Are the next-generation households ready for the energy transition? A survey on their positioning and practice with energy management tools

Are the next-generation households ready for the energy transition? A survey on their positioning and practice with energy management tools

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Abstract. In the last decades, significant effort has been put towards technological advancement in housing for energy transition. Massive retrofitting actions have been called for, and innovative technologies for smart energy management at home have been deployed. However, undesired energy trends in housing suggest that relevant factors have been neglected. Among these, increasing importance is now given to occupants' behaviour, and their capacity to interact with energy management devices available in dwellings. This study investigates what is the position of next-generation users on energy transition at home. Two years ago, the authors launched a survey to explore people's awareness of energy use practices, interaction with metering devices, and user motivation to change when informed. As a pilot survey, over 300 people from the academy were involved to see what was the position of a sample which was supposed to be informed more than the average, in Italy. The test yielded early outcomes on how people become more interested to change as they gain knowledge and are offered suggestions. Despite the expectations, the sample's level of awareness was low. This suggested that a more user-centred approach is needed for wide-scale progress. Especially results from the youngest were below prospects. The questionnaire was relaunched to examine if the pandemic, energy crisis and latest news on climate change have affected positions of the youngsters. A testing session involving university students was performed, and results have been compared with the previous. As a result, reflections on the energy use patterns of the next-generation households are provided.

1. Background and context

A fast and effective energy transition is crucial to meet climate neutrality and sustainability targets globally, including economic, environmental, and social benefits for all [1,2]. The housing sector is critical in this pathway, both due to its overall impact and the estimated energy-saving potential for households. In figures, in 2021 the operation of buildings accounted for 30% of global final energy consumption and 27% of total energy sector emissions at a global level [3]. The same goes for Europe (EU), where buildings are still today the largest single consumer accounting for around 40% of the EU energy consumption and 36% of greenhouse gas emissions [4,5].

Most of the sector's energy and carbon savings can be achieved through deep retrofit of the built environment, as clearly emerges from the latest recast of the European Building Performance Directive (EPBD) [6]. However, despite some positive results mainly due to building retrofitting incentives, energy demand and carbon emissions due to buildings operation are still out of track compared to the Net Zero Scenario.

To this end, a growing body of literature and policies suggests that households' behavioural change could greatly accelerate the process, either stimulating further technical interventions or reducing energy demand through a change in habits [7–11]. Considering the future energy-demand reduction due to massive retrofit supported by the EU, citizens' energy-use patterns will become progressively more significant since the more buildings become energy efficient the more increase the relevance of occupants' behaviour on the overall energy demand and the potential of monitoring and smart managing tools. To this regard, the end-users behaviours most frequently cited in the literature as relevant are those targeting the comfort temperature setpoints (for both winter and summer), window opening patterns, lighting control, the efficiency of devices and appliances, use of hot water [12–15]. Part-time or part-space use approaches are also frequently mentioned, as well as the reduced need for mechanical systems (and linked energy use) through passive strategies that make use of windows for natural ventilation, or natural daylight or thermal gains in winter, or open-air cloth-drying rather than using electric machines [16].

Whether it is a change in habits or a one-shot occurrence, several studies prove these behavioural changes related to energy can be greatly affected by people's levels of awareness and willingness to change, as well as the provision of feedback on consumption [8,9,17]. As a response, energy management tools and systems have been developed to support households in monitoring their demand; some automatically manage the exchanges in the house and with the network, and others return feedback to induce users' adjustments in energy use practices. These often include the use of smart meters, user-friendly interfaces, e.g., In-Home Displays, web, or mobile applications. Regardless of the device, the goal is to enable households to improve indoor comfort while limiting energy expenses and reducing their environmental footprint [18–20]. However, the diffusion and effectiveness of smart technologies returning feedback largely depend on the ability of users to actively interact with them, which has been for long underestimated in the literature.

Therefore, the availability of technological advancements alone seems not to be enough in boosting energy transition at home. What appears to be urgent now is to understand how behavioural change can be mobilised to realise the potential for reducing energy demand that scholars estimate it can provide. The purpose of this research is to gain insight into how individuals are responding to the energy transition. Understanding how technological solutions can be supported by more sustainable household lifestyles and behaviours is a critical first step. This can indeed help researchers in detecting the real potential of energy monitoring and management devices to be effectively used in achieving energy savings at a larger scale, as their functioning cannot be completely separated from a proper level of awareness and understanding by the end users. These underlying assumptions suggest that is of utmost importance to identify what is actually and currently required to support the household change in energy behaviours, with the goal of more effectively and quickly exploiting their potential.

Most of the literature in this field focuses on how attitudes and energy-saving behaviours affect energy demand, as well as on what sort of devices and feedback people need to change their behaviours, but leaves the question of what motivates people to take action after learning something unresolved [21]. Thus, the study-specific objectives are:

1. To investigate people's level of awareness in relation to their energy consumption habits.
2. To examine whether and how available devices influence household energy behaviour.
3. To understand people's willingness to adopt certain (shared and recognised) simple energy-saving practises.

This will help to better identify the tools and levers that consumers believe are most appropriate for motivating themselves to change their energy-related behaviour at home.

2. Materials and methods

Within this framework, the article particularly focuses on the position of next-generation users on energy transition at home. Two years ago, the authors designed and launched a survey to be launched as a test run at the university level to investigate people's awareness about energy use practices, interaction with metering devices (considering both utility reporting services and in-home display when available), and

user motivation to change when informed. Details on the survey design and full list of questions is available at [21].

As a pilot survey, about 300 people from the academy in Italy were involved to understand the positioning of a sample supposed to be more informed than the average. The test yielded early outcomes on how people become more interested to change as they gain more knowledge and are offered suggestions. Despite the expectations, the sample's level of awareness and information resulted low, suggesting that a more user-centred approach is needed for wide-scale progress on energy transition at the home level. Consistently with literature, it was found that those who use energy feedbacking devices are generally more aware of environmental issues, but not necessarily more willing to change their behaviour. However, the diffusion of these devices is still limited – even if their use in the selected pool was higher than expected likely because of their proximity to the building sector.

Beyond general findings, notable results from the younger age bands were discussed. These represented about 81% of the pool, accounting for 235 respondents. Out of the total, 47.8% were 18-24 y.o., and 33.3% were 25-39. Although the literature tends to identify them as more aware and concerned about general environmental topics, the survey suggested that is slightly overestimated since few of them are aware of their consumption (less than 1 out of 3). In relation to these younger age bands, they performed well on awareness at the general level (e.g., use of ecological footprint at least once), worse with reference to energy use at home. Furthermore, the diffusion of smart metering and management devices was low in this sample, with the vast majority of those having an In-Home Display being over 40. For these reasons, two years after the survey was relaunched to examine if the pandemic, energy crisis and latest news on climate change have affected citizens' position in the energy transition, and especially that of the younger generations. A testing session involving university students and academics was performed, expecting the sample to be more sensitive than before to environmental concerns and be more digitally skilled. Results have been interpreted and compared with the previous ones. Notably, not only are the participants' potential next-generation households, but they are also representing those who are going to guide the design (or redesign) of houses in the next decades.

2.1. The survey

The survey, as designed in the previous study by the Authors, includes twenty multi-answer questions that are organized into four sections each to investigate a specific aspect.

- Section 1: general pieces of information on participants and their houses (questions 1-7), to get an understanding of the general framework the user is operating within and his/her level of engagement and environmental responsibility.
- Section 2: personal knowledge and awareness of energy consumption (questions 8-11), to detect the user's level of knowledge on energy behaviour and the awareness of the effect of given energy-use practices.
- Section 3: familiarity and interaction with energy metering devices, interfaces, and feedback (questions 12-18), to investigate the familiarity of participants and level of interaction with energy metering devices (if any), and the type of information she/he believes may affect her/his behaviour the most.
- Section 4: personal preferences on energy saving practices and intention-action gap (questions 19-20), to examine the predisposition and willingness to change of participants.

The questionnaire is anonymous and designed in Google Forms both in Italian and English, given that the pool includes international researchers and students. Some questions are redundant to test the consistency of responses.

Moreover, hidden scores are linked to the questions about their own habits and attitudes towards energy-saving behaviours. By completing the questionnaire, the participant receives a total score that corresponds to one of three energy-saving profiles: A*pprentice* (0-8 points), *Expert* (9-18 points), or *Pioneer* (19-27 points) of the energy transition. This is intended as a potential direct impact of the study, which as feedback might stimulate itself behavioural change.

2.2. Relaunching the survey

Given that useful insights were retrieved from the survey results, but also not "fully" satisfying findings on the overall level of awareness and willingness to change the sample, a new round of investigation has been performed focusing on youngsters. No changes in the survey were made to ensure comparability of results. As for participants, even if they are different from the previous, consistency in terms of education and background were assumed as basic requirements. For this reason, a pool of around 150 participants from the School of Engineering and Architecture was selected, including international students (either students enrolled in international courses or Erasmus+).

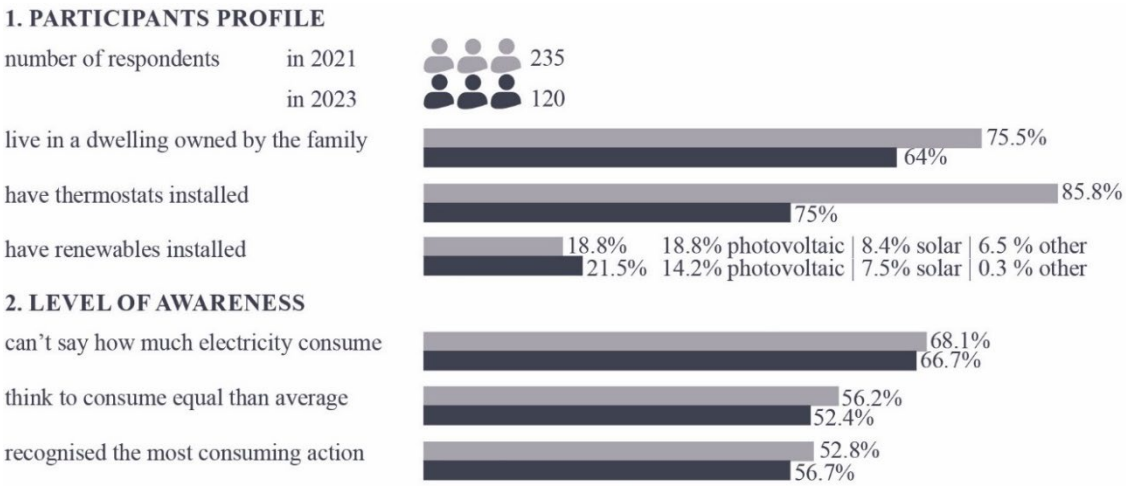
Both bachelor and master students in Architecture were addressed, as well as students from the Architecture and Creative Practices for the City and Landscape Master programme. Participants were asked to answer the questionnaire (either in Italian or English according to their origin) between January 2nd and 16th 2023. Then, results have been interpreted and compared with those of the first round.

3. Results discussion and conclusions

As in the first round of the survey, responses were examined and commented on per section and when relevant, interlocked issues were discussed. From the 2021 survey, results only for age bands 18-24 and 25-39 were considered. Even if in the 2023 sample these latest represented a minor share compared to the youngest, they were considered for the relevance they had in the 2021 survey in terms of devices' availability and level of interaction (less diffused in the lower age band).

From 2023 respondents were 120, mostly aged 18-24 (88%) with a few 25-39 (12%). In terms of ownership, 64% of participants live in houses they or their parents own, the remaining are tenants. As for the age and status of the house, 27.5% lives in houses built after 2000; 22.5% in houses built before 2000 but recently retrofitted; the remaining in houses built before 2000, not retrofitted. Services and systems are autonomous in 76.6% of involved houses, which reflects the diffusion of thermostats (75%). The vast majority (78.5%) of the houses are not equipped with renewable energy source systems.

As for awareness on energy consumption, 66.7% cannot say how much electricity they consume on average per month. Over half of the sample thinks to consume the same as the average, 20.8% below and the remaining do not know or declared to consume more than average. Given four energy-consuming actions, over 56% recognised the most consuming one (i.e., raising the room temperature by 1 °C for 1 day). Only 15.8% of respondents use devices or apps that allow them to periodically know their energy consumption, however, these are mostly convinced of their positive impact on their behaviour (over 93%). When asked to select one or more types of feedback they would like to receive about energy use, about 73% chose qualitative feedback, 58.8% quantitative, and 61.1% comparative ones. Regarding willingness to change, only 24.4% declare they are available to reduce room temperature in winter by 1°C as the first option, but this share raises to 47.5% when informed about the average consumption of this action. With references to the overall positioning, over half of the sample was appointed as 62.5% Expert in the Energy Transition. Figure 1 compares the most relevant variations between the two years.



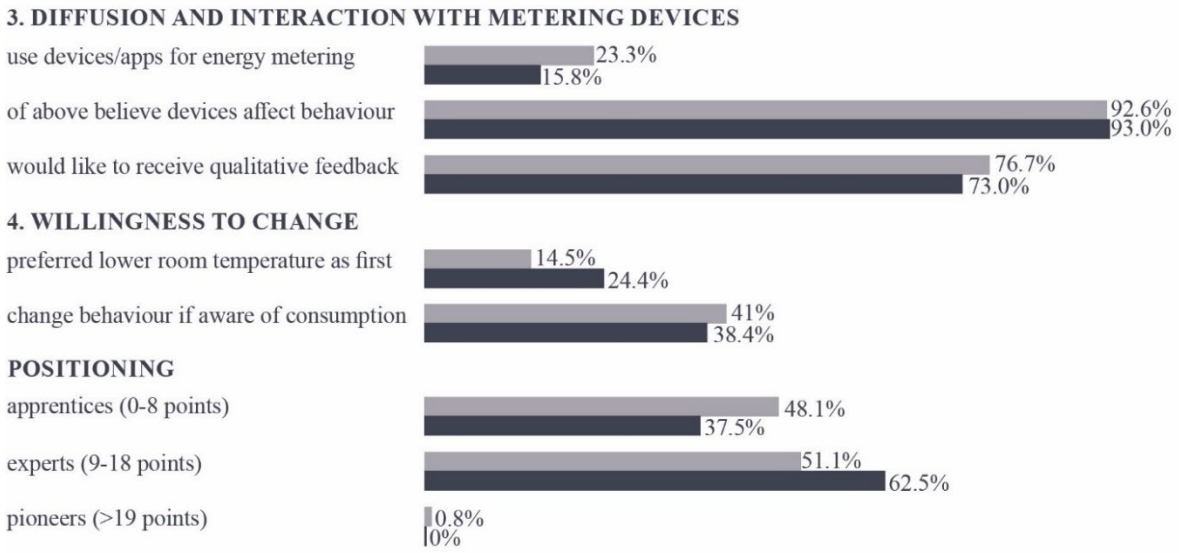


Figure 1. Comparison of the results from the two years.

3.1. Final reflections

The comparison of relevant questions among the two rounds revealed no significant differences. However, some interesting reflections and trends can be drawn. Concerning the profile of respondents, lower availability of home thermostat is registered in the recent pool, but this might be related to the high obsolescence of houses where students are living compared to the researchers that massively responded in 2021. Instead, a positive increase in renewables is recorded.

Notably, despite climate change alerts and economic crisis, a slight decrease in the overall level of awareness is registered in the new sample, which confirms that young generations tend to be well positioned when it comes to general environmental awareness, less with specific energy consumption at home. Indeed, a significantly lower share uses devices for energy metering, which again confirms that more than developing new tools, a massive deployment of existing smart ones should be supported. In fact, their willingness to change when informed results are higher than in the previous sample. This might suggest that more attention should be paid to communication channels and not simply to the functionalities of physical devices, leading to more targeted awareness campaigns and a combination of technological and social changes.

Overall, the findings show that research and policies must collaborate across the three levels that were examined in the survey, as progress in one area alone does not ensure advancement in others. With reference to the most compelling drivers (whether a purely economic benefit or a genuine willingness to meet the environmental challenge of the energy transition), this survey seeks to elicit the direct impact a self-reflection on one's own commitment and attitude to change habits or behaviours.

3.2. Limitations and further developments

The size and representativeness of the pool are currently a limit of the study, but at this stage, we were more interested in detecting variations in the awareness and practice of youngsters with energy tools rather than extending the survey to a large population sample, which will be the next step. After the severe environmental and societal disruptions of the last three years, we were curious to spot relevant changes and/or invariant. Furthermore, it should be pointed out that the reliability of answers might be affected by social desirability (reporting a better behaviour than the actual one). To this end, a control sample was set for the previous survey (2021), by asking part of the pool of providing evidence about actual consumption and declarations. Although no great discrepancies were detected, redundancy and control questions will be included in the refined version of the survey for a wider target pool.

Thus, the survey that is planned to be launched will include these reflections and those that emerged in 2021. Among these, inferential statistics might be performed to understand, for example, if responses change with different demographic groups or other profile or housing differences.

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