ENERGY SAVING IN ITALIAN HOUSEHOLDS: PERCEPTIONS, MOTIVATIONS AND BEHAVIOURS

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Abstract: Household energy consumption is an important determinant of overall energy demand. To improve individual energy-related behaviours, it is crucial to first understand why people may not be engaging in these behaviours, in other words, to diagnose the behavioural problems.

We conducted an online behavioural diagnosis of energy-saving behaviours in Italian households, with a representative sample of N=400 adults. The aim was to assess (i) awareness of energy-saving behaviours, (ii) perceptions of effectiveness of such behaviours, (iii) actual and planned energy-saving behaviours, and (iv) motivations and barriers for these behaviours.

We found that the Italian households made efforts to save energy during the global energy crisis in 2022, mostly in terms of small adjustments to their everyday energy-related behaviours, while omitting some potentially more efficient energy-saving actions. Energy security and environmental reasons mattered, but monetary reasons were nevertheless the leading motivation to save energy at home. Misperceptions about efficiency of energy-saving actions related mostly to heat pumps.

These and other findings offer insights into the Italian citizens' knowledge gaps, behaviours, barriers and motivations related to saving energy in their homes, and can be used to design effective interventions. Thus, they are of interest not only to researchers, but also to policy-makers.

Keywords: behavioural diagnosis; energy-saving behaviours; perceptions of energy efficiency; energy-saving motivations

1. INTRODUCTION

In 2022, Europe and other parts of the world were hit by an energy crisis. Since 2021, the prices of natural gas have been growing due to the economic recovery following the COVID-19 pandemic and other factors, and the situation worsened significantly after the Russian invasion of Ukraine in February 2022 (International Energy Agency, n.d.). Consequently, the European Union had to deal with a significant drop in the supply of natural gas from Russia alongside the high prices (European Commission, n.d.). Measures were taken on the European and national levels to find alternative energy supplies, to ensure energy security, and ease financial strain on citizens and businesses (European Commission, n.d.). Effort was also put into finding ways of lowering the energy consumption. In Italy, for instance, the government put forward the "National plan for the containment of natural gas consumption" (hereafter referred to as "the Government Plan") in early September 2022, outlining measures for a voluntary reduction in demand for natural gas (Ministry of Ecological Transition, 2022).[1]

The proposed measures concerned energy production and its consumption by businesses, the public sector, and also households. The measures targeting households were a crucial part of the Government Plan, as they were supposed to account for roughly two-thirds of the planned natural gas savings (Ministry of Ecological Transition, 2022). They included mandatory reduction of heating in terms of time and temperatures, and a set of voluntary behavioural measures with or without initial costs, which would be encouraged through an awareness campaign. The Italian government was not the only one encouraging households to save energy in late 2022. Online platforms of energy providers, websites dedicated to energy and many others were bustling with energy-saving tips (e.g., Mosca, 2022; QualEnergia, 2022; Sorgenia, 2022) and so if a household wanted to save energy, there were plenty of resources available. What remained unknown was, however, how useful these tips were and how successful the households were in lowering their energy consumption.

Of course, individual-level interventions encouraging energy saving had been in practice well before the recent energy crisis. Although these efforts have intensified in the context of this crisis, their primary motivation has usually been related to environmental concerns and to potential monetary benefits for the individuals. Often, these efforts were supported scientifically, for instance by using insights from behavioural science to create efficient behaviour change interventions.

There are various examples of such behaviourally-informed interventions (called "green nudges") being successful. One is certainly the use of "green default options", which proved promising for different types of environmentally-relevant behaviours (Schubert, 2017). For example, presenting the green option as a default was shown to increase the number of customers choosing green electricity provision (Pichert and Katsikopoulos, 2008), and presenting the vegetarian menu as a default increased the proportion of people ordering meals without meat (Campbell-Arvai et al., 2014).

[1] The emphasis on natural gas is probably due to the fact that it is by far the most important resource to produce electricity in Italy (International Energy Agency, 2023).

Another behavioural lever used successfully to promote pro-environmental behaviours is the use of social norms, which inform people about the behaviours of others similar to them. These have famously helped encourage hotel guests to reuse their towels (Goldstein et al., 2008) and motivate households to save energy at home (Schultz et al., 2007). However, in the latter study, the social norms only worked for high-consuming households. For the lower-consuming households, a "boomerang effect" was observed whereby these households tended to increase their electricity usage after being informed about how much their neighbours use (Schultz et al., 2007).

Other promising applications of behavioural insights to promote pro-environmental behaviours can be found, but the success is not always guaranteed (Schubert, 2017). Some efforts to replicate the previously mentioned experimental findings questioned their effectiveness in different contexts (Bohner and Schlüter, 2014), or found diminished or no effects when scaled up to larger populations (Delmas et al., 2013). It has also been shown that the same behavioural lever may successfully help change one specific pro-environmental behaviour (e.g., reducing waste), but have no effect on another one (e.g., reducing driving) (Byerly et al., 2018). Another important point about the effectiveness of behavioural interventions has been raised in a meta-analysis of studies on information interventions for energy saving, which showed that these interventions achieved the most effective results when an individualised energy audit was conducted prior to the intervention, highlighting the critical role of preliminary diagnosis of existing problems (Delmas et al., 2013).

In fact, behavioural scientists agree on the importance of diagnostic studies before implementing solutions. Guidelines for using behavioural science developed by international organisations or national bodies that have been doing so in the context of public policy emphasise the need of thorough analysis to first understand the context of target behaviours and identify behavioural barriers (BIT, 2022; OECD, 2019). At the same time, the common use of nudges (a typical representative of behavioural interventions) as a universal solution has been criticised, noting that without precise problem diagnosis, interventions can be ineffective or even counterproductive (Lunn, 2019; Macchi and Cucchiarini, 2020). Furthermore, a behavioural diagnosis identifies not only the necessary interventions but also potential unintended side effects. Thus, the diagnostic phase is crucial for developing targeted, responsible, effective, and ethical solutions.

What this means for energy saving is that it is necessary to first understand people's beliefs and motivations to save energy, their actual energy-related behaviours and the obstacles they face when trying to save energy, before giving them any energy-saving tips, launching an awareness campaign or developing other solutions for behaviour change.

The existing research offers some insight into people's knowledge and perceptions of energy-saving actions and energy consumption more in general. What it suggests is that there are gaps between people's beliefs and facts. For instance, an important and quite prevalent misconception is believing that turning off the lights is the most efficient strategy to save energy at home (Attari et al., 2010). Surprisingly, this belief is also persistent, as it has been prevalent also almost forty years ago (Kempton et al., 1985). People in general slightly overestimate energy use and saving of the actions where these are low, and largely

underestimate energy use and saving of actions where these are high (Attari et al., 2010). If this is the case, they may be saving less energy than they could simply because they do not know which are the best actions to take. However, without diagnosing this problem, a researcher or a policy-maker would only see that people do not save much energy and may thus focus their intervention on, for instance, increasing the motivation to save.

In more general terms, people tend to favour curtailment actions (e.g., turning off lights) over efficiency improvements (e.g., using efficient light bulbs) as the most effective ways to conserve energy (Attari et al., 2010). This is possibly due to the fact that efficiency improvements require an initial investment and effort (e.g., to search for the best alternative), while curtailment actions may just consist in small changes in everyday behaviours, which is more easily imaginable for people (Attari et al., 2010). When asked about the most effective measures that others could take to save energy, people tend to suggest actions that are actually more effective but also more challenging, such as driving less (Attari et al., 2016). Possible explanations provided in the article are motivated cognition, or the actor/observer bias (Jones and Nisbett, 1971), whereby people are more aware of their own situational limitations that prevent them from undertaking certain actions than of similar situational limitations of other people (Attari et al., 2016). This suggests the need to understand such limitations by the researchers and policy-makers aiming at changing people's energy-related behaviours.

People's perceptions of energy consumption and saving also seem to be influenced by a number of biases and heuristics. For example, cognitive accessibility matters (Schley and DeKay, 2015). In particular, individuals in a study tended to estimate the energy consumption of different devices based on the frequency with which they interacted with them (Schley and DeKay, 2015). In other studies, people were using heuristics relying on various (superficial) cues like size of an appliance, its warmth or the frequency of use to assess energy usage (Cowen and Gatersleben, 2017; Schille-Hudson et al., 2019). In most of these cases, these strategies did not prove to be very effective (Cowen and Gatersleben, 2017; Schley and DeKay, 2015), though some (such as reliance on warmth of an appliance) performed better than others (e.g., relying on the size of an appliance) (Schille-Hudson et al., 2019). Once again, in order to improve people's energy-saving behaviours, it is crucial to understand how they think about the energy consumption of their appliances.

Another crucial factor that determines people's energy-saving behaviours is their motivation to do so and its nature. A number of different reasons that lead people to save energy in their homes have been identified by past research, such as saving money, saving energy or saving the environment (Pelenur & Cruickshank, 2014). Which of these is the most important, however, seems to differ across population subgroups (Pelenur & Cruickshank, 2014), and motivations thus should be examined before acting upon them.

Given the findings above and the context of the energy crisis, we decided to run a behavioural diagnostic study of energy-saving behaviours in Italian households. The main aims were to assess (i) people's awareness of behaviours that they can do in their homes in order to save energy, (ii) their perceptions of the effectiveness of these behaviours and of the actions proposed by the Italian government, (iii) their actual and planned energy saving behaviours, and (iv) the motivations and barriers for these behaviours. These aims translated into a set of

research questions that can be found in Table A1 in the Appendix. The results stemming from this study should then inform the design of policy interventions aiming at helping Italian households reduce their energy consumption.

2. METHOD

The study was run online in February 2023 on the Qualtrics platform with N=400 adults broadly representative of the Italian adult population in terms of basic socio-demographic characteristics (Table A2 in the Appendix).[2] The participants were recruited through a market research company, which compensated them for their participation in the study.[3] The duration of the study was around 15 minutes and its design was approved by the Committee for Research Evaluation for minimal-risk studies of the Department of Psychology at the University of Milan-Bicocca.

The study design, which was pre-registered at the Open Science Framework platform together with some of the planned analyses, is summarised in Figure 1.[4]

As a very first thing, the participants were asked to read an information sheet and give their consent to participate. Afterwards, the socio-demographic questions (i.e., gender, age, nationality, region, urban/rural area and education) were asked, some of which allowed us to screen out participants who fell outside of our set quotas.

The main part of the experiment had three stages. The first stage was designed to examine participants' thoughts, behaviours and plans relative to energy saving in their home. They were asked first to list any actions that they could think of that could save energy in their home. If they listed more than one action, they were then asked to rank them in terms of their efficiency for saving energy at home (starting from the most efficient one). Subsequently, the participants were asked about their behaviours – first about whether they adopted some energy-saving actions in their home since the beginning of 2022, and if so, which, and then about whether they were planning on adopting some further actions before the end of March 2023 (i.e., end of the winter), and if so, which.

The second stage was designed to understand the participants' perceptions of some of the energy-saving actions outlined in the Government Plan (Ministry of Ecological Transition, 2022). For each of the 11 actions (presented in random order, listed in Table A3 in the Appendix), the participants were asked to state their likelihood of adopting it during the winter (or to indicate that they had done so already). In case of a negative answer, they were asked to select the main barriers for adoption of each action from a list (multiple options could be selected). Finally, the participants were asked to rank these 11 actions in terms of their

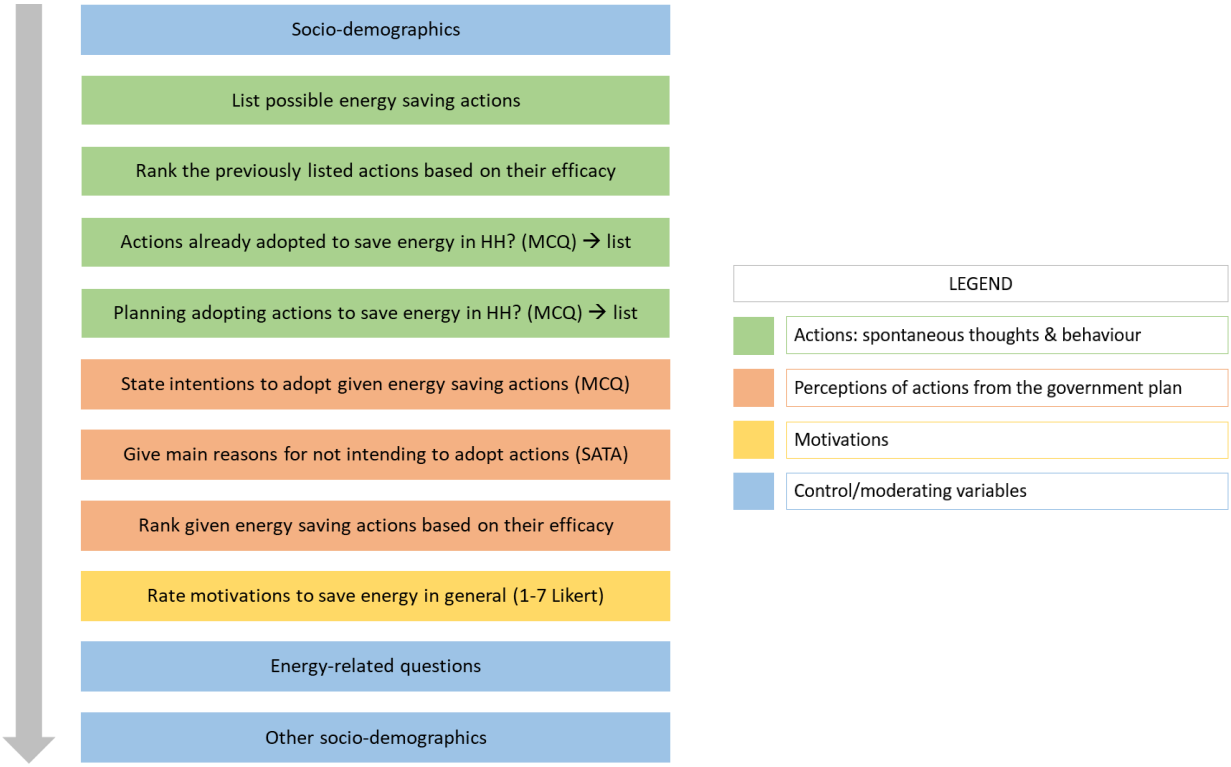
[2] In particular, the participants were nationally representative in terms of gender, age and region. The initial intention was to have a representative sample also in terms of the social class (represented by the highest educational level attained), but this goal proved unreachable because of the composition of the panel of the market research company we used. We nevertheless report data on educational attainment in Table A2 in the Appendix.
[3] The participants received points redeemable in various forms, such as Amazon vouchers.
[4] Given the exploratory nature of the study, the pre-registered data analyses are broad and the actual analyses do not follow them strictly.

efficiency for saving energy. Since official calculations exist that estimate the monetary and energy saving of each of these actions in a typical Italian household (ENEA, 2022) (Table A3 in the Appendix), we could then benchmark the participants' rankings against the official ranking.

The third part of the study focused on people's motivations to save energy at home. We presented the participants with three possible reasons (presented in random order), namely, monetary, environmental and energy security, and asked them to indicate the importance of each reason for them personally on a scale from 1=Not at all important to 7=Very important.

At the end of the study, the participants were asked a series of detailed questions about their energy usage at home (e.g., type of heating system, oven or hob, ownership of electrical appliances), energy bills, their worries related to energy bills, the environment, and the energy crisis, about their engagement with information on energy crisis, pro-environmental lifestyle, and some additional socio-demographic questions including political orientation. These additional variables were collected to be used as potential covariates in the analyses.

Figure 1. Outline of the study design



Notes: HH = household, MCQ = multiple-choice questions, SATA = "select all that apply" task

3. RESULTS

Following the pre-registration, we excluded n=24 participants (6%) who completed the study too quickly (i.e., in less than 5 minutes), leaving us with the analytic sample of N=376 participants. Unless otherwise stated, all findings are robust to using different exclusion

thresholds. We present the results separately for different study tasks, answering different research questions.

3.1. Possible actions to save energy

The actions that could help save energy at home listed by the participants were categorised independently by two raters (MB and LC) according to a coding framework that was developed based on a random sample of ~20 answers and further adapted. The interrater agreement was "substantial" following Landis and Koch's classification (82.6%, κ=.809) (Landis & Koch, 1977) and all disagreements were resolved through discussion. To make the analyses more manageable, categories with similar content were pooled together (hereafter referred to as macro-categories, Table A4 in the Appendix).

Over 80% of participants provided a valid answer to this task. On average, they listed 1.7 macro-categories of energy-saving actions (Mdn=1, SD=.945), with a maximum of six achieved by one participant. By far the most popular macro-category was the one including turning off lights and appliances when not in use, listed by almost half of the participants overall (Figure 2). This was followed by the macro-category related to space heating (i.e., reduction in the heating hours and in the temperature) listed by more than one in four participants, and smart energy usage (including using appliances less, more efficiently, and being careful about one's usage in general) indicated by almost one in four participants.

Using a different re-categorisation based on whether an action requires an initial investment (however small) or consists solely in behaviour change (Table A4 in the Appendix), it turns out that 17% of participants who gave a valid answer listed a mix of behavioural and costly actions, 9.7% listed only costly actions (one or more) and 73.3% listed purely behavioural actions (one or more).[5]

3.2. Energy saving behaviours and intentions

3.2.1. Open text answers

When asked about saving energy in 2022 and the start of 2023, the large majority of participants (83.5%) claimed to have adopted some actions, 10.9% said they did not adopt any and the rest (5.6%) were not sure (Table 1). The percentage of participants claiming to have adopted energy-saving actions did not change based on individual or household-level characteristics except for political orientation and source of information about the energy crisis. Based on bivariate analyses, the participants defining themselves as right-leaning were more likely to declare they have adopted energy-saving actions in their home compared to the participants at the centre of the political spectrum (89.6% vs 76.5%, respectively, p=.016 on a test of proportions, Bonferroni corrected). Moreover, those who claimed to have saved energy used

[5] Of course, only the participants who listed more than one action could list a mix of behavioural and costly actions. If we only consider participants who listed one action, for 85% this was a behavioural action and for 15% a costly action. If we only consider participants who listed more than one action, 57% listed behavioural actions, 3% costly actions and 40% a mix of the two.

social media more to keep themselves informed about the energy crisis compared to those who did not save energy (M=4.05, SD=1.68 and M=3.1, SD=2.07, on a scale from 1=not at all to 7=very much, p=.0001 on a Wilcoxon rank-sum test).[6]

As for the intentions to adopt new energy-saving actions before the end of the winter season, almost two-thirds of the participants (62.5%) said they would or probably would adopt some (Table 1). The intentions to save energy at home seem to be related to previous energy-saving behaviour (65.6% of those who had saved energy in the past intended to do so in the near future compared to 46.8% of those who had not saved, p=.005 on a test of proportions), even though this effect was found only in bivariate analyses. Those with intentions to save energy in the near future kept themselves more informed about the energy crisis through governmental and other institutional websites compared to those without energy-saving intentions for the near future (M=3.87, SD=1.70 and M=3.08, SD=1.77, on a scale from 1=not at all to 7=very much, p=.000 on a Wilcoxon rank-sum test) and this effect was confirmed in multivariate analysis.[7]

Table 1. Number of participants claiming having adopted (rows) and planning to adopt (columns) energy-saving actions at home

		INTENTIONS TO ADOPT ACTIONS IN THE FUTURE				
		Yes	**Probably yes**	**Probably no**	**No**	**TOTAL**
PAST ADOPTION OF ACTIONS	**Yes**	89	117	85	23	314 (83.5%)
	No	2	13	15	11	41 (10.9%)
	Not sure	1	13	7	0	21 (5.6%)
	TOTAL	92 (24.5%)	143 (38%)	107 (28.5%)	34 (9%)	376 (100%)

The participants who had adopted or were planning to adopt energy-saving actions at home were subsequently asked to specify which ones in open text boxes. The answers were coded independently by two raters (MB and VC) and re-categorised following the same coding framework as for the possible actions to save energy (Table A4 in the Appendix). The interrater agreement was "almost perfect" for past actions (84.2%, κ=.827) and "substantial" for future actions (79.6%, κ=.781) (Landis & Koch, 1977). The remaining disagreements were again resolved through discussion.

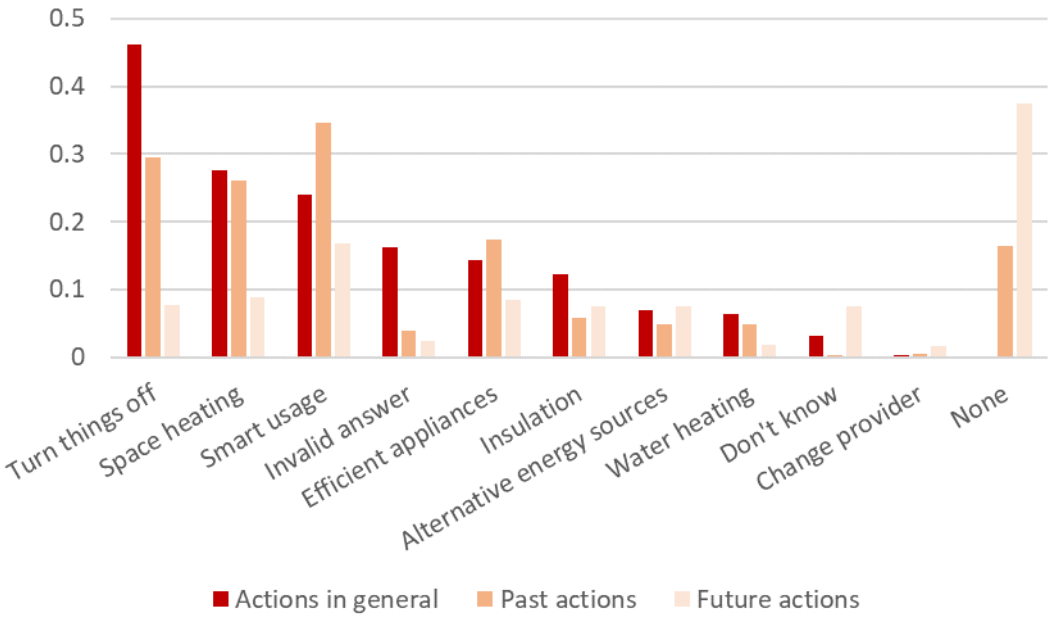
[6] Both these results are confirmed (with p-values <.01 and <.05, respectively) by a logistic regression model that includes socio-demographic, and other individual and household-level characteristics (Table A5 in the Appendix). In addition, having the gas bill with variable costs (as opposed to a fixed cost) becomes significant in this regression (p=.009), while it is not so in the bivariate analyses. Other effects are found in bivariate analyses, namely, on the relationship between having saved energy in the past and being worried about the climate change, keeping oneself informed about the energy crisis in general, and using more radio, other people and institutional websites as sources of information, but they all vanish in multivariate analysis (Table A5 in the Appendix).

[7] As before, other effects found in bivariate analyses (related to subjectively perceived income, being worried about the electricity bill, about there not being enough energy for all Italian households and using social media to keep informed about the energy crisis) lost their statistical significance when other variables were accounted for. Also, an effect that became significant in multivariate analysis (with a p-value < .05) was that of political orientation, in the same direction as for the past energy saving behaviour (Table A5 in the Appendix).

On average, participants claimed to have adopted energy-saving actions from 1.5 macro-categories (Mdn=1, SD=.833), with one participant achieving six, and to intend to adopt actions from 1.1 macro-categories (Mdn=1, SD=.379), with a maximum of three indicated by three participants.

The most frequently mentioned macro-category for both past and the future was smart energy usage (Figure 2). Other popular macro-categories of energy-saving actions already adopted by participants included turning off appliances and lights when not in use, using less heating and lowering the temperatures, and changing the lights and appliances for the more efficient ones. In terms of intentions for the future, however, only the smart usage stood out.

Figure 2. Proportion of participants listing actions in each macro-category or not listing any actions (N=376)



Again, we re-grouped the energy-saving actions into costly and behavioural, to see which type of actions the participants were focusing on. Of those with valid answers for their past behaviours (N=302), the majority (71.9%) listed actions in purely behavioural categories, 12.6% only in costly categories and 15.6% a mix of the two. As for the future actions (N=200), the majority again focused on behavioural categories of actions (66.5%), followed by costly categories (29.5%), with only 4% listing a mix of the two. This low percentage of participants listing a mix of behavioural and costly actions is probably due to the fact that participants listed fewer future actions in general, making it more likely to list just a single category of actions and so less likely to end up in the mixed category.[8]

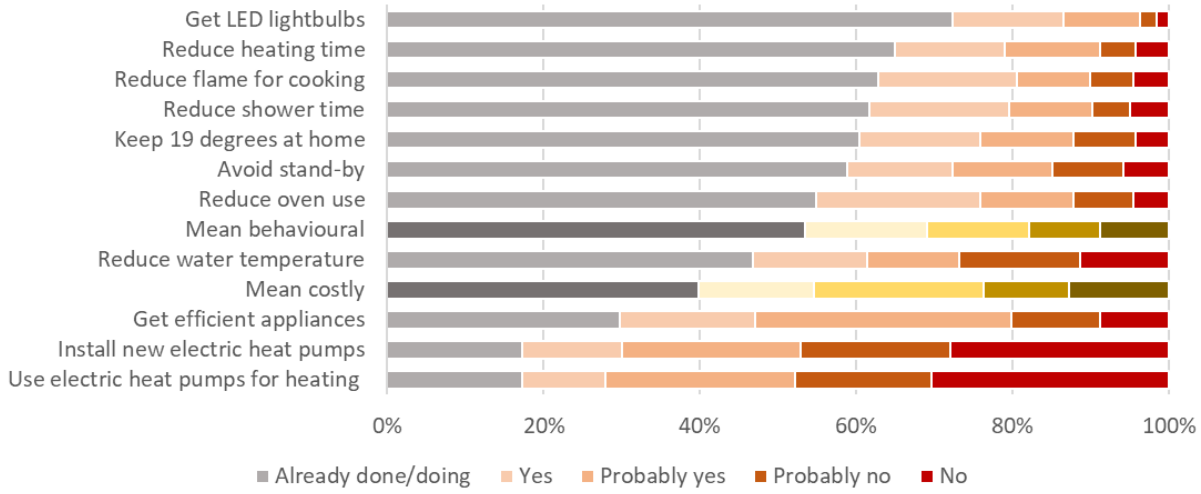
[8] Looking only at participants who listed one category of actions, 81% (out of N=190) listed a behavioural action and 19% a costly action for their past behaviours, while 71% and 29% (out of N=177) did the same for the future actions, respectively.

3.2.2. Actions from the Government Plan

When asked about the selected actions from the Government Plan, the participants stated to have adopted or to be willing to adopt 8.9/11 actions on average (Mdn=9, SD=2.13). However, there was large diversity in responses to the specific actions. The proportion of participants who claimed having already adopted an action varied between 72.3% for changing older types of light bulbs for the LED ones and 17.3% for installing and using electric heat pumps for heating (Figure 3). This diversity was mirrored in the proportions of people who did not intend (with certainty or probably) to adopt specific actions – only a small minority (3.7%) claimed this about getting LED light bulbs, while almost one in two did not intend to install and use electric heat pumps for heating.

Re-categorising the actions into costly (installing new electric heat pumps, getting more efficient appliances and LED light bulbs) and behavioural (all others) revealed that the latter have been adopted or were planned to be adopted by more participants (82.1% vs 76.3% for behavioural and costly actions, respectively, p=.0008 on a test of proportions adjusted for clustering at the participant level).

Figure 3. Intentions to adopt energy-saving actions proposed in the Government Plan



As a further exploratory step, we re-grouped these actions once more, this time following our coding framework for the qualitative data analysis (Table A4 in the Appendix). In particular, we split them into (1) turning things off (represented by avoiding stand-by), (2) smart energy usage (including reducing oven use and reducing the flame for cooking), (3) getting more efficient appliances (together with LED light bulbs and new electric heat pumps), (4) heating (reducing heating time, keeping 19 degrees at home and using electric heat pumps for heating) and (5) water heating (quicker and colder showers). Then, we went back to the qualitative data from the previous task and we calculated the proportions of participants who either adopted or were planning to adopt actions in each macro-category (previously these were separate, as in

Figure 2). Doing this exercise made the two tasks more comparable and thus allowed us to look at participants' consistency.

Table 2 shows the outcome of this exploratory analysis. The first observation is that numbers were substantially higher for the MCQ task containing actions from the Government Plan, compared to the open text exercise. A possible explanation for this is twofold. First, having to list energy-saving actions is cognitively more demanding. Especially actions that have already been adopted may not come to mind easily and only a subset containing the more salient ones is thus listed. Second, in the open text task we asked about actions that have been adopted in the past year, while there was no time limit in the MCQ task. This means that the open text task should include only a subset of actions taken in the past. Nevertheless, the second observation is that the order of different categories was the same in both tasks. The only exception to this was water heating, which was mentioned by very few participants in the open text exercise, while being endorsed slightly more than space heating or efficient appliances in the MCQ task. Overall, however, the participants were fairly consistent across the two tasks.

Table 2. Percentage of participants claiming having adopted or intending to adopt energy-saving actions in different macro-categories, in two different tasks

MACRO-CATEGORY	% LISTED IN OPEN TEXTS	% CHOSEN IN MCQs
Smart usage	42.8	88.8
Turning things off	34.3	85.1
Space heating	31.6	77
Efficient appliances	22.3	76.3
Water heating	6.4	81.6

3.3. Perceptions of efficiency of energy-saving actions

As stated in the pre-registration, participants were asked to rank energy-saving actions according to their effectiveness in saving energy twice in the study – first they ranked the actions that they had listed themselves and later they ranked the actions from the Government Plan (Table A3 in the Appendix). Nevertheless, we only present the results from the second ranking task, the reason being that many participants (almost one half) listed just one energy-saving action and thus did not do the ranking task, or did not provide a valid answer (roughly one sixth), leaving us with too small a sample to conduct meaningful analyses.

Thanks to the availability of official calculations estimating how much energy (in Sm^3 for natural gas and kWh for electricity) and money a typical Italian family could save per year by adopting each of the actions in the Government Plan, we were able to construct objective rankings of effectiveness of these actions in saving energy and money (which differ slightly) and benchmark the rankings produced by study participants against these. We use the monetary ranking as well despite the fact that the study participants were asked to rank the actions *"in order of how effective you consider them to be in saving energy in your home"*, because we cannot be sure that the participants really thought about energy saved and not money saved on their bills as the latter is cognitively an easier thing to do.

There was a large heterogeneity in the participants' rankings of effectiveness of the actions, with each action being ranked at each position (1-11) by at least some people. This resulted in mean ranking scores[9] being all quite close to the midpoint value of six, with the minimum of 5.02 (SD=3.21) and maximum of 7.43 (SD=3.16) (Table 3). The participants saw reducing the heating (in terms of time and temperature) as the most efficient thing to do to save energy in their homes, while installing and using electric heat pumps were seen as the least efficient. This second result is in sharp contrast with the official calculations, which suggest that electric heat pumps should save the most money and energy. As in previous analyses, we also split the actions into behavioural and costly, but we found no significant differences between them (p=.361 on a Wilcoxon rank-sum test).

Table 3. Energy-saving actions ordered from the most to the least efficient as perceived by study participants, benchmarked against the rankings based on official calculations

ACTION	RANKING SCORE			% RANKED FIRST*
	MEAN (SD)	OFFICIAL (ENERGY)	OFFICIAL (MONEY)	
Reduce heating time	7.43 (3.16)	6	5	20.4%
Keep 19 degrees at home	7.19 (3.17)	8	8	19.9%
Get LED light bulbs	6.48 (3.02)	3	4	10.2%
Get efficient appliances	6.28 (3.16)	5	6	9.4%
Reduce oven use	6.16 (2.96)	2	3	7.5%
Reduce shower time	5.98 (2.84)	9	10	4.7%
Avoid stand-by	5.53 (3.07)	1	1	6.4%
Reduce flame for cooking	5.44 (3.1)	4	2	4.7%
Reduce water temperature	5.44 (2.96)	7	7	4.7%
Use electric heat pumps for heating	5.06 (3.11)	10	9	5%
Install new electric heat pumps	5.02 (3.21)	11	11	7.2%
Costly actions	5.93 (3.19)	6.33	7.00	26.8%
Behavioural actions	6.03 (3.15)	5.88	5.63	73.2%

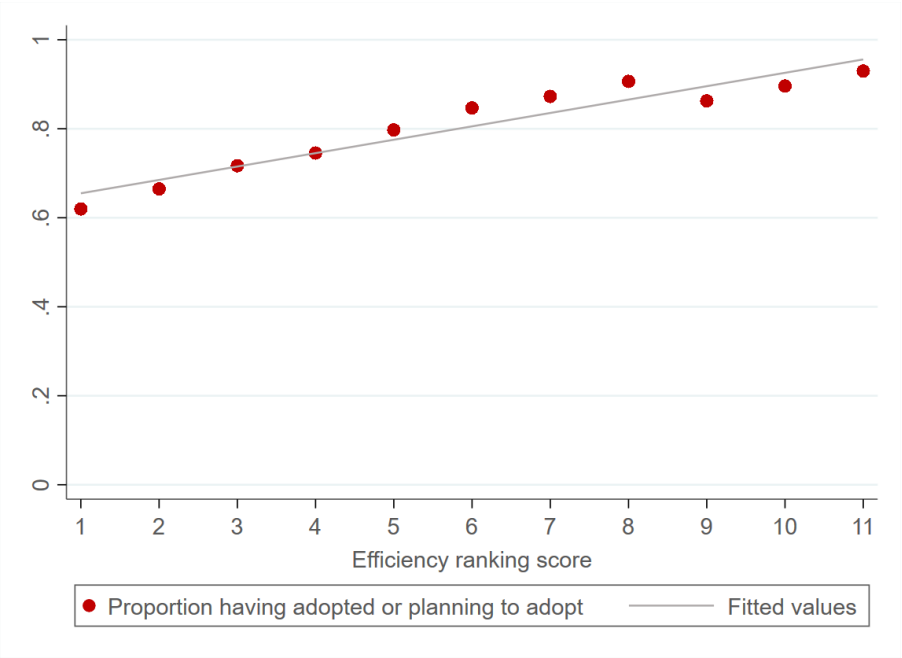
Note: The higher the score, the more efficient the action
** First = most important*

An interesting exploratory question is whether these perceptions of efficiency of different actions were linked to the participants' actual behaviours or behavioural intentions. Figure 4 depicts this link and reveals a strong positive relationship. In other words, we found that higher average rankings of efficiency were associated with a higher proportion of participants having adopted or planning to adopt a given energy-saving action. This link was confirmed by a mixed effects logistic regression with an indicator of having already adopted or planning to adopt an energy-saving action as the dependent variable, the ranking score as the main independent

[9] We present the results in terms of ranking scores, which were created by reversing the rankings, so that a higher score means the action was ranked as more important. For instance, an action ranked by a participant as the most important of all 11 actions (i.e., with a rank=1) would have a ranking score of 11, an action ranked second in order of importance would have a ranking score of 10, etc.

variable, and with random intercepts at the participant level (Model 1, Table A6 in the Appendix). Moreover, the effect remained stable even when controlling for the type of action, and adding the individual and household characteristics as additional independent variables to the model (Model 2, Table A6 in the Appendix).[10] Nevertheless, despite finding a strong association between perceptions of efficiency and energy-saving behaviours, our study design does not allow us to determine whether this association is causal.

Figure 4. Association between perceptions of efficiency and energy-saving behaviours (past and planned)



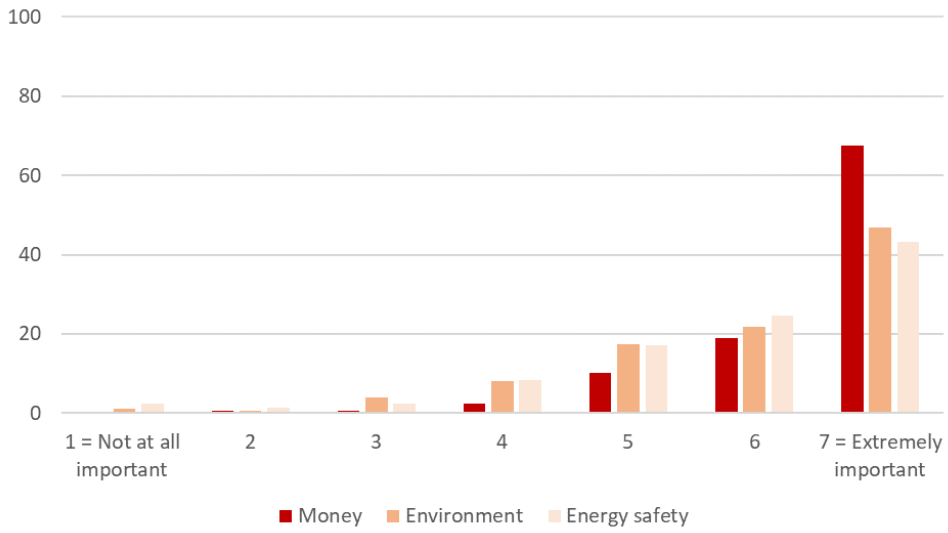
3.4. Motivations to save energy

All three motivations were rated at the higher ends of the Likert scale (Figure 5), with the median rating of 7 (i.e., maximum) for the monetary motivation (M=6.49, SD=0.88) and 6 for the other two (M=5.93, SD=1.30, and M=5.85, SD=1.40 for the environmental and energy security motivations, respectively). The differences between the monetary and other two motivations are statistically significant (p=.000 on both Wilcoxon signed-rank tests), while the ratings for environmental and energy security motivations are not significantly different from each other (p=.313).[11] This means that despite high ratings for all proposed reasons, financial matters are, on average, the strongest motivation to save energy in one's home.

[10] In addition, Model 2 showed a strong positive association between having adopted or intending to adopt energy-saving actions from the Government Plan and getting information about the energy crisis from institutional (governmental and other) online sources (β= .251, p=.001), and that the participants who place themselves on the left of the political spectrum were less likely to have adopted or be willing to adopt energy-saving actions than those at the centre of the political spectrum (β= -.515, p=.040).

[11] The same results are found if ratings are dichotomised and we compare the proportion of people who gave the maximum rating for each motivation, using a test of proportions.

Figure 5. Distributions of answers to Likert scale questions about different motivations to save energy



However, we found some differences in how highly-rated each motivation was, based on the socio-demographic characteristics of our study participants. The monetary motivation was significantly more likely to be rated at 7/7 (i.e., extremely important) by the participants without a university degree as opposed to those with a degree (71.2% vs 50.7%, respectively, p=.001 on a test of proportions). Also, those who rated the monetary motivation as extremely important perceived greater difficulties to make ends meet compared to those who rated it lower than 7/7 (M=4.65, SD=1.7 and M=4.06, SD=1.42, respectively, on a scale from 1=very easy to 7=very difficult to make ends meet, p=.0005 on a Wilcoxon rank-sum test). Thus, the importance of the monetary motivation to save energy varied with the indicators of socio-economic status. Perceived difficulties to make ends meet displayed a similar effect for the environmental motivation (M=4.66, SD=1.67 and M=4.28, SD=1.58, for those who rated it at 7/7 vs others, p=.025), however, this effect became marginal when different exclusion criteria were used. Instead, the importance of both environmental and energy security motivations varied with demographic characteristics. Namely, they were rated as extremely important less often by the participants under 35 years of age (30.7% of them rated the environmental motivation at 7/7, vs 48.8% of those aged 35-65, and 55.8% of those over 65, p=.02 and p=.003, respectively, both p-values Bonferroni corrected and the difference between the latter two age groups not statistically significant; energy security motivation rated as extremely important by 26.9% of participants under 35 years of age, 42.9% of those aged 35-65, and 57.9% of those over 65, p=.042 for those under 35 vs those aged 35-65, p=.000 for those aged under 35 vs over 65, p=.046 for those aged 35-65 vs over 65, p-values Bonferroni corrected). The energy security motivation was also less often rated at the maximum of the scale by men compared to women (35.6% vs 50%, respectively, p=.005). All these effects were confirmed in logistic

regression models where other socio-demographic characteristics were controlled for (Table 4).[12]

Table 4. Logistic regression models for different motivations to save energy at home

	Monetary	Environmental	Energy security
Age group *(ref. Under 35)*:			
35-65	0.227	0.827**	0.829**
	(0.298)	(0.299)	(0.317)
Over 65	0.441	1.331***	1.318***
	(0.371)	(0.365)	(0.374)
Woman	0.316	0.327	0.583*
	(0.238)	(0.226)	(0.235)
University degree	-0.790**	-0.530	-0.501
	(0.303)	(0.310)	(0.329)
Employed	0.002	0.266	-0.399
	(0.289)	(0.273)	(0.279)
Difficulties in making ends meet	0.197**	0.155*	0.139
	(0.073)	(0.069)	(0.071)
Political orientation *(ref. Centre)*:			
Left	-0.054	-0.182	0.032
	(0.291)	(0.272)	(0.282)
Right	-0.227	-0.512	-0.345
	(0.285)	(0.272)	(0.283)
Macro-region of Italy *(ref. North-West)*:			
North-East	0.095	-0.367	0.483
	(0.348)	(0.332)	(0.345)
Centre	0.053	0.008	0.679*
	(0.339)	(0.322)	(0.337)
South	0.073	-0.080	0.559
	(0.341)	(0.325)	(0.338)
Islands	0.311	-0.075	-0.231
	(0.431)	(0.398)	(0.429)
Geographical area *(ref. Metropolitan)*:			
Urban	0.131	0.316	0.287
	(0.319)	(0.313)	(0.327)
Rural	-0.000	0.187	0.019
	(0.355)	(0.346)	(0.364)
Constant	-0.414	-1.707**	-2.132***
	(0.573)	(0.568)	(0.594)
Observations	376	376	376
Log-likelihood	-225.077	-245.748	-230.994

** p < 0.05, ** p < 0.01, *** p < 0.001*

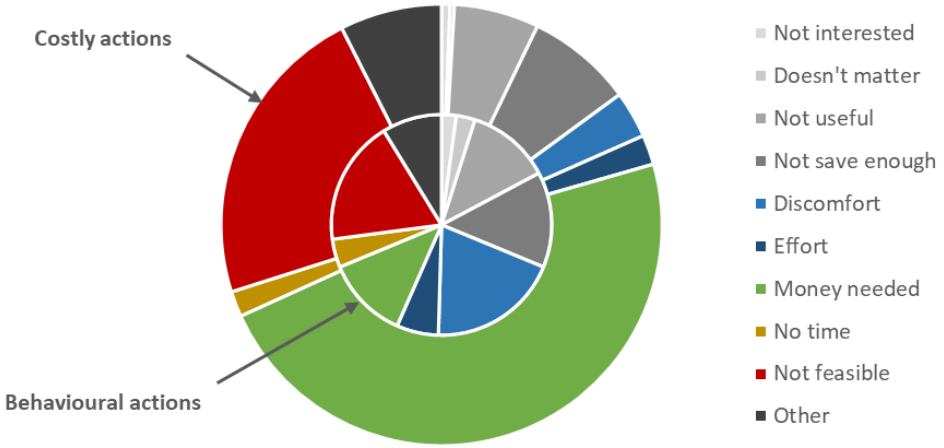
[12] In bivariate analyses, we found some other statistically significant effects that then vanished when other factors were controlled for. Namely, we found that participants without the university degree rated all three motivations as more important than those with a degree (but the effect remained significant only for the monetary motivation). We also found that participants with greater difficulties to make ends meet rated all three motivations as extremely important more often (but the effect disappeared for the energy security motivation). Finally, we also found that the unemployed rated the monetary and the energy security motivations as more important than those currently employed.

3.5. Perceived barriers for saving energy

If the participants stated they were not or probably not going to implement an energy-saving action from the Government Plan, they were asked to select the main reason(s) for this from a list. On average, participants selected between 1.07 and 1.43 barriers for various actions (Mdn=1), suggesting that mostly they perceived one main barrier for adoption of each action.

Figure 6 shows the breakdown of the barriers separately for behavioural and costly actions. The main reasons against adopting behavioural actions (inner circle of Figure 6) were related to their perceived uselessness (31% of the chosen barriers, areas in shades of grey), followed by the negative aspects of behaviour change, i.e., having to make an effort and facing discomfort (25% of barriers, areas shaded in blue). Another important aspect was that certain behavioural actions (mostly those relative to heating) were seen as unfeasible in participants' homes (18% of selected barriers). The picture was very different for costly actions, where the monetary investment being needed represented 48% of selected barriers alone and was followed by unfeasibility of these actions (22% of selected barriers) and their perceived uselessness (15% of selected barriers). Thus, the main issue with behavioural actions seems to be the perception that they may not be worth the effort, while for the costly actions the problem lies in the practical aspects of feasibility and initial investment.

Figure 6. Barriers to adoption of behavioural and costly energy-saving actions



4. DISCUSSION

The aim of the current study was to shed light on energy-saving behaviours in Italian households, on the citizens' understanding of efficiency of different energy-saving actions, and their motivations and barriers for saving energy at home. The study was designed and run in the second half of 2022 and the start of 2023, against the backdrop of the global energy crisis, and serves as a snapshot of people's behaviours and opinions during that specific time period.

Overall, the respondents were active in energy conservation, with five out of six having implemented energy-saving measures in their homes in 2022 and start of 2023. Additionally, nearly two in three expressed a desire to implement further actions in the near future. This positivity towards energy saving was mostly confirmed when considering specific energy-saving measures outlined in the official plans of the Italian government to reduce national natural gas consumption. At least half of the participants reported having already implemented or being willing to implement any suggested action (with considerable variability between actions, however).

The main driver of energy-saving behaviours was to save money on the bills. While monetary, environmental and energy security motivations to save energy at home were all rated as very important on average (i.e., quite close to the maximum of the 1-7 Likert scale), the monetary motivation was still rated significantly higher than the other two. We do acknowledge that the social desirability bias may have played a role in these high ratings, but we think that if anything, it affected the monetary reasons less than the other two, so the observed difference between the motivation holds and may even be an underestimate.

When asked about concrete actions that can save energy at home, turning off lights and appliances not currently in use was mentioned by far the most – it was indicated by almost one half of the participants. Around one in four cited using less heating (in terms of both temperature and time) and using energy more efficiently and carefully (for instance, using the washing machine or the dishwasher at full load, or using the oven less). This smart energy usage had also been the main focus of energy conservation efforts in the participants' homes, as well as something they would like to do in the near future. Important minorities of participants also implemented actions like turning off lights and appliances, and using less heating. Again, these results were roughly confirmed when evaluating the actions proposed by the Government Plan, with actions related to smart usage and turning things off being the most popular.

The popularity of these actions probably lies in the fact that they are purely behavioural – requiring only attention and perhaps time investment, without any monetary costs. In fact, by far the most important barrier to adoption of costly energy-saving actions is the necessity to invest, while the unwillingness to adopt behavioural actions to save energy is linked more to potential discomfort and perceptions of uselessness of the given actions.

This brings us to the final set of results concerning the perceived efficiency of various actions in saving energy, which we found to strongly correlate with actual or intended behaviours. While this link between perceptions of efficiency and behaviours seems to be reasonable, it can lead to errors if efficiency is not judged accurately. In fact, we found notable misperceptions of efficiency of certain actions, particularly regarding the installation and use of heat pumps. Despite the official calculations indicating that heat pumps can save the most energy among the actions considered (ENEA, 2022), participants on average ranked them as the least effective. At the same time, they overweighted the importance of some less efficient actions, such as getting LED light bulbs or using the oven less. Thus, this may be another contributing factor explaining the focus on smaller, behavioural actions, while overlooking potentially more impactful measures. An exception to this is heating, which was rated quite high in terms of

efficiency by the participants and the official calculations, and was also adopted quite frequently.[13]

Of course, this rich set of results needs to be considered bearing in mind the limitations of the study, which are mainly due to its online and hypothetical nature. It is possible that our data suffer from some reporting biases, such as the social desirability bias, or memory-related issues. Nevertheless, collecting real, detailed data on how households use and save energy is costly and complicated, so a survey like ours can provide useful insights more efficiently. Another limitation is a rather restricted sample size which, however, is compensated by its representativeness of the Italian adult population in terms of basic demographic characteristics.

To summarise, we found that the Italian households put effort into saving energy in their homes during the global energy crisis in 2022-2023, but perhaps focused too much on small adjustments to their energy-related behaviours, without making investments that could bring higher savings. This behavioural diagnosis suggests that interventions aimed at improving energy-saving behaviours in Italian households should focus on correcting misperceptions about certain actions, especially related to heat pumps (where even raising awareness may be necessary), and perhaps incentivising investment into these and other more efficient appliances. Green nudges may further support the efforts, but may not solve the biggest problems we identified.

This conclusion, we believe, underlies the importance of behavioural diagnoses, which help identify the main issues related to people's behaviours and thus serve as a basis for the design of interventions. The findings of our diagnostic study are thus relevant for the research community, policy-makers, and energy providers alike and we believe our study marks a first important step in developing evidence-based interventions to enhance energy-saving behaviours in Italian households.

[13] Note that keeping the temperature at home at 19 degrees and reducing the number of heating hours at home by one per day were proposed by the Italian government as mandatory, even though the enforcement of this rule remains unclear.

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APPENDIX

Table A1. Research questions for the current study

AIM	RESEARCH QUESTIONS
Assess people's awareness of behaviours that they can do in their homes in order to save energy	RQ1a) Which do people think are the behaviours that can lead to household energy savings?
Assess people's perceptions of effectiveness of energy-saving behaviours (those listed by themselves or proposed in the Government Plan)	RQ1b) Which do people think are the behaviours that lead to the biggest household energy savings?
Assess people's actual and planned energy-saving behaviours	RQ2a) Which behaviours have people recently adopted in order to save energy in their homes? RQ2b) Which behaviours do people plan to adopt in the near future in order to save energy in their homes?
Assess people's motivations and barriers for energy-saving behaviours	RQ3a) What are the perceived barriers to adopting energy-saving behaviours? RQ3b) What are the motivations for people to adopt energy-saving behaviours?
Examine the role of socio-demographic factors in energy-saving behaviours of households	RQ2c) Which individual, household and action characteristics are associated with the adoption of energy-saving actions at home or the intention to do so? RQ4) How do the answers to previous research questions differ by socio-demographic and other individual and household characteristics?

Table A2. Socio-demographic characteristics of the Italian adult population and the study sample

	STUDY DATA	ISTAT* DATA	
AGE GROUP			*p*[†]*=.517*
18-24	8.0%	8.3%	
25-34	14.0%	12.5%	
35-44	15.8%	14.5%	
45-54	20.5%	19.0%	
55-64	17.8%	17.5%	
65+	24.0%	28.3%	
GENDER			*p=.393*
Men	46.0%	48.3%	
Women	53.8%	51.8%	
REGION			*p=.997*
Northwest	26.8%	26.8%	
Northeast	19.8%	19.6%	
Centre	20.3%	19.9%	
South	22.3%	22.9%	
Islands	11.0%	10.9%	
EDUCATION			*p=.000*
No/elementary	1.5%	15.9%	
Middle school	26.5%	32.2%	
Professional qualification	6.3%	5.5%	
High school	47.5%	31.2%	
Degree or higher	18.3%	15.3%	

** ISTAT = Italian National Institute of Statistics; raw data from ISTAT representing the Italian population on 1 January 2022 (2020 for education); percentages based on own calculations representing shares of population aged 18+ for age and gender; aged 15+ for education, and total for regions)*

[†] *p-values from Pearson's chi-squared tests*

Table A3. Actions from the Government Plan used in the study and the respective estimates of yearly gas, electricity and bill savings at household level

ACTION	GAS SAVING (Sm^3/year)	ELECTRICITY SAVING (kWh/year)	COST SAVING 2021 (€/year)	COST SAVING 2022 (€/year)
Reduction of water temperature in the shower	48.88	N/A	47.34	65.39
Reduction of shower time	153.63	N/A	148.79	205.52
Use of electric heat pumps for heating (normally used for air conditioning)	606.66	N/A	147.00	196.78
Reduction of the flame once the water boils	9.32	N/A	9.02	12.46
Reduction of the time using of the oven	N/A	33.3	9.90	13.78
Avoiding use of standby regime by the TV, decoder, DVD player	N/A	10.95	3.25	4.53
Replacement of the electrical appliances with the more efficient ones	N/A	Washing machine*: 164.25 Dishwasher*: 113.15 Fridge*: 203.00 Oven*: 110.60	48.78 33.61 60.29 32.85	67.90 46.78 83.92 45.72
Installation of new electrical heat pumps to replace old gas boilers	645.59	N/A	294.84	402.56
Replacement of traditional light bulbs with the LED ones	N/A	43.31	12.86	17.90
Reduction of heating temperature to 19 degrees	81.94	N/A	79.36	109.62
Reduction of heating time by 1 hour/day	27.44	N/A	26.58	36.72

** Savings from 4 appliances averaged for the analyses*

Source: ENEA (2022)

Table A4. Coding framework for open text answers and re-categorisations for the analyses

DETAILED CATEGORY	MACRO-CATEGORY	TYPE
1 = Turn off lights that are not in use	1 = Turn things off	0 = no cost, just behaviour
2 = Turn off appliances not in use		
3 = Use things less/less things	2 = Smart/careful usage	0 = no cost, just behaviour
4 = Use/do things more efficiently		
5 = Change timing of using appliances		
7 = Use less energy in general / be careful with energy use		
8 = Heat pumps (use, install)	3 = Space heating	1 = initial cost
9 = Use less/no heating (time)		0 = no cost, just behaviour
10 = Lower temperatures in the house		0 = no cost, just behaviour
11 = Better insulation of the house	4 = Insulation	1 = initial cost
12 = Keep the heat in the house		0 = no cost, just behaviour
13 = Wear heavier clothes		0 = no cost, just behaviour
14 = Efficient appliances	5 = Efficient appliances	1 = initial cost
15 = Efficient/LED lightbulbs		
16 = Quicker showers	6 = Water heating	0 = no cost, just behaviour
17 = Water/showers with lower temperatures		
6 = Make use of alternative energy sources	7 = Alternative energy sources	1 = initial cost
20 = Alternative energy sources for heating		
19 = Change energy provider/contract	8 = Change energy provider/contract	0 = no cost, just behaviour
200 = DK	9 = DK	. = N/A
18 = Listed energy provider	10 = Invalid	. = N/A
100 = Invalid		

Table A5. Having adopted and planning to adopt energy-saving actions by individual and household characteristics

	Energy-saving behaviours in the past	Energy-saving intentions for the future
Age group *(ref. Under 35)*:		
35-65	-0.377	-0.383
	(0.466)	(0.342)
Over 65	0.027	-0.479
	(0.608)	(0.437)
Woman	0.058	-0.006
	(0.358)	(0.257)
University degree	0.665	0.092
	(0.518)	(0.344)
Employed	-0.345	0.103
	(0.399)	(0.310)
Difficulties in making ends meet	-0.131	0.113
	(0.116)	(0.086)
Political orientation *(ref. Centre)*:		
Left	0.581	0.013
	(0.405)	(0.307)
Right	1.297**	0.662*
	(0.431)	(0.315)
Macro-region of Italy *(ref. North-West)*:		
North-East	-0.274	-0.335
	(0.510)	(0.372)
Centre	-0.580	-0.755*
	(0.488)	(0.370)
South	0.448	0.220
	(0.542)	(0.375)
Islands	-0.439	-0.112
	(0.609)	(0.456)
Geographical area *(ref. Metropolitan)*:		
Urban	-0.429	0.047
	(0.498)	(0.343)
Rural	-0.313	-0.060
	(0.550)	(0.385)
Worry about electricity bill	0.037	0.194
	(0.165)	(0.131)
Worry about gas bill	-0.240	-0.179
	(0.140)	(0.104)
Worry about climate change	0.223	-0.033
	(0.133)	(0.108)
Worry about energy security	0.130	0.152
	(0.114)	(0.089)
Environmentally friendly behaviour *(ref. None)*:		
In some things	0.377	-0.406
	(0.505)	(0.402)
In quite a few things	-0.177	0.160
	(0.603)	(0.492)
In most things	0.466	-0.472

	(0.609)	(0.453)
In all things	0.133	0.162
	(0.740)	(0.591)
Keeping informed about energy crisis	0.179	-0.030
	(0.152)	(0.121)
Importance of information source with regards to energy crisis:		
TV	0.001	-0.046
	(0.121)	(0.090)
Radio	0.038	-0.046
	(0.107)	(0.078)
Newspapers (also online)	-0.048	-0.097
	(0.110)	(0.080)
Social media	0.329*	0.006
	(0.139)	(0.095)
Governmental/institutional websites	-0.184	0.318***
	(0.128)	(0.093)
Other people	0.102	0.017
	(0.117)	(0.087)
Type of electricity bill *(ref. With fixed costs)*:		
With variable costs	-0.901	0.139
	(0.601)	(0.424)
Don't know	-0.255	0.626
	(0.733)	(0.568)
Type of gas bill *(ref. With fixed costs)*:		
With variable costs	1.662**	0.215
	(0.632)	(0.442)
Don't know	0.129	-0.245
	(0.692)	(0.535)
Household size *(ref. One)*:		
Two	-0.982	-0.357
	(0.580)	(0.413)
Three or more	-0.611	-0.270
	(0.583)	(0.399)
Past energy saving behaviours		0.503
		(0.337)
Constant	-0.057	-0.762
	(1.252)	(0.961)
Observations	376	376
Log-likelihood	-135.695	-216.731
Pseudo R2	0.194	0.129

** p < 0.05, ** p < 0.01, *** p < 0.001*

Table A6. Logistic regressions showing the association between energy-saving behaviours (past and planned) and perceptions of efficiency

	Model 1	Model 2
Ranking score *(ref. 1=least efficient)*:		
2	0.223	0.292
	(0.176)	(0.205)
3	0.585**	0.670**
	(0.181)	(0.211)
4	0.817***	0.881***
	(0.185)	(0.216)
5	1.194***	1.243***
	(0.193)	(0.226)
6	1.645***	1.595***
	(0.207)	(0.239)
7	1.900***	1.867***
	(0.217)	(0.250)
8	2.353***	2.485***
	(0.239)	(0.278)
9	1.815***	1.837***
	(0.213)	(0.249)
10	2.164***	2.149***
	(0.229)	(0.261)
11	2.821***	2.862***
	(0.271)	(0.305)
Constant	0.588***	-3.249***
	(0.143)	(0.778)
Var(Constant)	1.695***	1.894***
	(0.237)	(0.284)
Control variables	NO	YES
Observations	3,982	3,982
Participants	362	362
Log-likelihood	-1,674.567	-1,351.140

** p < 0.05, ** p < 0.01, *** p < 0.001*