = top 5 highest mean share.
b = bottom 5 lowest mean share.
[*] Not significant different from EU27 mean share at the 1 % level of significance.

3.4. *Quantitative multivariate methods employed*

As the approach in this study is to test hypotheses and quantify relationships in relation to the dependent variable, quantitative multivariate methods will be employed [42]. Two different sets of multivariate models are estimated. In each case the dependent variable is related to a set of socio-demographic and attitudinal independent variables which will be described in Section 3.5.

3.4.1. *Binary logit models of energy saving actions undertaken*

The first set of estimations are a series of logistic or logit regression models relating the binary choice of a specific energy saving action to a set of socio-demographic and attitudinal variables. In total nine logit models are estimated based on the list of energy actions given in Table 1 ('*Other*' is excluded). An additional logit model examining the decision to take none of the energy actions listed is also examined. Binary Logit models have been used extensively in the literature to examine the decision to adopt energy saving actions or practices [4,6,8,19,20,30,31].

3.4.2. *Ordered logit models of cumulative categorised energy saving actions*

A second set of estimations using ordered logit models [43] are also carried out. These models relate the cumulative number of energy actions taken to a set of socio-demographic and attitudinal variables [18,25,39]. In total four ordered logit models are estimated. The first model examines the cumulative number of all energy actions. The dependent variable in this model therefore ranges from 0 to 10 ('*Other*' is included in this instance). The other three models use the categorical dependent variables previously described in Section 3.2 under curtailment (ordered from 0 to 3), efficiency (0–4) and transport (0–2) headings.

3.5. *Independent variables*

3.5.1. *Socio-demographic independent variables*

The socio-demographic variables derived from the Flash Eurobarometer 514 survey and used as explanatory variables in the model include the following (with categories listed where the variable is categorical):

- Age and Age Squared
- Gender (Male, Female)
- Household Size, number of persons aged 15+ (1 person, 2 people, 3 people, 4+ people)
- Children aged <15 (No Children, 1 Child, 2 Children, 3+ Children)
- Finished Education when aged 20+ Years (No, Yes)
- Occupation (Self-employed, Employee, Manual worker, No Professional Activity)
- Personal Standard of Living (Very Bad, Rather Bad, Rather Good, Very Good)
- Accommodation Status (Own, Rent, Other)
- Location (Rural Area/Village, Small/Medium Town, Large Town/City)

These socio-demographic variables were chosen based on what is seen as common determinants in the literature i.e., age, gender, education, income, and other socio-demographic data, collected in the Flash Eurobarometer 514 survey. As the exact age of the respondent is available from the survey (as opposed to categories), this can be included as a continuous variable. The added benefit of this is that age squared can also be included to capture non-linear effects which have been evidenced from previous research [5,13]. This specification adds to previous research as age has tended to be specified as either a categorical variable or a continuous variable but without the quadratic term. A direct measure of income is not available in the data set so personal

Table 3
Descriptive statistics for the variables used in the statistical analysis.

Dependent variables	Mean	St. Dev.	Min.	Max.
Unplug Electronic Appliances	0.6299	0.4829	0	1
Alternatives to Car/Motorbike	0.3844	0.4865	0	1
Renewable Energy in Home	0.2894	0.4535	0	1
Equipment to Reduce Energy Consumption	0.2478	0.4317	0	1
Add Insulation in Home	0.3190	0.4661	0	1
Buy Energy Efficient Equipment	0.4284	0.4949	0	1
Reduce Room Temperature, Home or Work	0.5557	0.4969	0	1
Take the Train rather than a Plane	0.2016	0.4012	0	1
Turn off Lights, Home or Work	0.7948	0.4038	0	1
No Energy Actions Taken	0.0308	0.1728	0	1
All Energy Saving Actions	3.899	2.047	0	10
Energy Saving Actions – Curtailment	1.980	0.997	0	3
Energy Saving Actions – Efficiency	1.285	1.212	0	4
Energy Saving Actions – Transport	0.586	0.713	0	2

Independent variables	Mean/Proportion of Sample	St. Dev.	Min.	Max.
Socio-demographic variables				
Age	48.46	16.73	15	97
Gender				
Female	49.65			
Male	50.35			
Household Size 15+				
1 person	24.44			
2 people	47.12			
3 people	16.57			
4+ people	11.87			
Children <15				
No Children	71.36			
1 Child	16.72			
2 Children	9.24			
3+ Children	2.68			
Finished Education aged 20+ Years				
No	44.52			
Yes	55.48			
Occupation				
Self-employed	11.08			
Employee	49.37			
Manual Worker	6.44			
No Professional Activity	33.10			
Personal Standard of Living				
Very Bad	12.70			
Rather Bad	36.09			
Rather Good	46.71			
Very Good	4.50			
Accommodation Status				
Own	70.24			
Rent	23.32			
Other	6.44			
Location				
Rural Area/Village	25.28			
Small/Medium Town	39.24			
Large Town/City	35.48			
Attitudinal variables				
Reduce Energy Consumption During Peak Hours				
Disagree	16.10			
Tend to Agree	44.74			

Table 3 (*continued*)

Dependent variables	Mean	St. Dev.	Min.	Max.
Totally Agree	39.16			
Rising Energy Prices Impact my Purchasing Power				
Disagree	13.39			
Tend to Agree	42.21			
Totally Agree	44.39			
Future Prices Will				
Decrease	3.01			
Stabilise	11.22			
Increase Moderately	41.93			
Increase Sharply	43.84			
EU should Reduce Dependency on Russian Gas and Oil				
Disagree	15.16			
Tend to Agree	30.83			
Totally Agree	54.01			
No. of Observations	20,408			

standard of living acts as a proxy. Occupational status can also capture an affluence effect and Belaïd and Garcia [5] found evidence to suggest that the extent of energy-saving behaviours differs by occupation. Accommodation status and location are included as there is evidence in the literature that a divide exists between owners and renters [31,44,45] and by urban/rural status [34,39].

3.5.2. *Attitudinal independent variables*

The attitudinal variables used as explanatory variables in the model are based on the following four questions and responses (in brackets):

- We should all make an effort to reduce energy consumption during peak hours (Disagree, Tend to Agree, Totally Agree)
- Rising energy prices have a significant impact on my purchasing power (Disagree, Tend to Agree, Totally Agree)
- Do you think that in the next twelve months, prices in general will…? (Decrease, Stabilise, Increase Moderately, Increase Sharply)
- The EU should continue to take actions to reduce its dependency on Russian gas and oil as soon as possible (Disagree, Tend to Agree, Totally Agree)

As mentioned in the literature, researchers have included various different measures to account for attitudes to the environment, concerns over the climate crisis and other global crises and other psychological variables. Making an effort to reduce energy consumption during peak hours can capture a sense of responsibility to help solve energy issues which has been found to positively influence energy saving behaviours [14,19,20]. Several studies have also shown that concerns over rising energy prices are positively related to engagement in energy saving behaviours [24,25]. The effect of general price rises has not been examined previously but is arguably important because it can stifle the demand for energy saving actions, particularly ones that involve high initial investment costs. General price increases can also force households to postpone efficiency investments if money needs to be directed to general day to day subsistence purchases. Finally, by examining the influence that agreement on addressing energy security concerns, through reducing the dependency on Russian gas and oil, has on energy saving actions, the effect that recent global events and the responses of policy makers can be examined [2].

3.6. *Sample size for multivariate models*

The 27 EU countries in the sample are included in the model using

Table 4
Logit estimates, individual energy saving actions.

	Unplug electronic appliances	Alternatives to car/ motorbike	Renewable energy in home	Equipment to reduce energy consumption	Add insulation in home	Buy energy efficient equipment	Reduce room temperature, home or work	Take the train rather than a plane	Turn off lights, home or work
Socio-demographic variables									
Age	0.018***	−0.013**	−0.022***	−0.019***	0.011*	0.049***	0.037***	−0.041***	0.042***
Age Squared	−0.000**	0.000	0.000*	0.000*	−0.000*	−0.001***	−0.000***	0.000***	−0.000***
Gender									
Female (ref)									
Male	−0.422***	−0.087***	0.155***	0.192***	0.047	0.102***	−0.107***	0.041	−0.488***
Household Size 15+									
1 person (ref)									
2 people	−0.003	−0.032	0.176***	0.117***	0.125***	0.171***	0.049	−0.118***	0.154***
3 people	−0.025	0.007	0.256***	0.124**	0.155***	0.142***	0.056	0.007	0.151**
4+ people	0.041	0.077	0.324***	0.149**	0.200***	0.106*	0.053	0.127*	0.224***
Children <15									
No Children (ref)									
1 Child	−0.073*	−0.098**	0.113**	0.092*	0.017	−0.030	−0.194***	−0.096*	−0.252***
2 Children	−0.180***	−0.000	0.146**	0.131**	0.098*	−0.009	0.009	−0.205***	−0.330***
3+ Children	−0.255***	−0.109	0.262***	0.202**	0.040	−0.144	0.024	−0.070	−0.548***
Finished Education aged 20+ Years									
No (ref)									
Yes	0.098***	0.132***	0.155***	0.064*	0.134***	0.195***	0.152***	0.102***	0.088**
Occupation									
Self-employed (ref)									
Employee	0.138***	−0.036	−0.160***	−0.093*	−0.150***	−0.036	0.102**	−0.223***	0.122**
Manual Worker	0.107	0.013	−0.215**	−0.181**	0.041	−0.106	0.023	−0.191**	0.064
No Professional Activity	0.207***	0.070	−0.302***	−0.312***	−0.212***	−0.118**	0.082	−0.189***	0.304***
Personal Standard of Living									
Very Bad (ref)									
Rather Bad	0.149***	0.120**	0.082	0.094	0.152***	0.241***	0.091*	−0.023	0.349***
Rather Good	0.012	0.143***	0.258***	0.170***	0.177***	0.441***	0.094*	−0.065	0.422***
Very Good	−0.145*	0.085	0.426***	0.325***	0.243***	0.456***	−0.143	0.038	−0.127
Accommodation Status									
Own (ref)									
Rent	0.114***	0.132***	−0.440***	−0.217***	−0.364***	−0.159***	−0.077*	0.147***	0.028
Other	0.060	0.071	−0.137**	−0.087	−0.161**	−0.136**	−0.164**	0.048	0.135*
Location									
Rural Area/ Village (ref)									
Small/Medium Town	0.061	0.449***	−0.340***	−0.028	−0.117***	0.064*	0.157***	0.161***	0.119**
Large Town/City	0.009	0.623***	−0.463***	−0.079*	−0.213***	0.001	0.120***	0.326***	0.141***
Attitudinal Variables									
Reduce Energy Consumption During Peak Hours									
Disagree (ref)									
Tend to Agree	0.755***	0.624***	0.187***	0.393***	0.193***	0.330***	0.944***	0.416***	0.815***
Totally Agree	1.234***	1.097***	0.463***	0.681***	0.407***	0.620***	1.507***	0.909***	1.182***
Rising Energy Prices Impact my Purchasing Power									
Disagree (ref)									
Tend to Agree	0.258***	0.024	0.012	−0.003	0.076	0.126***	0.239***	0.015	0.273***
Totally Agree	0.324***	0.009	0.052	0.089	0.177***	0.204***	0.314***	−0.018	0.457***
Future Prices Will									
Decrease (ref)									
Stabilise	−0.030	0.036	−0.153	−0.156	−0.018	−0.012	0.114	−0.027	−0.002
Increase Moderately	0.100	0.111	−0.179*	−0.229**	−0.034	−0.031	0.138	−0.048	0.331***
Increase Sharply	0.113	0.007	−0.215**	−0.225**	0.051	−0.141	0.089	−0.155	0.239**
EU should reduce Dependency on Russian Gas and Oil									
Disagree (ref)									
Tend to Agree	0.259***	0.125**	0.232***	0.105*	0.107**	0.157***	0.402***	0.139**	0.285***
Totally Agree	0.364***	0.291***	0.446***	0.262***	0.202***	0.443***	0.604***	0.197***	0.730***

(continued on next page)

Table 4 (*continued*)

	Unplug electronic appliances	Alternatives to car/ motorbike	Renewable energy in home	Equipment to reduce energy consumption	Add insulation in home	Buy energy efficient equipment	Reduce room temperature, home or work	Take the train rather than a plane	Turn off lights, home or work
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	20,408	20,408	20,408	20,408	20,408	20,408	20,408	20,408	20,408
Pseudo R^2	0.0759	0.0538	0.0755	0.0402	0.0559	0.0525	0.1140	0.0615	0.1150
LR χ^2 (55)	2041.23***	1462.85***	1854.35***	919.08***	1428.76***	1462.91***	3197.67***	1261.57***	2384.99***

*** *p*-Value < 0.01.
** p-Value < 0.05.
* p-Value < 0.10.

fixed effects (i.e., dummy variables). Additionally, there were a number of non-responses/don't knows in the responses to some of the questions in the data set. After cleaning, a usable sample of 20,408 individuals forms the basis for the binary logit and ordered logit estimations. Table 3 provides descriptive statistics for the useable sample of observations (*n* = 20,408).

4. Results

4.1. Binary logit models of energy saving actions undertaken

Table 4 presents the results from estimating binary logit models on the nine individual energy saving actions. Age has a significant effect on almost all the actions but not universally in the same direction. The probability of undertaking the following actions increases with age, '*Unplug Electronic Appliances*', '*Add Insulation in Home*', '*Buy Energy Efficient Equipment*', '*Reduce Room Temperature, Home or Work*' and '*Turn off Lights, Home or Work*'.

The probability of undertaking the following actions decreases with age, '*Alternatives to Car/Motorbike*', '*Renewable Energy in Home*', '*Equipment to Reduce Energy Consumption*' and '*Take the Train rather than a Plane*'. Only for '*Alternatives to Car/Motorbike*' is there a negative linear relationship with age [6,46]. For all the other energy saving actions, there is evidence that the effect is non-linear. In contrast to the work of Belaïd and Garcia [5] and Belaïd and Joumni [13], however, this research suggests that age and energy saving actions comprises of a mix of U-Shape and inverted U-Shape relationships, depending on the type of energy saving action.

The turning points for each energy saving action with a significant quadratic age term can be calculated using the estimated coefficients.[4] For the actions '*Unplug Electronic Appliances*', '*Reduce Room Temperature, Home or Work*' and '*Turn off Lights, Home or Work*' with an inverted U-shaped relationship with age, they are equal to 68.0, 60.1 and 62.4 years respectively, suggesting some fall off in the likelihood of engaging in these actions after these ages. For '*Add Insulation in Home*' and '*Buy Energy Efficient Equipment*', the age turning points are lower at 47.1 and 48.4 years respectively. Thus, the nature of this inverted U-shaped relationship is quite different, increasing to middle aged individuals and decreasing thereafter.

For the actions that decrease non-linearly with age, a U-shaped relationship, '*Renewable Energy in Home*', '*Equipment to Reduce Energy Consumption*' and '*Take the Train rather than a Plane*' the turning points are equal to 81.5, 68.3 and 53.6 years respectively. For '*Renewable Energy in Home*' this in effect constitutes a negative relationship with age for the entire sample, as <1 % of the sample are aged 80 or over. For the latter two actions, these figures suggest some uptake for older aged respondents relative to middle age respondents. These results contribute to the existing literature by highlighting the complex relationship between energy saving actions and age. Assuming that energy saving actions increase or decrease in a linear fashion with age appears to be too simplistic. The view that the relationship is non-linear from previous research is supported by this research, but this may also not fully capture the extent of the complexity. The results here present new evidence to suggest that the type of non-linear effect differs depending on the type of energy saving action, that is, U-shaped or inverted U-shaped. The estimated turning points indicate that the nature of the U-shaped or inverted U-shaped is also not uniform with turning points occurring at different stages of the life-cycle for different types of energy saving actions.

Gender also displays differing effects with particularly strong male effects for '*Renewable Energy in Home*' and '*Equipment to Reduce Energy Consumption*' and strong female effects for '*Unplug Electronic Appliances*' and '*Turn off Lights, Home or Work*'. This to an extent confirms the male/female divide previously highlighted in the literature [5,6,9,13,27,28]. Females are more likely to use '*Alternatives to Car/Motorbike*', which supports findings by Limtanakool et al. [47] but contrasts with Liobikienė and Minelgaitė [6] who found that males were more likely to consider the carbon footprint of their transport and adapt accordingly. Having more adults in the home increases the probability of adopting more energy saving actions with particularly strong effects for actions that require the installation of renewable energy, energy efficiency equipment or adding insulation [4,25,28].

Having more children in the home increases the probability of '*Renewable Energy in Home*' and '*Equipment to Reduce Energy Consumption*' [31,32,48]. Interestingly the presence of children in the home decreases the probability of '*Unplug Electronic Appliances*' and '*Turn off Lights, Home or Work*'. This may suggest that there are counterbalancing effects when children are present are in the home, that is, the likelihood of energy saving equipment being installed increases but the likelihood of poor energy saving habits also increases. This supports research by Belaïd and Garcia [5] who suggest that families with children do not exhibit certain types of energy saving behaviours because they choose to favour their child's convenience and comfort against savings. It may also be the case that parents do not have the time and mental space to encourage positive curtailment behaviours in their children. Once children get older and become less dependent, both them and their parents can shift their behaviours to more environmentally positive ones, as evidenced by the fact that age and household size display positive coefficients.

Education has unambiguously and universally positive effects on the likelihood of adopting all energy saving actions confirming previous research in this area. According to Meyer [9] education teaches individuals to be better citizens through the curriculum and pro-environmental behaviour is one manifestation of this general effect. There are some occupational effects present with self-employed persons tending to have a higher probability of '*Renewable Energy in Home*', '*Equipment to Reduce Energy Consumption*' and '*Add Insulation in Home*', relative to other occupations. Employees and those with no professional activity are more likely to '*Unplug Electronic Appliances*' and 'Turn off Lights, Home or Work' relative to the self-employed [5].

[4] Equal to Coefficient on Age/(2*Coefficient on Age Squared). Calculated using the `nlcom` command in Stata.

Having self-declared good or very good standards of living increases the probability of actions related to '*Renewable Energy in Home*', '*Equipment to Reduce Energy Consumption*', '*Add Insulation in Home*' and '*Buy Energy Efficient Equipment*' [4,12,14,15,29,48]. For other actions such as '*Unplug Electronic Appliances*' '*Reduce Room Temperature, Home or Work*' and '*Turn off Lights, Home or Work*' the relationship is more ambiguous. Taking this as a proxy for household income, these results support previous findings in the research regarding the diverging effect that income has depending on the type of energy saving actions defined [11,25,28,36]. Better standards of living is also not strongly associated with using alternative transport options than a car, motorbike or plane [46,47].

Renters are more likely to use alternative transport options than a car, motorbike or plane and are less likely to opt for renewable energy, install energy efficiency equipment or add insulation [31,44]. In the case of the latter result, this is because renters would not be the primary decision makers within the household while for the former, renters are more likely to be located in urban areas and thus use public transport, or the accommodation does not have space perhaps for private transport options [4,31]. Unsurprisingly, there are similar strong positive transport effects for location with respondents in large towns and cities more likely to choose alternative transport options and take the train rather than the plane. Respondents located in rural areas are more likely to opt for renewable energy in the home and add insulation [29,34,39] while respondents located in urban areas are, in contrast, more likely to reduce room temperatures and turn off lights. This result is possibly due to the fact that urban respondents are more likely to face tariffs which incentivise curtailment i.e. peak/off-peak. They are also more likely to have better building standards and technology installed in their homes, such as smart metering, which further incentivises curtailment.

The final set of variables aims to capture the effect that a sense of responsibility, prices and energy security have on the propensity to engage in energy saving actions. The results clearly show that having positive attitudes toward reducing energy consumption during peak hours is positively associated with the likelihood of adopting all types of energy saving actions with strong effects for '*Reduce Room Temperature, Home or Work*', '*Unplug Electronic Appliances*' and '*Turn off Lights, Home or Work*'. Concerns surrounding energy security are similarly positively associated with the likelihood of adopting all types of energy saving actions. The effect that energy prices have on purchasing power and the trajectory of future general prices is less obvious with only positive and significant effects on '*Unplug Electronic Appliances*', '*Add Insulation in Home*', '*Buy Energy Efficient Equipment*', '*Reduce Room Temperature, Home or Work*', and '*Turn off Lights, Home or Work*' for the effect that prices have on purchasing power and a positive and significant effect on '*Turn off Lights, Home or Work*' if general prices are expected to increase into the future. The results do confirm previous research on the positive effect that rising energy prices has on energy saving behaviours [24,25] but contradicts some research [26] in finding that the positive effect is more for curtailment actions than efficiency actions. This supports previous research [49] which found that households delayed efficiency investments like solar panels or insulation measures during the winter of 2022 in order to assess its severity and examine possible investments afterwards. Interestingly there are negative effects on the probability of '*Renewable Energy in Home*' and '*Equipment to Reduce Energy Consumption*' if general prices are expected to increase into the future. Aravena et al. [32] did find that higher prices negatively influenced the adoption of energy efficiency measures, but this relates to electricity prices rather than general prices. This is therefore a new result to the literature and confirms the premise that general price increases may make these investments less affordable, especially if the prices of other household necessities increase.

4.2. Binary logit model of no energy saving actions undertaken

Table 5 displays logit estimates for the cohort of respondents who did not choose any of the energy saving actions from the survey questionnaire. Although this cohort may be small in proportionate terms (3.74 %) some patterns emerge from the analysis. Specifically, the likelihood of choosing none of the energy saving actions, increases with age albeit in a non-linear fashion. The turning point in this instance is 50.9 years,

Table 5
Logit estimates, individual energy saving actions.

	No energy saving actions taken
Socio-demographic variables	
Age	0.078***
Age Squared	−0.001***
Gender	
Female (ref)	
Male	0.379***
Household Size 15+	
1 person (ref)	
2 people	−0.027
3 people	−0.156
4+ people	−0.470***
Children <15	
No Children (ref)	
1 Child	−0.158
2 Children	−0.443***
3+ Children	−0.678**
Finished Education aged 20+ Years	
No (ref)	
Yes	−0.062
Occupation	
Self-employed (ref)	
Employee	−0.026
Manual worker	−0.185
No Professional Activity	0.245
Personal Standard of Living	
Very Bad (ref)	
Rather Bad	−0.212*
Rather Good	−0.060
Very Good	0.421*
Accommodation Status	
Own (ref)	
Rent	0.167
Other	0.140
Location	
Rural Area/Village (ref)	
Small/Medium Town	−0.196*
Large Town/City	−0.092
Attitudinal variables	
Reduce Energy Consumption During Peak Hours	
Disagree (ref)	
Tend to Agree	−1.689***
Totally Agree	−2.730***
Rising Energy Prices Impact my Purchasing Power	
Disagree (ref)	
Tend to Agree	−0.423***
Totally Agree	−0.365***
Future Prices Will	
Decrease (ref)	
Stabilise	−0.186
Increase Moderately	−0.371
Increase Sharply	0.094
EU should reduce Dependency on Russian Gas and Oil	
Disagree (ref)	
Tend to Agree	−0.664***
Totally Agree	−0.872***
Country Fixed Effects	Yes
No. of Observations	20,408
Pseudo R^2	0.2100
LR χ^2 (55)	1180.29***

*** p-Value < 0.01.
** p-Value < 0.05.
* p-Value < 0.10.

Table 6
Ordered logit estimates, categorised energy saving actions.

	All energy saving actions	Energy saving actions – curtailment	Energy saving actions – efficiency	Energy saving actions – transport
Socio-demographic variables				
Age	0.017***	0.039***	0.005	−0.027***
Age Squared	−0.000***	−0.000***	−0.000*	0.000***
Gender				
Female (ref)				
Male	−0.113***	−0.371***	0.155***	−0.040
Household Size 15+				
1 person (ref)				
2 people	0.115***	0.052	0.193***	−0.067*
3 people	0.148***	0.048	0.215***	0.008
4+ people	0.226***	0.092*	0.258***	0.098*
Children <15				
No Children (ref)				
1 Child	−0.111***	−0.197***	0.067*	−0.111***
2 Children	−0.065	−0.166***	0.108**	−0.062
3+ Children	−0.111	−0.263***	0.117	−0.072
Finished Education aged 20+ Years				
No (ref)				
Yes	0.216***	0.145***	0.174***	0.128***
Occupation				
Self-employed (ref)				
Employee	−0.076*	0.131***	−0.144***	−0.097**
Manual worker	−0.094	0.059	−0.150**	−0.058
No Professional Activity	−0.074	0.204***	−0.301***	−0.014
Personal Standard of Living				
Very Bad (ref)				
Rather Bad	0.244***	0.198***	0.194***	0.082*
Rather Good	0.328***	0.146***	0.351***	0.088*
Very Good	0.243***	−0.158**	0.468***	0.083
Accommodation Status				
Own (ref)				
Rent	−0.141***	0.030	−0.388***	0.164***
Other	−0.063	−0.025	−0.192***	0.066
Location				
Rural Area/ Village (ref)				
Small/Medium Town	0.079**	0.122***	−0.147***	0.373***
Large Town/ City	0.072**	0.094***	−0.260***	0.559***
Attitudinal variables				
Reduce Energy Consumption During Peak Hours				
Disagree (ref)				
Tend to Agree	0.954***	1.023***	0.337***	0.581***
Totally Agree	1.573***	1.610***	0.676***	1.102***
Rising Energy Prices Impact my Purchasing Power				
Disagree (ref)				
Tend to Agree	0.207***	0.315***	0.073*	0.013
Totally Agree	0.319***	0.432***	0.160***	−0.013
Future Prices Will Decrease (ref)				
Stabilise	−0.043	0.046	−0.119	0.019
Increase Moderately	0.033	0.183**	−0.165**	0.065
Increase Sharply	−0.035	0.160**	−0.207***	−0.055
EU should reduce Dependency on Russian Gas and Oil				
Disagree (ref)				
Tend to Agree	0.406***	0.408***	0.200***	0.153***
Totally Agree	0.719***	0.654***	0.433***	0.277***
Country Fixed Effects	Yes	Yes	Yes	Yes
No. of Observations	20,408	20,408	20,408	20,408
Pseudo R^2	0.0430	0.0754	0.0420	0.0466
LR χ^2 (55)	3693.21***	3946.89***	2511.96***	1833.22***

*** p-Value < 0.01.
** p-Value < 0.05.
* p-Value < 0.10.

therefore for older age groups the effect is in fact downward sloping. Males, those respondents with a very good personal standard of living (relative to very bad), and those in rural areas/villages (relative to small medium towns) are also more likely not to choose any of the energy saving actions.

The likelihood of not choosing any of the energy saving actions decreases for very large households sizes (4 or more adults) and for households with 2 or more children and for those respondents who agree that efforts should be made to reduce energy consumption during peak hours, that rising energy prices have impacted purchasing power and that the EU should continue to take actions to reduce its dependency on Russian gas and oil as soon as possible. Very little research has examined the factors determining non-engagement in any energy saving actions. The results presented here are not overly surprising especially in terms of males and attitudinal variables. One interesting result is the fact that those with high standards of living are more likely not to choose any of the energy saving actions which suggests that there may be some non-linearity in the effect that living standards or income has on engagement in energy saving actions.

4.3. Ordered logit models of cumulative categorised energy saving actions

Table 6 presents results from estimating ordered logit models on the categorised energy saving actions. The first column of results is based on the cumulative total of all energy saving actions. Positive estimates would thus represent an increase in the likelihood of undertaking a higher number of energy saving actions, relative to the reference category where applicable. This includes older respondents (albeit with a non-linear effect), those with 2 or more adults in the home, who are on higher levels of education, with relatively good standards of living, located in urban areas, who agree that efforts should be made to reduce energy consumption during peak hours, and that rising energy prices have impacted purchasing power and that the EU should continue to take actions to reduce its dependency on Russian gas and oil as soon as possible. Those who are more likely to adopt lower numbers of energy saving actions include males, employees (relative to the self-employed) and renters.

The other three columns of results further confirm the hypothesis that the relationship between the decision to adopt energy saving actions and socio-demographic variables depends on the type of energy saving action, which could be broadly categorised under curtailment, efficiency and transport headings. Age, for example, has an inverted U-shaped relationship with adopting higher numbers of curtailment energy saving actions, a statistically weak relationship with adopting higher numbers of efficiency energy saving actions, and a U-shaped relationship with adopting higher numbers of transport energy saving actions. These results contradict Nauges and Wheeler [10] and Umit et al. [25] who found positive age effects across both curtailment and efficiency energy saving actions, but support Trotta [11] who found positive age effects for daily energy-saving behaviours and insignificant age effects for the purchase of energy efficient appliances. Trotta [11] also found the positive effects for the curtailment actions to be in the middle age groups supporting the inverted U-shaped relationship result in this study.

Differences are also found with respect to gender with females being more likely to adopt higher numbers of curtailment energy saving actions and males being more likely to adopt higher numbers of efficiency energy saving actions. There is a lack of consensus in the literature on the gender effect. Karlin et al. [21] found negative effects for females for efficiency behaviour but insignificant effects for curtailment behaviour. Trotta [11] also found insignificant gender effects for daily energy-saving behaviours but positive female effects for the purchase of energy efficient appliances. In contrast, Umit et al. [25] found that females were more likely to engage in curtailment actions and efficiency actions while Testa et al. [35] found gender to have no significant effect on curtailment energy saving and purchase energy saving actions.

The composition of the household (number of adults and number of children) present interesting results. With more adults in the home, the likelihood of adopting higher numbers of equipment purchase related energy actions increases but there are less discernible effects on curtailment or transport related energy actions. Moreover, the presence of children in the home increases the likelihood of adopting higher numbers of efficiency related energy actions but decreases the likelihood of adopting higher numbers of curtailment actions. This supports the results in Table 4 of counterbalancing effects with positive energy saving actions (equipment purchases) being offset, to some extent, by negative energy actions (poor curtailment habits) if children are present. Very few researchers have examined the role that household composition, and particularly the role of children, play. Nauges and Wheeler [10] did find some positive efficiency effects and insignificant curtailment effects for increasing numbers of occupants aged under 18, but did not interpret the implications of these results. Urban and Ščasný [28] also found some evidence to indicate that the presence of children in the home negatively affected some curtailment actions for some countries but again did not interpret the potential significance of this result. Finally, Curtis et al. [50] found that preferences for curtailment contracts for electricity services were lower among larger families.

Self-employed individuals are more likely to engage in higher numbers of efficiency related (relative to all other occupational groups) or transport related energy actions (relative to employees) and are less likely to engage in higher numbers of curtailment actions (relative to employees and those with no professional activity). Having better self-reported standards of living is associated with higher numbers of all types of energy saving actions, although there is some evidence of a reduction in curtailment actions at higher standards of living levels. This may point to an inverted U-shaped relationship where initial increases in standards of living have a positive effect on the tendency to curtail energy use, but as standards of living improve, individuals may opt for, or can now afford, efficiency related energy saving actions such as purchasing/installing energy efficient equipment. The consensus in the literature is that higher levels of income negatively effects the extent of curtailment actions and positively effects the extent of efficiency actions [10,11,25,28,36] therefore the results in this study are, to an extent, in line with this past research.

Renters are less likely to engage in higher numbers of efficiency related energy actions [45] but are more likely to adopt higher numbers of transport related energy actions which supports the results given in Table 4. Interestingly the results are mixed with regard to the relationship with curtailment actions with an overall insignificant effect perhaps suggesting that renters do not feel they need to engage in good energy saving habits as they do not have personal responsibility for the accommodation, or their stay may be short. This is supported by the fact that renters are also more likely to report that they adopted no energy savings actions. Karlin et al. [21], also reported that renters were less likely to engage in efficiency related energy actions and have an insignificant effect on curtailment actions.

Those living in urban areas are more likely to undertake higher numbers of curtailment actions and higher numbers of transport related energy saving actions, presumably because of the availability of alternative transport options in their area. They are less likely to adopt higher numbers of efficiency related energy saving actions however, which may be because respondents in small/medium/large towns and cities are already living in better equipped and/or more energy efficient accommodation.

The perceived negative impact that rising energy prices have on purchasing power tends to positively impact the number of curtailment actions and the number of efficiency related energy saving actions undertaken [21,25,35] but has no impact on the number of transport related energy saving actions undertaken. The expectation that general prices will increase into the future has a positive effect on the number of curtailment actions and a negative effect on the number of efficiency related energy saving actions. The negative effect on efficiency related energy saving actions for future general price increases was previously observed in Table 4. The results in Table 6 confirm this effect and allied with the positive coefficients on curtailment actions, suggests that having an expectation of future general price increases, disincentivises investment in efficiency related energy saving actions with curtailment actions taking their place. As previously mentioned, this is a novel finding to the literature in this area.

Some variables have a consistent and predictable effect across all categories of energy saving actions. Individuals with higher education levels [10,25], those who agree that we should all make an effort to reduce energy consumption during peak hours [10,11,25] and those that agree that the EU should continue to take actions to reduce its dependency on Russian gas and oil as soon as possible, are all more likely to adopt higher numbers of all types of energy saving actions.

5. Conclusions

Having a clear understanding of the factors that are associated with an increased likelihood of engaging in energy saving actions is a crucial element of any policymaker's toolkit. This research has shown that examining individual energy saving actions or energy saving actions under broad headings can greatly help in this understanding. One of the key advances on existing literature is the finding that the profile of an energy saving person is more complex than previously presented. Age is a good example with both positive and negative effects for increasing values of age but also evidence of non-linear effects and, additionally, different turning points. This suggests that respondent's opt-in and opt-out of various energy saving actions at different stages of the life-cycle. The presence of children in the household is further evidence to support this as it increases the likelihood of energy saving equipment being installed but decreases the likelihood of good energy saving curtailment habits. The heterogenous nature of the underlying socio-demographic determinants is not just confined to life-cycle variables as respondents of a particular gender, occupation, standard of living, accommodation status and location also undertake certain energy saving actions but not others.

The implication of these results is that households may only be receiving marginal benefits from energy saving actions because they are not implementing all of them at the same time. This is a similar conclusion to Lundberg et al. [8], who argued that more significant household-level responses to climate change could be achieved if complementary effective energy saving actions are also undertaken. There is clearly an opportunity for policy makers to design measures which incentive this behavioural change. For example, there is a clear divergence between male and female energy saving roles. Previous research has suggested that women should be targeted when looking to increase the flexibility of electricity consumption in private households [38,51] but providing females with opportunities to engage in efficiency or investment actions also needs to be explored. Similarly, with regard to standards of living, financial supports need to be put in place to encourage those with poorer standards of living to engage in efficiency or investment actions. Targeting households based on location, for example, providing households in rural areas with the incentives to curtail energy use as well as investing in renewable energy and adding insulation, is another possible policy measure. Such targeted measures can also address calls for a just and inclusive energy transition across gender and other socio-demographic contexts [52,53].

As per existing literature, a set of attitudinal variables were included in the analysis. The variable capturing a sense of responsibility to address energy use issues, had as expected a positive effect on all types of energy saving behaviours. Concerns surrounding energy security as a result of the Ukraine conflict, also had positive effects on all types of energy saving behaviours, highlighting the effect that concerns surrounding ongoing geopolitical crises can have on energy saving behaviours. Perceptions of the effect that rising energy prices has on purchasing power and the expectation of general price movements present interesting and novel results. Having an opinion or strong opinion that rising energy prices will impact on purchasing power, positively influences a number of energy saving actions but not all, with the positive effect more present for curtailment actions than efficiency actions. Furthermore, having an expectation that general prices will rise into the future, has very few positive effects and in fact reduces the likelihood of engaging in some efficiency actions.

There are important policy implications to these results. Recent events such as the Ukraine conflict and the associated geopolitical tensions had clear effects on energy prices but also resulted in significant general price increases. The results in this study suggest that there are benefits in keeping energy prices down and ensuring security of energy supply, but it also might be just as important to ensure that general price increases are moderated so investments in energy efficiency measures made by respondents are not discouraged. Furthermore, although rising energy prices have the expected positive effects on curtailment actions, further work is needed to understand what effect energy price increases have on the various efficiency actions.

The analysis of individual energy saving actions displays a large amount of complexity and heterogeneity in the underlying determinants. Although this presents opportunities for the design of targeted measures there are clear difficulties in getting these measures right. The analysis in this study suggests that policymakers could approach the problem by profiling respondents based on curtailment, efficiency and transport actions. Such an approach to policymaking could also be carried out at an EU level given the consistency within these broad energy saving actions that were observed within the data. For most of the socio-demographic and attitudinal variables, it is clear which types of respondents engaged in broad energy saving actions. For example, females for curtailment actions and males for efficiency actions, positive non-linear age effects for curtailment actions and negative non-linear age effects for transport actions, increasing but possibly non-linear effects for standards of living on curtailment actions in contrast to increasing and linear effects for standards of living on efficiency actions and differences across urban/rural location. In conclusion, the results from this study suggest useful entry points for energy efficient initiatives as policymakers appropriately mainstream socio-demographic and attitudinal variables into energy saving policies.

The research is not without its limitations. Principally these relate to how the dependent variable is constructed within the Eurobarometer data set. Asking respondents to record actions already taken or actions that they are ready to take has advantages in capturing dynamics within energy saving behaviours especially during an energy crisis, but it would be of more interest to examine these actions separately. Future research could then examine for potential differences between actions that are done and actions that are planned to be done. Examining the energy saving behaviours of an individual is also somewhat limiting especially when trying to make inferences for household energy saving behaviours. Future research could look at determining the energy saving behaviours of all household members. This could be especially interesting for households with children given the counterbalancing effects identified in this study. Finally, Sovacool et al. [42] advocate for the use of repeated data collection and longitudinal research in energy social science research. Although there are many constraints in collecting repeated cross sectional and/or longitudinal data, such information would provide helpful insights into the effects of energy prices changes and general price changes on the energy saving behaviours of households.

CRediT authorship contribution statement

John Eakins: Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Bernadette Power:** Writing – review & editing, Formal analysis, Data curation, Conceptualization. **Geraldine Ryan:** Writing – review & editing, Formal analysis, Data curation, Conceptualization. **Helena Strömberg:** Writing – review & editing, Conceptualization. **Lisa Diamond:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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