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STEP-IN

D3.3 – Data analysis Report on Mountain Living Lab

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Abstract: The deliverable contains the results of the second and third rounds and the ex-post assessment socioeconomic survey of the mountainous Living Lab in Metsovo, Greece

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Dissemination Level

PU Public

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Glossary

Abbreviation / acronym	Description
LL	Living Lab
ELSTAT	Hellenic Statistical Authority
NGO	Non-governmental organisation
HDD	Heating Degree-Days

1. Executive Summary

The partners directly involved in the Greek Living Lab (LL) are the National Technical University of Athens (NTUA), the Municipality of Metsovo (MM), the Greek Regulatory Authority for Energy (RAE) and the Luxembourg Institute of Science and Technology (LIST). The mountainous LL is operated mainly by NTUA with the collaboration of MM which, as the local authority, has a long-lasting experience in energy poverty prevention and alleviation, RAE that provides impactful suggestions for national policy measures for vulnerable consumers, and LIST which develops software and other tools to assist consumers in making better energy consumption choices, and energy advisors and practitioners in being able to more effectively monitor and help local households. Also, STEP-IN has identified and invited a number of local stakeholders to get involved in the project's activities, such as the Epirus Regional Authority, Municipalities located in the Region of Epirus and local Trade Associations. These stakeholders were invited to presentations, panel discussions, round tables and energy cafés that took place in the LL, as well as to the national conference that was organised by NTUA and RAE and participated in the Stakeholders Community.

The V2 and V3 rounds of the mountainous LL took place in Metsovo, Greece, between November 2019 and December 2020 and included a series of activities, which are presented in Figure 1 (in order of occurrence).

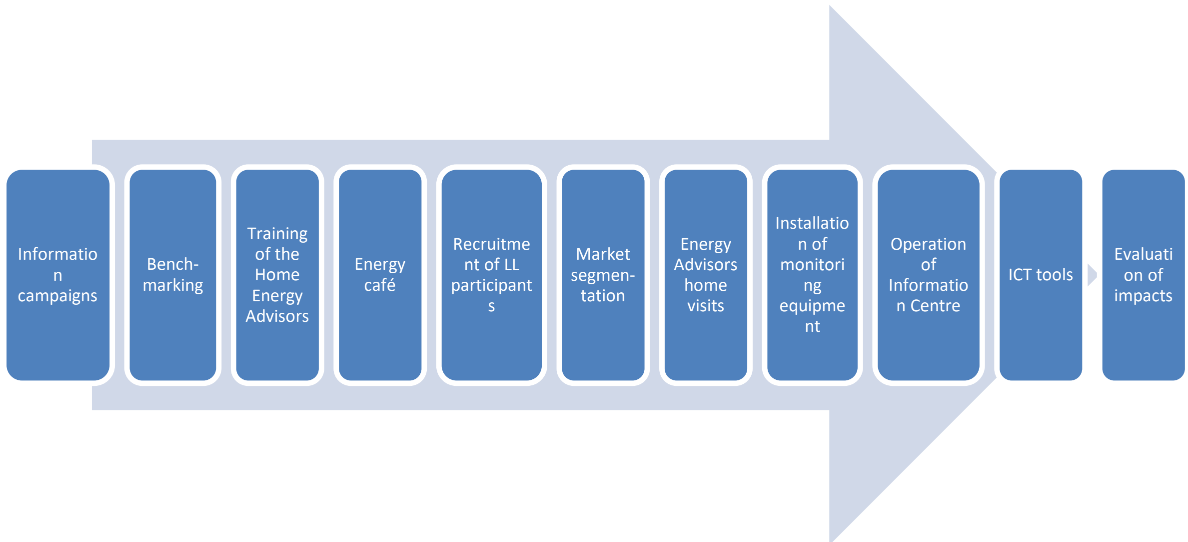

Figure 1: Mountainous LL activities

A total number of 100 houses were visited by the LL's Energy Advisors. In 30 of them, monitoring equipment was installed to measure electricity consumption and indoor temperature and humidity. According to the original schedule, monitoring equipment would be installed in 60 houses (i.e. 30 houses in V2 and 30 houses in V3, respectively). Nevertheless, due to the COVID-19 pandemic, the equipment that was installed in the houses of V2 round was kept there also during the operation of the V3 round, to gather data and information related to the impact of the pandemic-related restrictions on households' energy consumption. Information related to the buildings' energy efficiency, current energy costs, heating energy sources, heating system's condition, etc. was collected and in several houses, the "weak" points of the building shell were spotted using an infrared camera (Figure 2), and the heating systems were serviced for free (Figure 3).

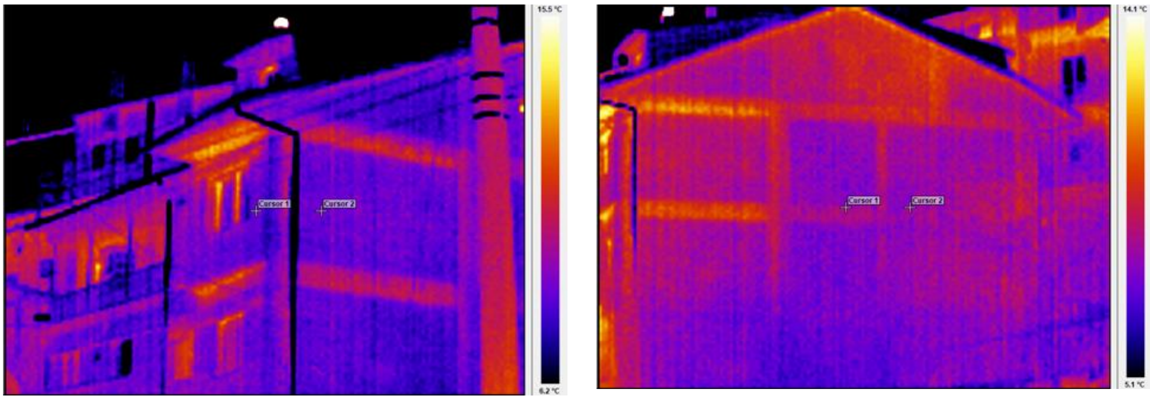

Figure 2: Thermal images

Figure 3: Service of heating systems

The information and data collected during the two rounds of the LL and the calculations made to estimate energy consumption and expenditure using models of the houses verified the findings of the baseline survey and the first round. Metsovo's residents face excess energy costs which are attributed mainly to the harsh climate and the old building stock that lacks energy efficiency. The portion of household budgets which is absorbed by energy needs (especially heating) is unacceptably high also because there was a considerable rise in fuel prices and a significant decrease in the average annual income, in Greece, between 2009 and 2014.

The average indoor temperature in the houses monitored was around 20°C (the outdoor temperature in the same period ranged between -5°C and 22°C) (Figure 4). In certain cases, significant differences (up to 9°C) were measured in the indoor temperature between rooms of the same house, which were attributed to the type of the heating system (i.e. local or central) or even the orientation of the room.

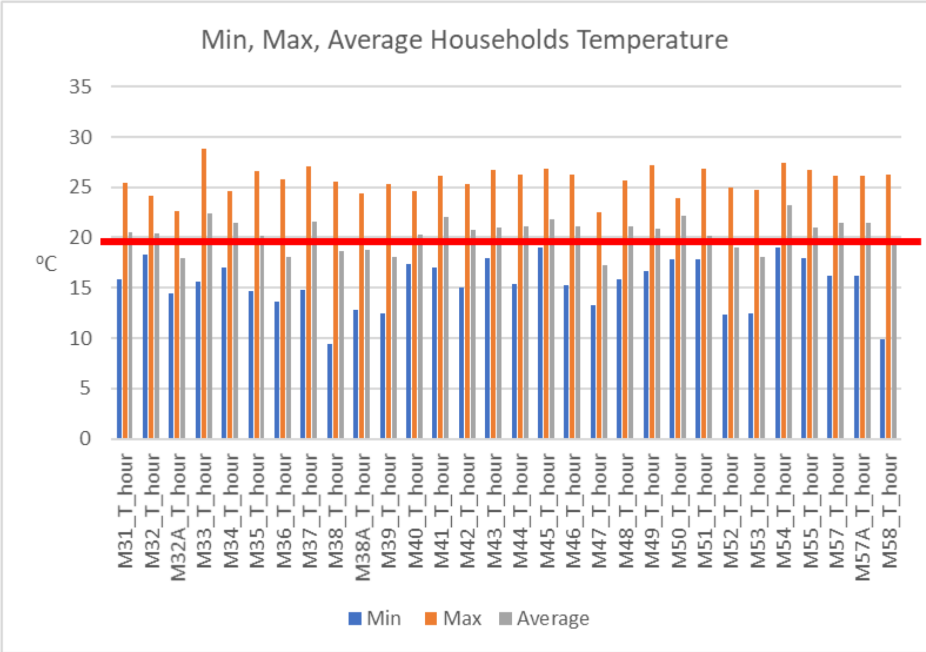

Figure 4: Comparison of average indoor and outdoor temperature, between November 2019 and May 2020

Based on the measured temperature, the total heating energy consumption of the monitored households for the V2 round amounts to 806,538 kWh_{th}, which is lower than the total required thermal energy (i.e. 879,054 kWh_{th}) to keep the houses at comfort levels (i.e. 20°C, as defined by KENAK and relevant standards). In some houses (around 30%), however, there is over-spending of thermal energy. In the cases where the temperature exceeds comfort level, the excess energy consumption is 17% greater than required. The average annual electricity consumption is around 3,684 kWh_{el}, about 22% lower than Greece's average. The households that use electric hot water boilers consume, on average, approximately 1,320 kWh_{el} more electricity per year than households without electric boilers. Based on the average heating consumption, it is estimated that the non-monitored households of the V2 round consume about 620,000 kWh_{th} and, hence, the overall thermal energy consumption is around 1,427,000 kWh_{th}. As far as the households that took place in the V3 round of the LL, it was estimated that the thermal energy consumption is around 1,500,000 kWh_{th}.

The Energy Advisors offered household-specific advice on conservation practices and potential efficiency investments. In total, 74% of those who participated in the V2 and V3 LL's activities said that the project was useful to them (approximately 39% changed everyday habits, 13% maintained their heating system, 23% were helped to gain a better understanding of electricity bills, 14% claimed that they learn how to use their heating system more efficiently, etc.). More importantly, around 43% of them (54% in the V2 and 32% in the V3 round, respectively) said that they noticed an improvement in the quality of their life during the operation of the two last rounds of the LL (e.g. reduction in energy spending, reduction in moisture/mould problems, improvement in thermal comfort, etc.). Some participants were motivated by the project and implemented, or stated that will implement in the near future, energy interventions, such as insulation of external walls, replacement of energy-consuming appliances, replacement of old analogue thermostats, maintenance of heating systems, installation of air insulation adhesive foam tape etc., and changed energy behavioural patterns concerning home ventilation, thermostat setting, etc. The heating energy savings triggered by the STEP-IN project within these two rounds sum to 135,400 kWh_{th} per year (76,400 kWh_{th} in the V2 and 59,000 kWh_{th} in the V3 round). Also, the minimum electricity energy savings are estimated at 1,200 kWh_{el} per year (just from two households). Besides improvements in the quality of life, these actions bring also environmental benefits. For instance, it is calculated that the potential reduction in CO_2 emission can be up to 30.7 tn per year.

Overall, considering the total number of households that took place in the three LL rounds, i.e. 150 or 442 people, the following benefits are estimated:

- STEP-IN helped 335 people
    - Better understanding of energy bills: 75 people
    - Change in everyday habits: 96 people
    - Change/maintenance of the heating system: 56 people (19 houses)
    - More efficient use of the heating system: 53 people
    - Motivated to implement insulation measures: 28 people (10 houses)
    - Change of electricity provider: 9 people (3 households)
    - Use of night tariff: 11 people (4 households)
- STEP-IN improved the quality of life of 170 people
    - Improved thermal comfort: 74 people
    - Energy cost reduction: 41 people
    - Moisture/mould reduction: 46 people
    - Payment of utility bills on time: 10 people
    - Replaced defective appliance/insulate the house: 5 people (2 houses)
- Actual and potential heating energy savings achieved during the project (on an annual basis):
    - Heating energy savings due to heating system maintenance: 19,640 kWh_{th}
    - Heating energy savings due to replacement of thermostats: 52,840 kWh_{th}
    - Heating energy savings due to insulation: 220,260 kWh_{th}
    - Electricity energy savings due to the replacement of old appliances: 3,200 kWh_{el}
- Potential reduction in CO_2 emissions: 63.6 tn per year

According to the results of the ex-post assessment survey, about 11% of the non-participating households received information (e.g. the energy advice booklet) from the project. It should be noted that the booklet should have been distributed to all local households by the Municipality of Metsovo. Yet, this task could not be completed due to the national and local restrictions imposed to curb coronavirus spread. Of those households who received information, 83% found this material useful. In particular, about 70% said that they gained a better understanding of the energy bills and changed some bad everyday habits, 35% were motivated to service their heating system and learned how to use their heating system more efficiently and less than 10% started examining the adoption of insulation measures. More importantly, about half of them (i.e. 48%) stated that their living conditions improved thanks to the advice received by the project, mainly by improving the level of thermal comfort at home (36%), by reducing energy costs (20%) and by facing less moisture/mould problems and paying energy bills on time (8%).

Considering the total number of households in the Municipality of Metsovo (after excluding those who participated in the LL to avoid double-counting), it is estimated that the STEP-IN information and advice material reached more than 240 households or 670 people. Based on the ex-post assessment survey findings, the following benefits are estimated:

- STEP-IN helped 525 people
    - Better understanding of energy bills: 365 people
    - Change in everyday habits: 365 people
    - Change/maintenance of the heating system: 185 people (about 70 houses)
    - More efficient use of the heating system: 185 people
    - Motivated to implement insulation measures: 40 people (15 houses)
- STEP-IN improved the quality of life of 305 people
    - Improved thermal comfort: 110 people
    - Energy cost reduction: 60 people
    - Moisture/mould reduction: 25 people
    - Payment of utility bills on time: 25 people
- Potential heating energy savings: 85 houses

- Heating energy savings due to heating system maintenance: 86,520 kWh_{th} per year (based on savings of 4% and average heating energy of 30,900 kWh_{th} per household for 70 households)
- Heating energy savings due to insulation: 139,050 kWh_{th} per year (based on savings of 30% and average heating energy of 30,900 kWh_{th} per household for 15 households)

- Potential reduction in CO_2 emissions: 51 tn per year

Based on the activities of the project in the area of Metsovo (i.e. social surveys and LL activities), the main conclusions drawn are as follows:

- The main problem faced by the local people in the mountainous LL is the excess cost of heating. As a result, they usually tend to underestimate the burden of electricity costs. The LL measurements, however, showed that important reductions in energy bills may be gained from reducing electricity consumption (e.g. when replacing old, energy-consuming, appliances). Thus, further attention needs to be paid to electricity conservation measures. In the same direction, a solution needs to be found regarding the use of solar water heaters in the settlement. As has been mentioned before, the use of solar panels is not allowed today. Yet, the estimates showed that households using electric water heaters spend on electricity around 350-400 Euros per year more than those without electric boilers.
- Thermal insulation is important in Metsovo because the area experiences a high number of heating degree-days. Based on the stated heating expenses and the engineering model calculations, the presence of thermal insulation leads to 30% lower heating expenses, on average.
- The LL activities revealed that many diesel-fired heating systems had a low-efficiency ratio (even lower than 84% compared to 90% which is the proper rate). The maintenance of the oil burner led to an average increase in the efficiency ratio of 4% (even up to 7%). Regular maintenance of the heating system is a low-cost and effective measure for reducing heating expenses.
- In some cases, zero-cost behavioural changes, like setting the thermostat to the right temperature, may result in a significant reduction in the heating cost. For example, it was shown that if the indoor temperature exceeds 20°C, heating expenses can increase even by 1,000 €/year. This is another reason why replacing old analogue thermostats with digital ones is a useful and cost-efficient measure.

As regards the general context of the LL, the following methodological remarks can be made:

- Even when there is a great interest in the local community on how to reduce energy consumption and spending, or how to improve the thermal comfort in their homes, it is not easy to engage households committed to the activities of the LL. Paying long and often visits for collecting the energy data or assigning tasks, such as keeping a complete energy diary for the use of heating and electrical appliances daily, is not possible without causing annoyance (or even withdrawal). Thus, a "compromise" between what is planned and what is acceptable from the local community needs to be found.
- Towards gaining the local community's trust and support, it is more than useful to involve local people in the LL activities. For instance, people who seemed reluctant to let the Energy Advisors install the monitoring equipment to the electric switchboard were appeased when local electricians were hired and paid visits together with the Energy Advisors.
- Discussing the benefits of the project is simply not enough. It is more than important to undertake promoting actions to motivate the local community. For example, in the case of the mountainous LL servicing for free oil-fired heating systems was strongly discussed among the members of the local community and promoted a sense of ownership of the LL actions.
- Relying on questionnaires for collecting information about the estimated heating and electricity consumption and spending is inevitable. Yet, in some cases, the estimated and measured figures do not fully coincide. This stands particularly for the electricity costs, as the electricity bills in Greece include charges for local taxes and public TV licence.

- People seem to be more convinced to get involved in energy conservation and to adopt the pieces of advice provided by the Energy Advisors when presented with actual measurements, as discussed later on. For example, less than 30% of those who did not have monitoring equipment installed said that they noticed an improvement in their quality of life, whereas around 60% of those who had monitoring equipment installed said that they noticed an improvement in their quality of life. Further, 80% of the participants who had monitoring equipment installed said that the installation of electricity consumption meters motivated them to check regularly their electricity consumption and almost all of the participants with temperature and humidity monitoring equipment said that they were helped in taking energy efficiency decisions, i.e. replacement of thermostat, purchase of a dehumidifier, etc.
- Using monitoring equipment is not only helpful towards convincing people to implement energy-saving measures (either technological or behavioural) but also useful towards identifying problems in the operation of malfunctioned appliances. In one case, in the mountainous LL, a defective appliance, namely a refrigerator, was found and replaced, saving hundreds of Euros per year. Moreover, temperature and humidity sensors revealed significant differences within certain residences that use non-central heating systems or are unable to heat the total house area.
- The Information Centre did not seem to work well, at least at the mountainous LL. This suggests that it is not always easy to inform energy vulnerable households because they need to be proactive to change their status quo. This problem is not unprecedented. As referred to in DellaValle, (2019), in Malta, there was a scheme to support energy vulnerable households. Every year, €500,000 vouchers were not claimed. Hence, the government changed the scheme without changing the eligibility criteria. More specifically, households identified as vulnerable categories were automatically enrolled in the voucher program and receive a credit to their bill through their service provider. Also, the Italian Regulatory Authority for Energy, Networks and Environment has advanced a proposal to automatically enrol energy vulnerable households automatically in subsidy programs. In the same direction, during the first energy café which was held at the premises of NTUA, the participants said that moving closer to the Metsovo's centre could attract more people. Thus, it was decided to move the next energy cafés to a more familiar place, either to the Municipality Hall or a local café. Indeed, the second energy café was held at the Municipality Hall. Unfortunately, the third energy café was organised as an online event to respect the social distancing measures in force.
- It seems that the remote operation of the LL cannot fully replace face-to-face LL activities. For instance, remote advice and assistance on energy issues are feasible on a one-to-one basis. Yet, participatory actions, such as energy cafés, at least in the mountainous LL did not work well. Further, remote assistance and advice may not reach the most vulnerable households, e.g. those who do not have internet access (or even telephone access in many cases). This is also reflected in the achieved energy savings in the three rounds. More specifically, the energy savings in the V1, V2 and V3 rounds were 9.2%, 5.4% and 3.9% of the total energy consumed by the households.

From a policy perspective, some interesting remarks can be made based on the Choice Experiment conducted in the ex-post assessment survey. First, it seems that the energy retrofit is the most preferred option (the other two options were upgrading/replacement of the heating system and replacement of old household appliances). This may be related to unobserved benefits of retrofits, e.g. insulation may enhance occupant's comfort and increase future resale value. Second, it is important to underline that the preferences of vulnerable households depend on the different aspects of energy poverty. For instance, those who are unable to keep a level of thermal comfort at home are less willing to invest in energy efficiency while the opposite stands for those who are faced with damp problems or arrears in bills. This is attributed to the fact that a significant percentage of the households who report thermal discomfort (at least in the study area) belong to the lower-income group. Third, vulnerable households hold different willingness to pay (WTP) values for each of the proposed interventions. These differences are not observed only across groups but also between groups. For example, those who claim inability to keep their houses adequately warm are willing to pay around 2.8

Euros for every Euro saved on an annual basis from the upgrading of the heating system, whereas those who face damp problems are willing to pay around 5 Euros, respectively. Finally, the socio-demographic characteristics of the respondents, which are known to be related to energy poverty, such as income and age, also possess a crucial role in the energy efficiency decision-making process. In general, elderly people, who are more prone to energy poverty, are at the same time more reluctant to invest in energy saving. The same conclusion is drawn for low-income households. Further, the estimated values show that households who are struggling to live on their income can afford to pay for energy retrofits only one-third of the amount estimated for households who are living comfortably. All in all, these findings are worrisome because, without support to implement structural measures like energy efficiency, elderly and low-income households could be trapped in the vicious circle of energy poverty, as previous studies suggest.

Finally, concerning the impact of the COVID-19 pandemic (and the restrictions adopted to prevent its spread) on households' socioeconomic status and energy consumption, the main findings from the survey and the LL activities are the following:

- About half of the households in the study area reported that their income decreased during the pandemic. Among those who stated that the household's income was affected by the restrictive measures, 20% claimed that the decrease was in the range of 5-25%, 40% in the range of 25%-45%, and the rest reported a reduction in income over 50%. It should be noted that there were households (10%) that reported a decrease in their income in the range of 80%-100%.
- Almost 3 out of 10 households that participated in the ex-post social survey stated that during the restrictive measures due to Covid-19 their heating system worked more hours than usual. About 10% of them reported working for an extra 1 to 2 hours and 80% reported working for between 3 to 6 hours. Further, 55.6% of the participants reported an increase in the operation of some electrical appliances during the restrictive measures. As far as the LL participants in rounds V2 and V3 are concerned, also 3 out of 10 households said that they used more their heating systems during the lockdown. In particular, 20% reported extra 1 to 2 hours, 24% between 3 and 4 extra hours, 20% between 5 and 6 extra hours and the rest (i.e. 27% more than 6 hours. Also, 64% of them reported an increase in the operation of some electrical appliances during the restrictive measures.
- Based on the measurements taken by the monitoring equipment, it was found that the average increase in electricity consumption during the first lockdown was 8.6% (or approximately 1 kWh per day). In more detail, the average increase in electricity consumption during weekdays was 9.2% and during weekends almost doubled, i.e. it reached 16%. During the second lockdown that started in late October, early November the hourly average electrical consumption between October 2020 (before the lockdown) and November 2020 increased by about 24%. In particular, the increase in the hourly average electrical energy consumption was about 29% at the weekends (compared to October 2020) and 22% during the weekdays. Further, the increase in the average hourly electricity consumption between November 2019 and November 2020 was 41%, between December 2019 and 2020 was 14% and between January 2020 and January 2021 was 29%, respectively.
- Based on a limited number of households where an electricity sensor was installed on the power line of the burner, it was found that the average increase in the operating hours of the heating systems was 1.3 (ranging from 0.1 to 3 hours per day). On a percentage base, this corresponds to an average increase of 39% (from 1.5% to 99.5%).
- The average increase in the house temperature was around 1%. This remark coincides with the fact that only one-third of the households said that they operated their heating system more hours per day. Even if the heating cost does not increase between the two periods, this finding is worrisome because almost half of the households stated that their income reduced during the pandemic. Hence, in the 'best-case' scenario, the subjective indicators of energy vulnerability will remain stable, but the already high "energy-cost-to-income" ratio will worsen, especially in the area of the mountain LL where heating is an "inelastic" good. It is also important to mention that significant differences exist between the households depending on

the housing characteristics, socio-demographic, and heating system characteristics. The analysis of specific examples shows that low-income households are forced to spend an even higher proportion of their income on heating and electricity cost to achieve the desired indoor temperature.

2. Introduction

The basic characteristics of the natural and man-made environment of the LL and the main findings of the baseline survey (e.g. living and housing conditions, housing infrastructure, heating systems, energy expenses, market segmentation, etc.) have been summarised in D2.2 "Interim Report on V1 Mountain Living Lab". This document aims to present the methodology used and the results derived by the V2 and V3 rounds of the mountainous LL in Metsovo, Greece, and the results of the second socioeconomic survey (ex-post assessment survey). Also, this document discusses the methodological modifications that were applied due to the COVID-19 pandemic.

In general, the V2 and V3 rounds of the mountainous LL followed the basic set-up process developed by the STEP-IN project (after certain modifications to account for the peculiarities of the mountainous LL and the pandemic-related restrictions) and included the following activities:

- Information campaigns;
- Organisation of energy cafés;
- Recruitment of Living Lab Participants (for the V2 and V3 LL activities);
- Market segmentation;
- Home visits from the Energy Advisors;
- Installation of monitoring equipment ('smart meters' and temperature and humidity monitors);
- Operation of an Information Centre;
- ICT tools;
- Evaluation of impacts.

The next sections present the results of the V2 and V3 rounds of the LL. The LL complied strictly with the EU's Charter of Fundamental Human Rights and Data Protection Regulations and local ethical norms and cultural sensitivities. It took into consideration and involved different local and national stakeholders and faced certain conditions in terms of housing and population characteristics. The analysis of the results of the V2 and V3 rounds of the mountainous LL is being carried out in three distinct levels of assessment:

(a) Initial assessment, i.e. analysis of the information gathered during the first one (or two) visits of the energy advisors, including information about the characteristics of the house and the heating system, the heating and electricity consumption, etc.
(b) Monitoring assessment, i.e. the calculations conducted using the results from the monitoring equipment, as well as the models constructed to estimate the heating energy consumption of the households.
(c) Evaluation assessment, i.e. the subjective and objective measurements of the mountainous LL's impacts on the participating households in terms of energy reduction, improvements in the quality of life, etc.

The analysis is based on information and data gathered from the monitoring equipment and the meteorological station operated by the NTUA (in Metsovo), as well as questionnaires and forms filled during the Energy Advisors' visits. Univariate and bivariate statistical analyses were conducted to summarise the most important results and statistical tests were run to determine the potential empirical relationship between critical variables.

As far as the ex-post socioeconomic assessment survey is concerned, a representative sample of local households (N=303) took place, including households who have been visited by a Home Energy Advisor during the three LL rounds. The survey aimed to: (a) assess the impact of STEP-IN by gathering data regarding people's attitudes and behaviours towards addressing energy poverty after the operation of the Living Lab; (b) explore certain informative, market and behavioural barriers to energy efficiency; (c) investigate the impact of the COVID-related restriction measures on households' energy consumption and; (d) understand the trade-offs among various energy-saving options offered using a discrete choice experiment. These trade-offs can inform policy design as regards the consumers' choices related to social, environmental, and most importantly financial factors by estimating implicit prices and willingness to pay for alternative energy-efficiency solutions.

3. Living Lab Implementation

3.1 Overview of Living Lab Timeline

The mountainous LL follows the basic set-up process described in D1.2 "Living Labs Global Methodology and implementation guidelines", which includes the following activities (Figure 5):

- Information campaigns;
- Benchmarking;
- Training of the Home Energy Advisors;
- Organisation of energy cafés;
- Recruitment of Living Lab Participants;
- Market segmentation;
- Home visits from the Energy Advisors;
- Installation of monitoring equipment ('smart meters' and temperature and humidity monitors);
- Operation of an Information Centre;
- ICT tools;
- Evaluation of impacts.

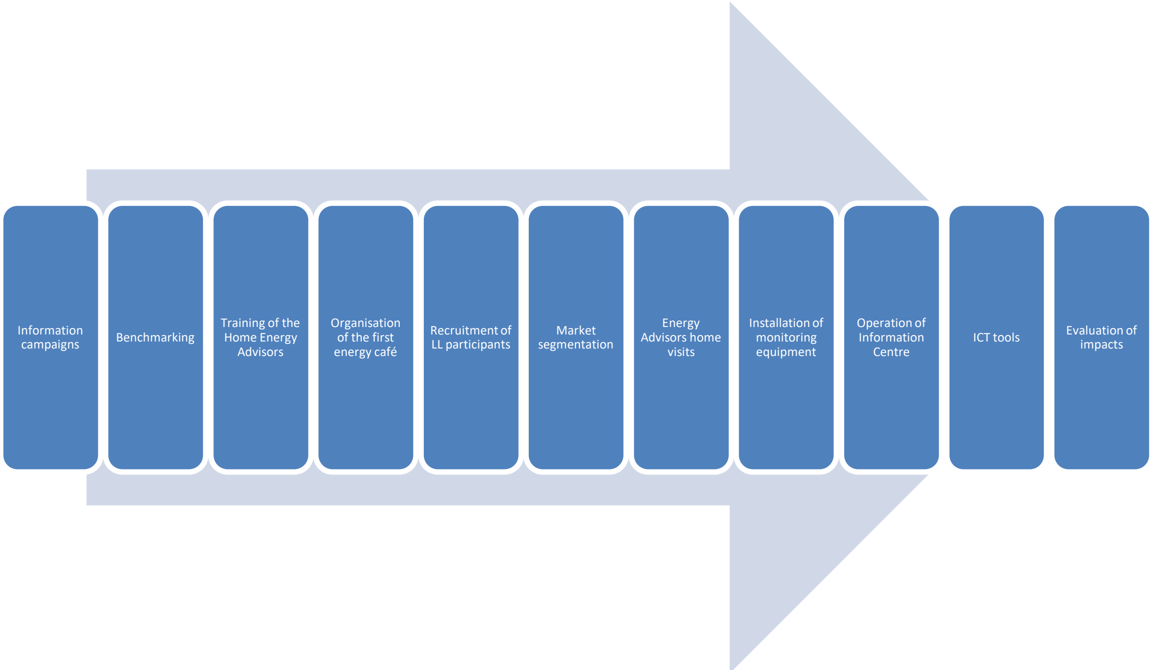

Figure 5: Mountainous LL activities

Nevertheless, not all of the above-mentioned activities were necessary for the V2 and V3 rounds of the mountainous LL. More explicitly, the benchmarking step was omitted. This activity was done before setting up the mountainous LL using existing data (population census and publicly available reports and scientific papers) and information from the ex-ante social survey conducted in Metsovo, between December 2018 and January 2019. In the same direction, there was no need to repeat the training of Home Energy Advisors, who have already participated in the V1 round of the mountainous LL. The rest of the stages of the V2 and V3 rounds of the LL are discussed in more detail in the following sections.

3.2 Methodology Employed

3.2.1 Information Campaign

The information campaign in the case of the mountainous LL in Metsovo started in December 2018 up to the end of the V3 LL activities. The main methods used were, as follows:

<u>A. Leaflets</u>

Leaflets were circulated to citizens of Metsovo (e.g. during the energy café) and made available at specific locations (mainly at the City Hall, the NTUA premises where the Information Centre is located, and some cafés at the Metsovo town). The leaflet used at the V1 activities was common with that of the other LLs, translated in the Greek language (Annex I).

<u>B. Social media</u>

Announcements were made via Facebook (Figure 6) and the Greek version of the project's official website (Figure 7).

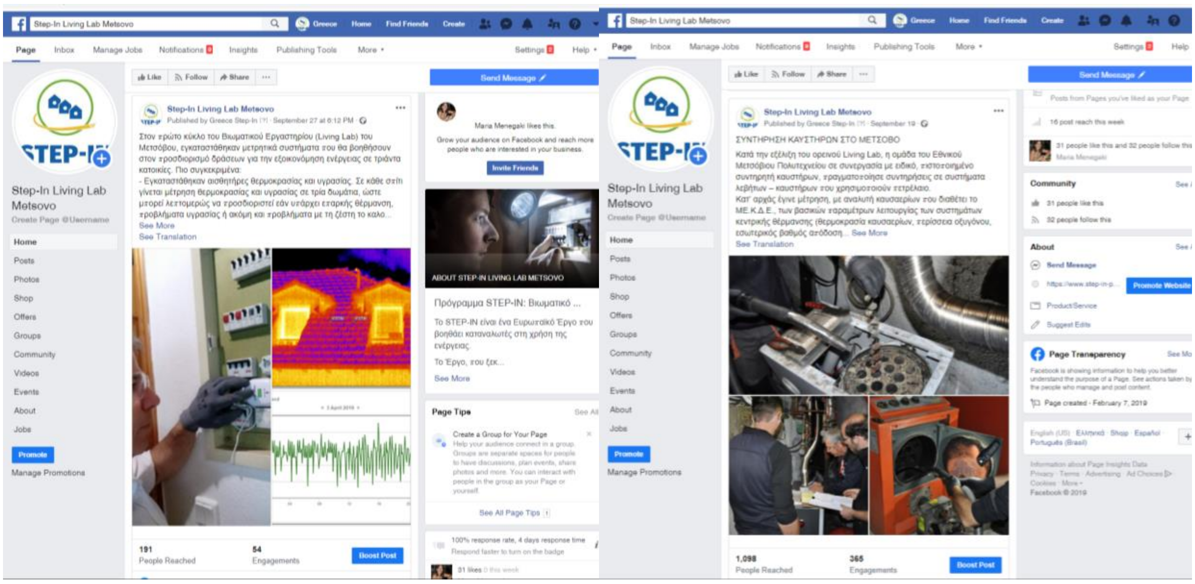

Figure 6: Posts from the Greek Facebook page of STEP-IN with mountainous LL activities

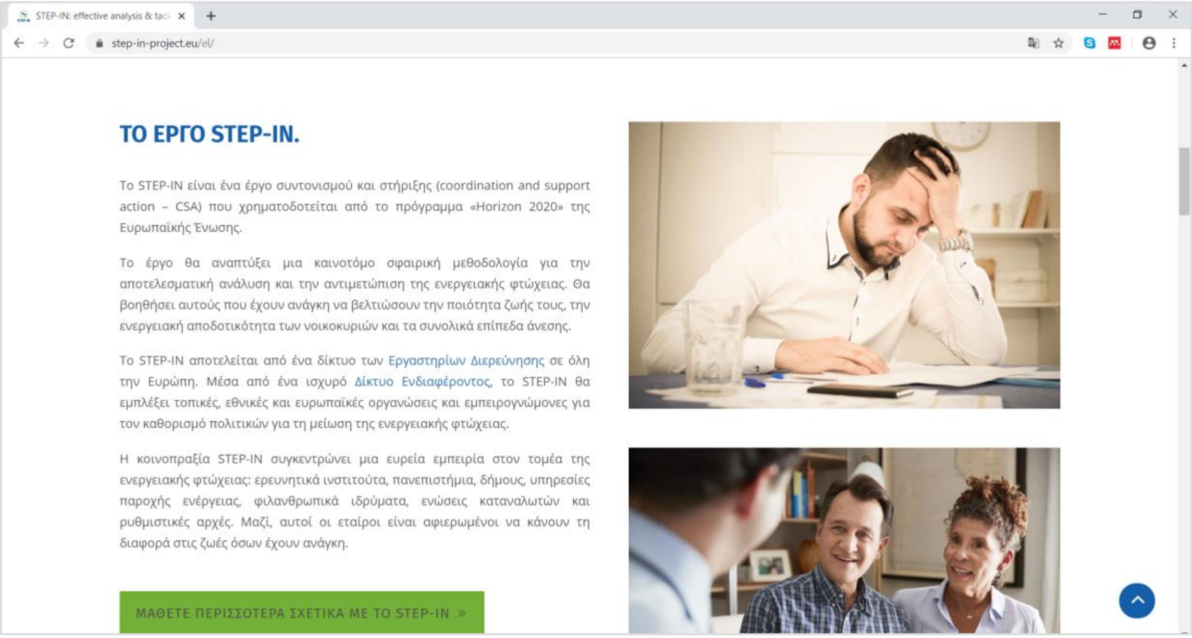

Figure 7: Screenshots from the Greek page of STEP-IN's website

C. Posters

Finally, posters (size A3 and A4 – Annex II) were used for informing the local community about the project not only to boost participation in the energy café but also to increase awareness of the issues surrounding energy consumption, energy cost, energy efficiency, etc.

3.2.2 Organisation of the second and third Energy Cafés

The second energy café of the mountainous LL was held on Saturday, January 25th, 2020, in Metsovo City Hall. The main theme of the event was the presentation of the results of the first round of the Mountain LL and was attended by about 40 residents of Metsovo. The energy café involved different stakeholders, i.e. Metsovo's citizens, policymakers, representatives of the local authorities (among them the Major and members of the Municipal Council), and representatives of the local trade stakeholders (i.e. Metsovo Trade Association).

The event had two parts. In the first part, the heating and electricity needs of the households of Metsovo were analysed, based on the measurements collected by temperature, humidity, and electricity consumption sensors in a selected sample of dwellings. The results confirmed earlier NTUA surveys, which had highlighted the problem of the excess energy costs in the mountainous areas. In the second part, the participants were presented with a bundle of recommended energy-saving measures, with examples of real and hypothetical homes in the study area. The proposed actions included a range of solutions - from zero-cost behavioural measures to relatively costly energy-saving housing interventions - and were accompanied by an indicative cost-benefit analysis.

The presentations provoked a rich dialogue concerning potential energy-saving solutions, both at household and community levels. Useful comments were made by researchers of NTUA and RAE, as well as by a licensed heating professional, who provided valuable advice and information. The participants, based on the feedback provided through a short questionnaire, said that the information and advice provided during the event were useful and improved their knowledge on how to reduce their utility bills. Further, they mentioned that they are willing to implement energy-saving measures based on what they heard at the event.

Similarly to the first energy café, the event invitation and the related poster were strictly focused on - and limited to - energy consumption, thermal comfort, energy savings and cost reduction issues. Moreover, during the event, all legal (i.e. GDPR) and ethical requirements were fulfilled (further details are given in the following sections). This was made to maximise the engagement of citizens facing energy-related problems and avoid any issues of stigmatisation.

The third and last energy café was organised on Wednesday, December 2nd, 2020, as an online event due to the pandemic-related restriction measures. The invitation was distributed through social media (mainly through the project's FB LL page). Again, to avoid stigmatisation the subject of the energy café was centred around the impact of the lockdown and the non-essential movement ban imposed by the Greek government on local households' energy consumption. Further, the energy café discussed measures for consumers to improve their quality of life based on the experience gained during the three LL rounds. In total, 38 residents participated in the online event. The presentation was given by the NTUA team and included information about the increased electricity consumption and usage of heating systems during the lockdown period. Further, similar data from other European and non-European countries were shown and discussed.

The participants asked questions and shared their experiences about the impact of lockdown on energy usage, confirming the main findings of the LL measurements. It should be noted, however, that participants' involvement in the online event was not the same as in the face-to-face events.

3.2.3 Recruitment of Living Lab Participants

The recruitment of the households for the V2 and V3 rounds of the LL took place through different routes, namely the leaflets of the project, the primary social survey (i.e. at the end of the interview the interviewee was asked if her/his household would like to participate more actively in the project, providing a short description of the role of participation), the energy cafés and the participants of the V1 round who recommended their fellow citizens to participate in the LL.

In total, for the V2 and V3 rounds, 100 households were directly involved (50 households in each of the LL's rounds). These households were selected randomly and voluntarily. Moreover, all ethical and data protection considerations and rules were strictly followed, as detailed later in this deliverable.

3.2.4 Market Segmentation

As mentioned in Deliverable 3.2 "Interim Report on V1 Mountain Living Lab", the market segmentation was undertaken through available census data for the Municipality of Metsovo and primary data gathered by the social survey.

As regards the 100 households that participated in the V2 and V3 rounds of the LL, 13% have children less than 5 years, 41% have members aged more than 65 years old, 23% have unemployed members and 8% have members with a disability or long-term illness. Around 26% declared moisture/mould problems, 10% said that delay the payment of electricity bills, and 16% claim that they don't feel warm enough in their houses. Energy-related health problems are practically insignificant. The main issue is again the excess heating cost.

3.2.5 Home Energy Advisor Visits

Similar to the V1 round, the households were divided into two groups. The first group involved houses where monitoring equipment was installed, besides the visits and advice of Energy Advisors. The second group included households that would be visited and advised by the Energy Advisors without the installation of monitoring equipment.

The original plan foresaw that the Energy Advisors would visit each household three times. Nevertheless, the Advisors visited the thirty households, where equipment was installed, four times. In the first visit, the Advisors installed the monitoring equipment (described hereinafter). The Energy Advisors used questionnaires designed to collect information that was necessary to calculate the heating energy needs and consumption of the household (e.g. residences' energy efficiency, current energy costs, heating energy supply sources, heating system's condition, electrical devices, behavioural aspects, households' demographic characteristics, etc.) and to evaluate the impacts of STEP-IN. Given that the installation takes some time, and in order to prevent the frustration of the households, the questionnaires were filled during a second visit. In some houses, the Advisors used an infrared camera to spot the "weak" points and areas of the building shell (thermal bridges, badly insulated walls, etc.) (Figure 8), and an exhaust-gas analyser to measure the characteristics of exhaust gases from the heating systems (Figure 9).

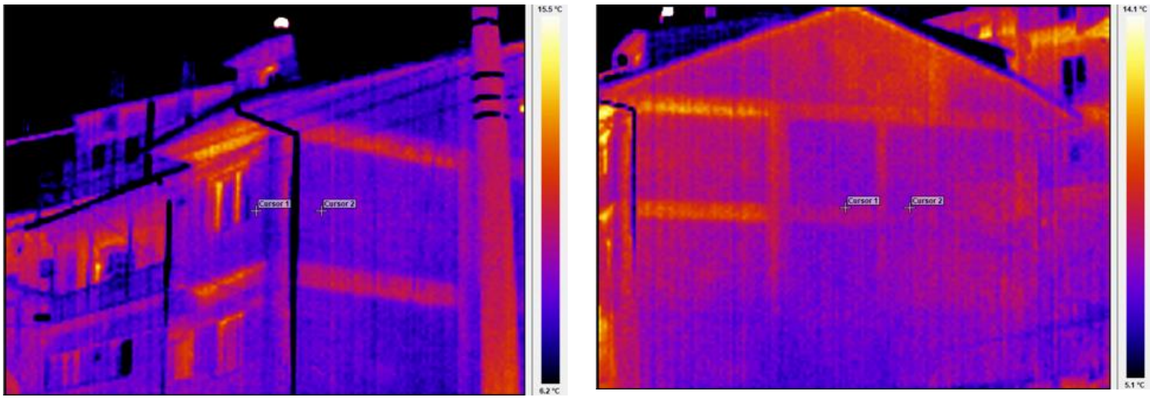

Figure 8: Thermal imaging

Figure 9: Exhaust gas measurement

Twelve oil-fired heating systems were checked and three of them, which did not comply with the competent standards of the Greek legislation were services for free by a certified technician (Figure 10). The fact that only three systems had to be maintained is a promising sign for the impact of the project. During the first round of the LL, almost half of the burners checked were out of specification. This remark was discussed during the energy café and promoted through leaflets and social media posts and seemed to resonate with many people.

Figure 10: Heating system service

During the third visit, the Energy Advisors provided advice based on the information and the measurements that they received from the visits and the monitoring equipment, respectively. The last visit aimed at the final assessment and the results achieved concerning the effects and the appropriateness of the measures and actions applied for reducing energy costs.

As described later on, the monitoring equipment that was installed in the houses of V2 round was kept there also during the operation of the V3 round. This decision was made to gather data and information related to the impact of the pandemic-related restrictions on households' energy consumption.

It should be noted that the Home Energy Advisor visits to the households without monitoring equipment were three and certain advices were more general, although some peculiar issues for each case were considered.

The questionnaires used by the Energy Advisors as well as illustrative examples of household-specific reports and leaflets of advices are given in Annexes III and IV.

3.2.6 Installation of monitoring equipment

As mentioned, in 30 out of 100 households, in total, monitoring equipment was installed, consisting of the following:

- Indoor temperature and humidity data-logger with external sensors, which were positioned in three different rooms (Figure 11);
- Electricity consumption hubs, which were connected wirelessly with sensors measuring in real-time households' electricity consumption. Electricity data were automatically captured and saved by the system to a web platform.

Figure 11: Indoor temperature and humidity monitors

Towards installing the electricity monitors (Figure 12), specialised personnel (i.e. certified electricity technicians) from the area of the LL was used not only for safety reasons but also to gain the trust of the local people participating in the project.

Figure 12: Installation of electricity consumption meters

The monitoring equipment allowed recording the above-mentioned parameters (i.e. temperature, humidity and electricity consumption) in the form of time-series data (Figure 13 & Figure 14) and helped, through appropriate processing techniques, to conclude the energy efficiency of the houses, behavioural patterns of household members, etc., that were then used to provide household-specific advice on energy conservation practices and potential energy efficiency investments to reduce their energy spending and/or increase their quality of life.

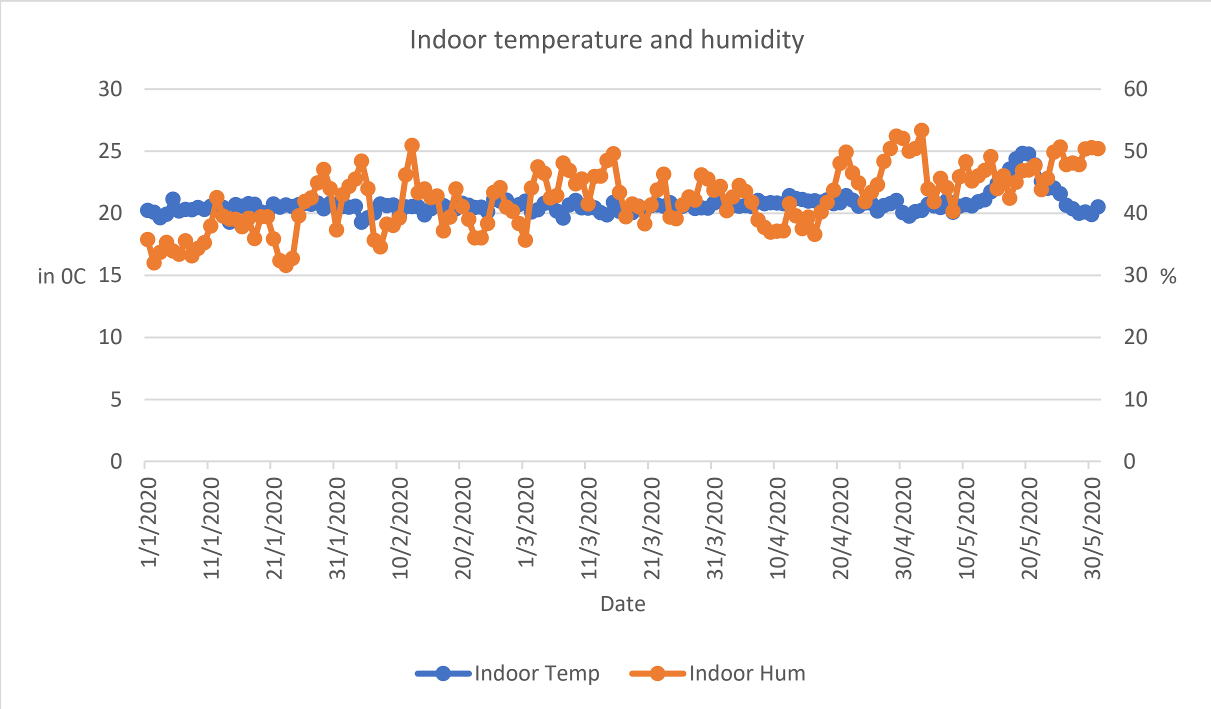

Figure 13: Time-series data of indoor temperature and humidity

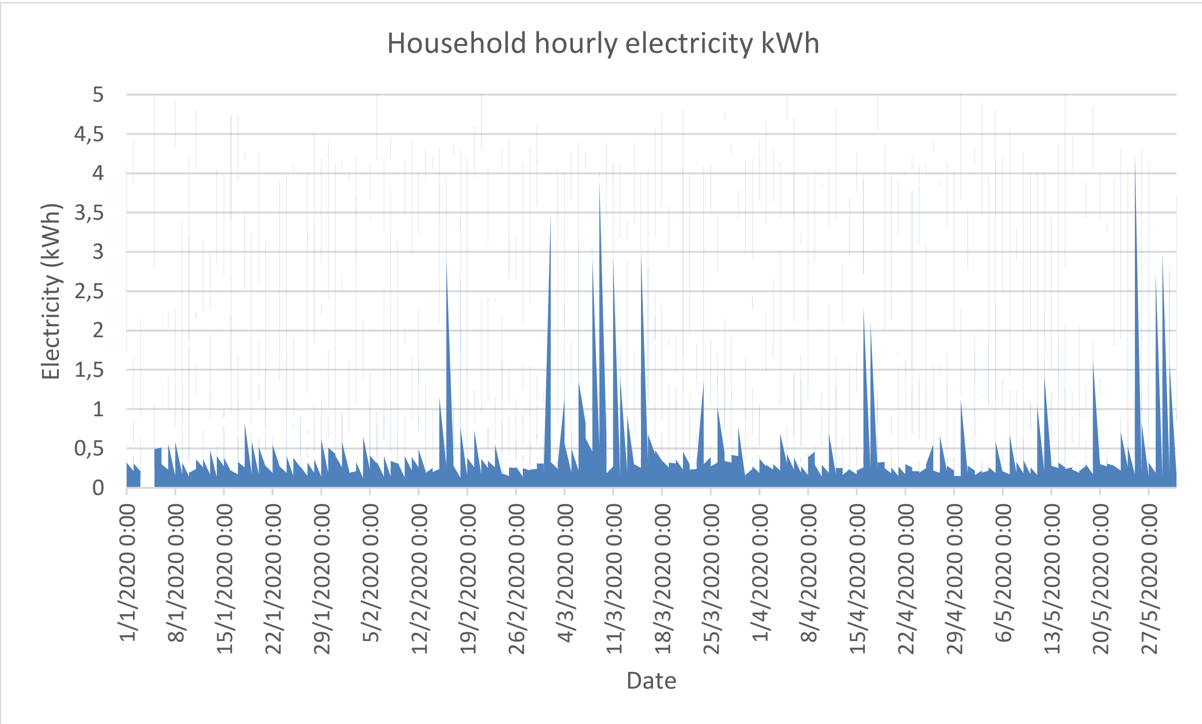

Figure 14: Time-series data of electricity consumption

3.2.7 Operation of the Information Centre

An Information Centre was run by the NTUA personnel within MIRC's (Metsovion Interdisciplinary Research Centre) premises. The office was open two days per week from 10.00-12.00 providing citizens with information about energy-related issues through access to materials, e.g. advice leaflets, and/or to sign-up for assistance via STEP-IN. The attendance of the public was generally low, especially after the coronavirus outbreak. It should be noted, however, that information about the project, as well as advice for the households under study was not restricted in the operation of the information centre. Local households received information through an energy advice booklet that was available in electronic and printed format, an online app and six animated energy advice videos (see below).

3.2.8 ICT Tools

During the V2 and V3 rounds of the mountainous LL, the focus – similar to the other LLs - was on improving the ICT tools used by the Energy Advisors to collect and monitor data about housing conditions (e.g. insulation, energy sources, room layout, etc.) along with information relating to bills and demographics. A full description of the STEP-IN ICT tools can be found within STEP-IN D5.6 “Final ICT Tools Review”. Figure 15 provides an overview of the dashboard layout for a LL participant, which includes support for assigning housing characteristics, creating personal advice, editing questionnaires, preparing reports, etc.

Additionally, in the mountainous LL, the energy monitors included a web app that could be accessed by the homeowners (Figure 16). For this purpose, the households were provided with a unique username and password to enter the platform and seek information about real-time usage of electricity, demand of energy at different hours of the day, the total cost of electricity for specific periods, etc. Ethical requirements and GDPR under which EU member states were strictly followed. Further information relating to GDPR and wider ethical concerns can be found in section 3.4 Ethical and GDPR issues of this Deliverable.

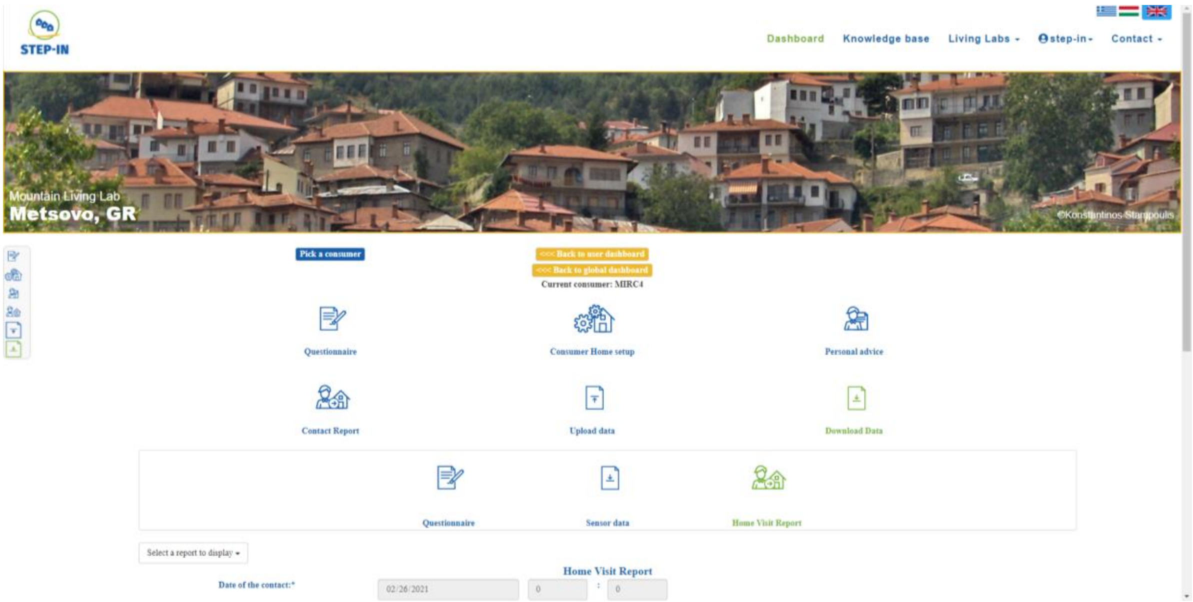

Figure 15: Dashboard Layout Display

Figure 16: Screenshot from the electricity consumption app

Moreover, the NTUA team developed an online app that helps users to calculate the cost required to meet their heat and electricity energy needs (Figure 17). Also, users have the ability, by changing the parameters (e.g. type of windows, the existence of thermal insulation, type of fuel, etc.) to see the possibilities of reducing their energy expenses.

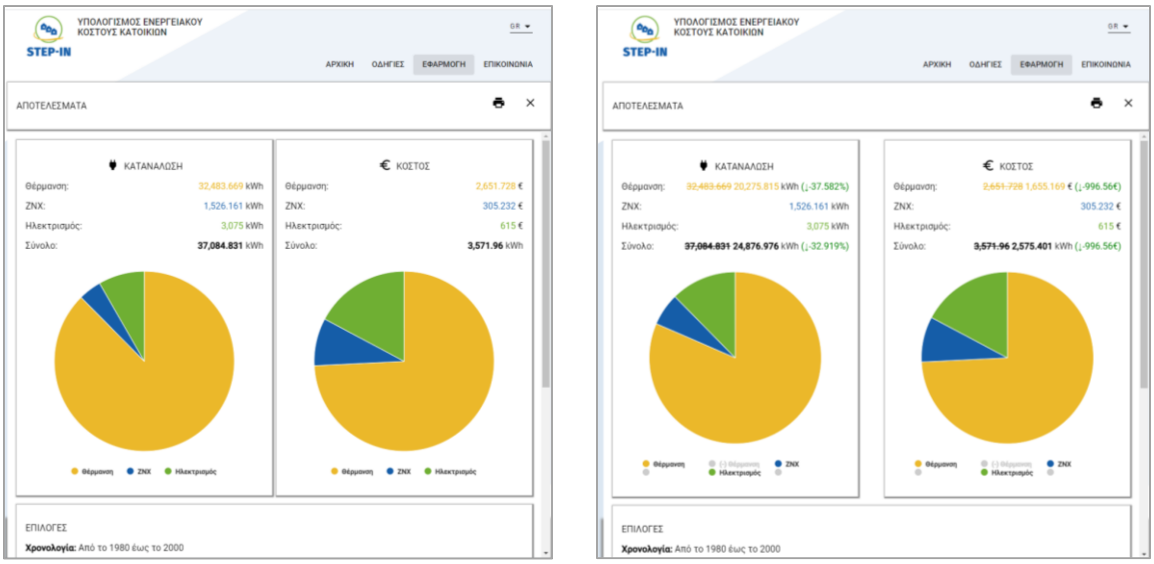

Figure 17: Screenshot from the energy cost calculation app

Finally, as a mean to provide advice to local and national households, six animated videos were created for social media. Each of these videos focused on a different subject, namely correct set-up of thermostats, benefits of regular maintenance of heating systems, advantages of digital thermostats, efficient use of fireplaces, advices about saving energy in the kitchen and during laundry. Figure 18 presents a snapshot from an advice video.

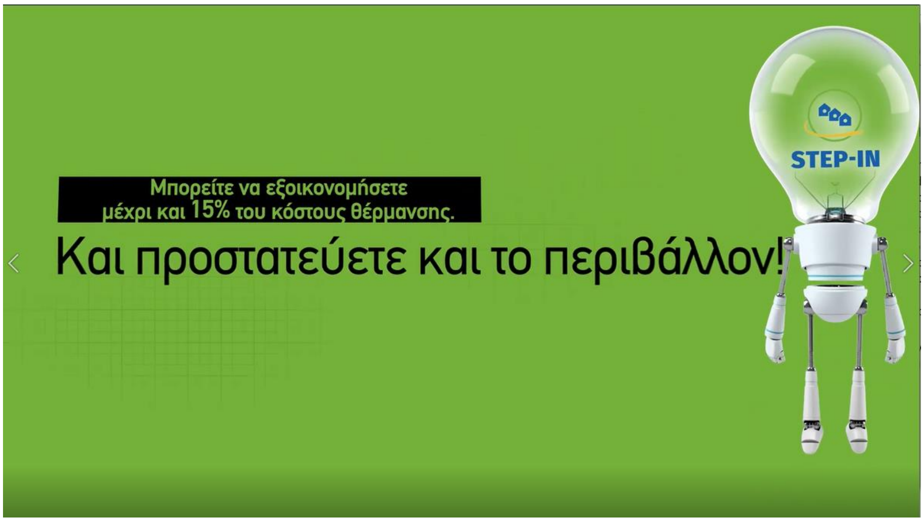

Figure 18: Snapshot from an advice video

3.2.9 Evaluation of impacts

Finally, in each of the LL rounds the impacts of STEP-IN (evaluation step) were monitored, as follows:

- Energy Consumption
    - Level of consumption;
    - Cost of consumption;
    - Heating energy sources (e.g. gas, electricity, oil and wood);
    - Arrears on bills.
- Thermal comfort:
    - Objective Measures (through temperature and humidity sensors);
    - Subjective measures (through self-reported levels of comfort and other related indicators).
- Uptake of Energy Measures or Advice
    - Repairs or replacement of inefficient systems or appliances;
    - Installation of insulation;
    - Energy efficiency measures.
- Evaluation of LL impact
    - Reduction in energy consumption/spending;
    - Reduction in pollutants emission;
    - Improvement of the quality of life of local households;
    - Changes in energy behaviour;
    - Understanding of energy bills, etc.

For this purpose, information and data gathered from the monitoring equipment, the questionnaires and the meteorological station operated by the NTUA (in Metsovo) during the LL operation were analysed using statistical and building energy efficiency software packages (the latter will be used for selected households). The analysis provided information about the energy consumption of the households before and after the implementation of measures suggested by the Home Energy Advisors. In addition, the actual energy consumption and the conditions within the houses (i.e. temperature) were compared to the theoretical energy needs and building regulations, as in some cases energy-vulnerable households tend to consume less energy than required. Finally, during this step, the lessons learned were considered to improve the operation of the LL for the operation rounds to come.

3.2.10 Modification of LL activities due to COVID-19 pandemic

To control the COVID-19 pandemic, Greece put in place a number of measures and restrictions on movement and business activities, as follows:

- On March 10, the operation of educational institutions of all levels nationwide was suspended.
- On March 13, all cafes, sports leagues bars, museums, shopping centres, sports facilities and restaurants were closed.
- On March 16, all retail shops were also closed and all services in all areas of religious worship of any religion or dogma were suspended.
- On March 23, from 6 a.m., all non-essential movement throughout the country were restricted and movement outside the house was permitted for only specific reasons. On 4 April these restrictions were extended until 27 April and on 23 April they were extended until 4 May.
- Starting from 4 May, after a 42-day lockdown, Greece began to gradually lift restrictions on movement and to restart business activities.

Because of the outbreak of COVID-19, the activities of all three LLs were suspended from March 18 until May 1st, 2020. Nevertheless, due to the continuation of certain social distancing measures, the face-to-face LL activities started again at the beginning of June 2020. Hence, the COVID-19 outbreak created new scientific, methodological, and ethical challenges and additional objectives. From a scientific perspective, the objective for the V3 round was to understand new issues arising due to COVID-19 concerning energy poverty (e.g. changes in energy consumption and patterns, changes in the socio-economic status of the households, potential multiplication of factors leading to energy vulnerability etc.). From a methodological perspective, the objective was to test the effectiveness of the remote provision of advice and assistance for vulnerable consumers (e.g. via energy café webinars, online information campaigns, personal communication via phone, email or online chat, etc.). Finally, from an ethical perspective, the objective is to continue helping vulnerable households while avoiding exposing them - and those who work for STEP-IN - to unnecessary risks of infection from COVID-19. In this direction, certain actions were taken to support those households participating in mountainous LL activities, such as energy advices via phone or email, preparation of a booklet regarding energy-saving tips, energy literacy issues, etc., development of online apps, etc. More particularly, the LL actions for the V3 round were planned, as follows:

1. Webinars for focus groups: one focus group was held via an online meeting platform with approximately 10 people from NTUA and MM for preparing the second socioeconomic survey.
2. Webinars for energy cafes: one webinar via an online meeting platform for the last energy café was organised.
3. Webinars for round tables: one consultation round table entitled "Energy Poverty in Greece: Quantification, Monitoring and Alleviation Policies" was organised on June 18, 2020, via an online meeting platform. Around 20 Greek experts in the field of energy poverty from universities, research centres, governmental authorities, and consumer unions, participated in the round table for the preparation of the Greek National Strategy against Energy Poverty (NSEP), as a part of the National Energy Efficiency Action Plan (NEEAP) and of the National Energy & Climate Plan (NECP).
4. Telephone assistance: 50 households were provided with information and feedback on energy-related issues.
5. Web assistance: Households participating in STEP-IN Round 3 actions were provided with real-time information and feedback on energy-related issues when needed. Also, a web app was developed to support consumers in reducing their energy expenditures. Finally, six short videos were created with energy advice that will be communicated via social media (e.g. Facebook).

6. Mail assistance: a new energy advice booklet targeting mountain households was prepared. The leaflet includes information and advice on energy efficiency and consumption, refurbishment schemes, subsidy programmes, energy labelling schemes, etc.
7. Questionnaires: Questionnaires were collected by the households that participated in Round 3 activities (app. 50) and the second social survey (app. 300, including households who have been visited by a Home Energy Advisor) remotely. Interviews were completed via phone and/or web-based video conferencing.
8. Home Installed Equipment: In the V3 round, instead of installing the equipment to 30 new households, the monitoring equipment stayed at the same households as in Round 2. There were two arguments for this approach. First, due to the COVID-19 outbreak, it was not easy to find households willing to open their homes in this period. Also, it was a matter of ethics and compliance with safety measures suggested by the Greek authorities during the current season. Second, and perhaps more importantly, leaving the equipment in the same households as in the V2 round allowed collecting empirical data to study the impacts of COVID-19 on energy vulnerability (i.e. to examine energy consumption prior, during and after the confinement measures, changes in the socio-economic status and how they are related to energy consumption and behaviour, etc.).
9. Benchmarking of the impact of COVID-19: The COVID-19 outbreak is expected to exacerbate energy poverty issues. The energy needs of residential consumers will grow, as they tend to spend more time in their homes, work by distance, etc.), and, at the same time, many people will lose their jobs, either temporarily or permanently, and their income will decline. The last round was dedicated, to a great extent, to studying the impact of COVID-19 on energy vulnerability.
10. National conference: The conference was initially scheduled for June-July 2020 but was postponed for a later date. Due to pandemic-related restrictions on travelling and social distancing, it was not possible to organise a live event. Hence, the conference was co-organised with RAE as Web Conference on November 19, 2020. With over 220 people attending, the conference was a great success especially considering the COVID-19 situation (approximately 100 attendees were expected).

3.3 Stakeholder Involvement

The local stakeholders were involved in LL's activities were citizens of Metsovo town, the Municipal Authorities and representatives of the Pindos Perivallontiki and the Metsovo Trade Association. The local stakeholders have been involved through the energy cafés that were held in the context of the V2 and V3 rounds of the mountainous LL.

National stakeholders (energy poverty experts from universities, research centres, governmental authorities, and consumer unions) were involved in the LL through the consultation round table "Energy Poverty in Greece: Quantification, Monitoring and Alleviation Policies" and the National Conference.

3.4 Ethical and GDPR issues

The mountainous LL operated complying strictly with the EU's Charter of Fundamental Human Rights and Data Protection Regulations. As a result, operators of EU–based LLs (receiving funding) and the STEP-IN project should pay special attention to and comply with these regulations. The LL involves energy-related vulnerable consumers and raises privacy and data protection issues.

The key ethical issues that were considered in the mountainous LL (as in each of the three LLs) are outlined in Table 1, following the global methodology described in D1.2 "Living Labs Global Methodology and implementation guidelines". Particular attention was given to avoid stigmatising the citizens involved, starting from the development of the project. To this end, the LL operators were quite careful in using certain language in documentation through the recruitment processes or through the publication of information by focussing on creating positive feelings towards the LL activities and presenting the objectives and results in a positive light (e.g. to increase awareness of the issues surrounding energy consumption, reduce energy costs of the households, improve the energy efficiency of houses, etc.). During the operation of the LL only non-sensitive personal data, which are necessary for the project (i.e. factors influencing energy-related behaviours and choices, information necessary to provide energy advices and training on the efficient use of the heating system and electrical appliances, etc.), were collected and processed. Moreover, the mountainous LL operated with respect to local ethical norms and cultural sensitivities to obtain consent from the overall community. In addition, the highest ethical standards were always adopted, ensuring that the role of all those involved in LL's activities was made clear. Finally, it is noted that during the V3 round of the LL the directions provided by the Greek authorities responsible for health and civil protection were strictly followed to ensure the protection of the health of researchers and participants from unnecessary risks related to the COVID-19 epidemic. Also, the protection of personal data and support of GDPR from the online platforms that were used during the last round was considered, as discussed hereinafter.

In the handling of personal data, the General Data Protection Regulation (Regulation No 2016/679) that came into effect on 25 May 2018 was followed. In addition, the following regulations were considered:

- Data Protection Authority, Regulations 408, 1/99: Notification of subjects about recording personal data;
- Law 3471/2006: Personal data protection in electronic communications;
- Law 3917/2011: Personal data protection in electronic communications through public data networks.

Further, the mountainous LL received full approval for each required activity (e.g. primary social survey, energy café, installation of monitoring equipment, collection of information from households participating in LL's activities, preparation of consent forms and information sheets, etc.), by Prof. Peter Wahlgren, Internal Ethical Advisor of the project and the Research Ethics Committee of the National Technical University of Athens (on April 18th, 2019).

Table 1: High-Level Ethical Concepts

Concept	Relevance in STEP-IN
Balance Benefits: risk and harm	The LLs must primarily benefit the citizens involved. They must avoid issues such as erosion of privacy or stigmatisation or other negative side effects.
Consent and Voluntary Participation	All citizens taking part must be able to understand and voluntary participate in STEP-IN and be competent enough to take that decision. Citizens can also withdraw consent at any time.
Fidelity, Transparency and Dignity	Those working on the project should be able to benefit from its results, for example, the energy advisors. However, they should not benefit personally from taking part. All those taking part must behave in an open, transparent and honest way.
Respect for Rights and Dignity	Care should be taken to avoid bias or other problems related to aspects such as race, gender or age.

Source: STEP-IN (2019). Deliverable 1.2 - Living Labs Global Methodology and implementation guidelines.

The citizens who were involved in data collection tasks (during the baseline survey, the energy cafés and the LL activities) were provided with sufficient information in their native language that allowed them to make an informed decision as to whether or not to take part and were given a consent form, which they signed along with the representative from the LL (see sample consent and information sheets, which are provided in Annex V).

More explicitly, the information sheet provided information about the background, aims, methodology, funding, participants and finality of the STEP-IN project, in particular about the specific task in which they are invited to be involved. In addition, they were informed about the level of anonymity in the collection and storage of their data, how the information would be used in the project, where and by what means it would be stored and at what point it would be destroyed.

Participants were given time to ask questions and, after that, were asked to sign the consent form (the signed consents are kept on file by the LL Coordinators), which, in combination with the information sheet, included the following information:

- Participation is voluntary and refusal to participate will not result in any consequences or any loss of benefits;
- Details of who will be conducting the study and who to contact if questions or problems arise;
- Purpose, duration and procedures of the study;
- Questions can be asked before deciding to give consent;
- Any risks, inconveniences and benefits associated with the research;
- How their data will be collected, stored and protected during the project;
- What procedures will be employed to maintain confidentiality and anonymity (e.g. removing personal details from data, keeping data in password-protected folders, etc.);
- How the findings from the study will be used and disseminated;
- How to withdraw themselves and their data from the project at any time.

The LL operators secured that all types of data will be anonymised, encrypted, and protected during storage and transmission (which usually takes place across third-party networks).

To this end, the names of the participants were replaced with ID codes to maintain anonymity. The identity of all participants was fully masked in any printed materials, project reports or dissemination materials unless specific permission was provided. Further, personal media and other content were not used in wider dissemination activities of the research project and no one outside of the research team has access to any of these data. Finally, files and other content were stored in password-protected folders within NTUA and were available only to authorised members of the research team.

3.5 Conclusions

The mountainous LL methodology follows the global LLs methodology that is presented in D1.2 "Living Labs Global Methodology and implementation guidelines". The overall methodology aims to help the citizens involved in the project's action to reduce their energy spending and improve their quality of life, by providing energy advice that leads to energy efficiency improvements. In addition, the methodology wishes to create longer-term sustainable impacts at a local, regional and national level by engaging several stakeholders (e.g. regulators, local governments, NGOs, etc.), since a wider stakeholder network is a prerequisite in shaping local and national policies.

The methodology has been designed to be customisable for different locations, and therefore certain peculiarities exist between the mountainous and the other two LLs, although the overall key steps remain in place. For example, the number of people involved, the type of data and mostly the approaches used to gather them, the number of energy cafés conducted, the Energy advisors trained, and the visits accomplished, are some examples of the 'deviations' between the LLs. To some degree, the customisation of the methodology is unavoidable, as the LLs do not exist in isolation from the local community. The LLs operate with respect to local ethical norms and cultural sensitivities, take into consideration and involve different local and national stakeholders, and face different conditions in terms of housing and population characteristics and (pre)existing resources and programmes dedicated to combating energy-related vulnerabilities.

Keeping in mind the above-mentioned remarks, the mountainous LL process, which was implemented in the second and third round of the mountainous, includes the following activities:

- Information campaigns;
- Organisation of the first energy café;
- Recruitment of Living Lab Participants (for the V1 LL activities);
- Market segmentation;
- Home visits from the Energy Advisors;
- Installation of monitoring equipment ('smart meters' and temperature and humidity monitors);
- Operation of an Information Centre;
- ICT tools;
- Evaluation of impacts.

Because of the outbreak of COVID-19, the activities of the LL were suspended from March 18 until May 1st, 2020. Further, due to the continuation of certain social distancing measures, the face-to-face LL activities started again at the beginning of June 2020.

The COVID-19 outbreak created new scientific, methodological, and ethical challenges and additional objectives. From a scientific perspective, the objective for the V3 round was to understand new issues arising due to COVID-19 concerning energy poverty. From a methodological perspective, the objective was to test the effectiveness of the remote provision of advice and assistance for vulnerable consumers. Finally, from an ethical perspective, the objective is to continue helping vulnerable households while avoiding exposing them - and those who work for STEP-IN - to unnecessary risks of infection from COVID-19. In this direction, certain actions were taken to support those households participating in mountainous LL activities, such as energy advices via phone or email, preparation of a booklet, development of online apps, etc. (details are given in Section 3.2.10 of this deliverable).

4. Results and Lessons Learned

4.1 Methodological Aspects

The analysis of the results of the V2 and V3 rounds of the mountainous LL is being carried out in three distinct levels of assessment:

(d) An initial assessment – it refers to the analysis of the information gathered during the first one (or two) visits of the energy advisors and includes information about the characteristics of the house and the heating system, the heating and electricity consumption and spending, the thermal comfort of the household, subjective measures of comfort and vulnerability, etc.

(e) A monitoring assessment – it involves all the calculations conducted using the results from the monitoring equipment, as well as the models constructed to estimate the heating energy consumption of the households. This level involves only houses where monitoring equipment was installed (that is the monitoring assessment has not been conducted for households participating in the V3 round, as mentioned in Section 3).

(f) An evaluation assessment – it includes subjective and objective measurements of the mountainous LL's impacts on the participating households in terms of energy reduction, improvements in the quality of life, adoption of energy efficiency measures, financial and non-financial barriers towards investing in energy efficiency, etc. It is noted that the evaluation level includes both actual and potential energy savings (in terms of consumption and cost) since in some cases households implemented (or plan to implement) the advices provided by the Energy Advisors, but the impact could not be measured. The latter stands mainly for advices relating to heating systems or energy retrofits.

The analysis is based on information and data gathered from the monitoring equipment, the questionnaires and the meteorological station operated by the NTUA (in Metsovo) during the LL operation. For this purpose, univariate and bivariate statistical analyses were conducted to provide a summary of the data collected from the survey and different statistical tests were implemented to determine the potential empirical relationship between critical variables. The confidence interval of all statistical analyses was 95%, and the significance level of 5%.

4.2 Results of Round V2

4.2.1 Initial assessment

Housing characteristics

As far as housing characteristics are concerned, the sample includes 50 houses, 4% of which are detached houses, 10% are maisonettes and 86% are apartments. About 14% are less than 70 m^2, 20% are between 70-90 m^2, 36% are between 90-110 m^2 and 30% are over 110 m^2. Further, 60% have two or fewer bedrooms, 32% have three bedrooms and 8% have more than three bedrooms. As far as the age of houses is concerned, 50% were built before 1980, 44% were built between 1980 and 2000 and just 6% after 2000.

As regards residences' energy efficiency, 46% have insulated external walls and about 38% have insulated roof. Moreover, 68% have double glazing windows. Finally, 54% of houses have a good air insulation level, 32% have medium air insulation level and 14% present bad air insulation.

Heating system characteristics

About 84% of households stated that the total area of their house is heated. As regards the primary heating system, the majority (82%) uses central heating systems. The main fuel used in central heating systems is diesel oil (about 60%), followed by firewood (18%) and pellet (4%). The rest of the houses use energy fireplace (6%), firewood stoves (6%), heat accumulators (4%) and a central heat pump (2%). Moreover, half of the households (52%) use secondary heating systems as well, with no special type prevailing though.

As regards automation/control systems in cases of central heating systems, the majority of households (86%) did not report any automation system, while 14% reported that they use digital thermostats.

Domestic hot water production system

About half of the households use diesel oil boiler for domestic hot water production (52%), followed by a wood boiler (28%), electrical boiler (16%) and pellets boiler (4%). Moreover, 1 out of 3 households uses an extra solar heater boiler for hot water production.

Electrical loads

Practically all households own electrical appliances with heavy power consumption, such as electric cooker (typical power: 2,000W – 6,000W), washing machine (typical power 500W – 750W), refrigerator (typical power 200W - 250W), etc. As far as lighting is concerned, less than 20% of households use old type bulbs. The rest use Light Emitting Diode (LED) bulbs and Compact Fluorescent Lamps (CFLs).

Energy-related behavioural aspects

According to the answers provided at the beginning of the V2 operation of the LL, 6% of the households use the heating system 2 to 4 hours every day, 10% use it 4 to 6 hours every day, 8% use it 6 to 8 hours and the rest (i.e. 76%) more than 8 hours every day.

Among those who have thermostats (either analogue or digital, although digital thermostats are rare), 2.4% reported that they set the thermostat below 18°C, 38.1% said that the thermostat is set between 18°C and 20°C, and the rest (i.e. 59.5%) claimed that they set the thermostat to over 20°C.

As regards the stated temperature inside the home, all households stated an average temperature over 18°C during the winter period. Specifically, around 60% of the households stated that the average temperature is more than 20°C, while about 40% stated that it ranges between 18°C and 20°C (Figure 22).

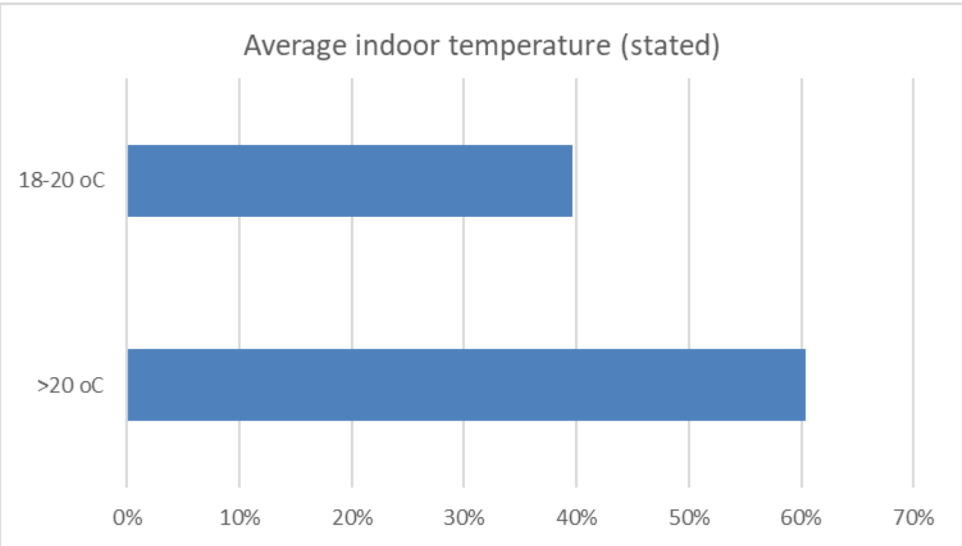

Figure 19: Average (stated) indoor temperature in the LL homes.

As expected, the average (stated) indoor temperature is correlated with the temperature set to the thermostat. The null hypothesis for the non-parametric Kruskal–Wallis test is rejected (χ^2=16.476, d.f.=2, p=0.000) (Figure 22).

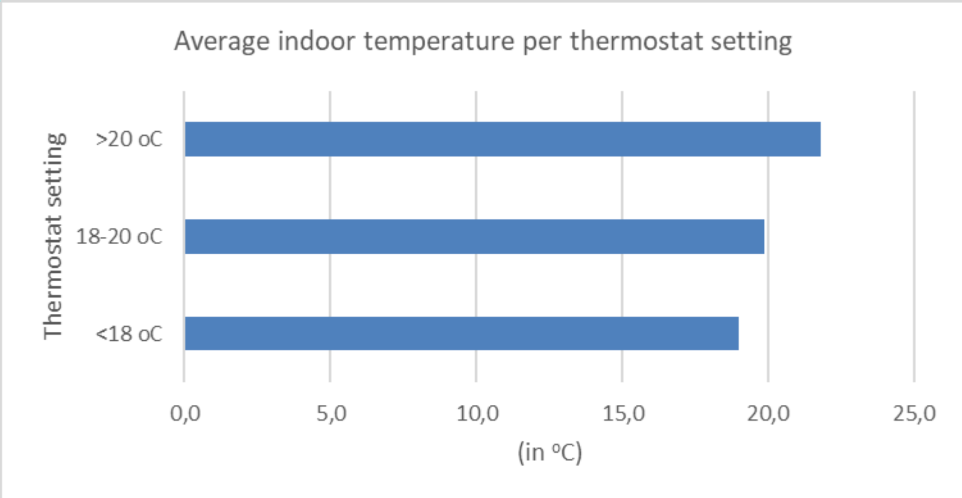

Figure 20: Average (stated) indoor temperature with respect to the thermostat setting.

By examining technical/building characteristics, it arises that the average indoor temperature is not correlated with the construction period of the house (Kruskal–Wallis: χ^2=7.142, d.f.=6, p=0.308) (Figure 22), the insulation of the external walls (Mann-Whitney U=271.5, p=0.573) (Figure 22), or the use of double glazing windows (Kruskal–Wallis: χ^2=1.685, d.f.=2, p=0.431) (Figure 23). This can be associated with the fact that heating is an "inelastic" need in Metsovo due to the cold climatic conditions, which means that people have to keep their houses warm, regardless of the building age and thermomechanical characteristics.

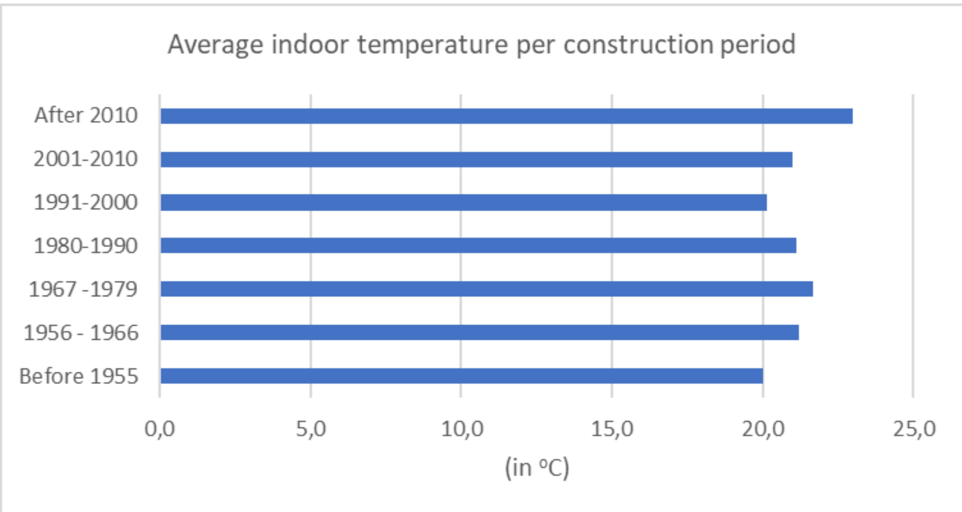

Figure 21: Average (stated) indoor temperature with respect to the construction period.

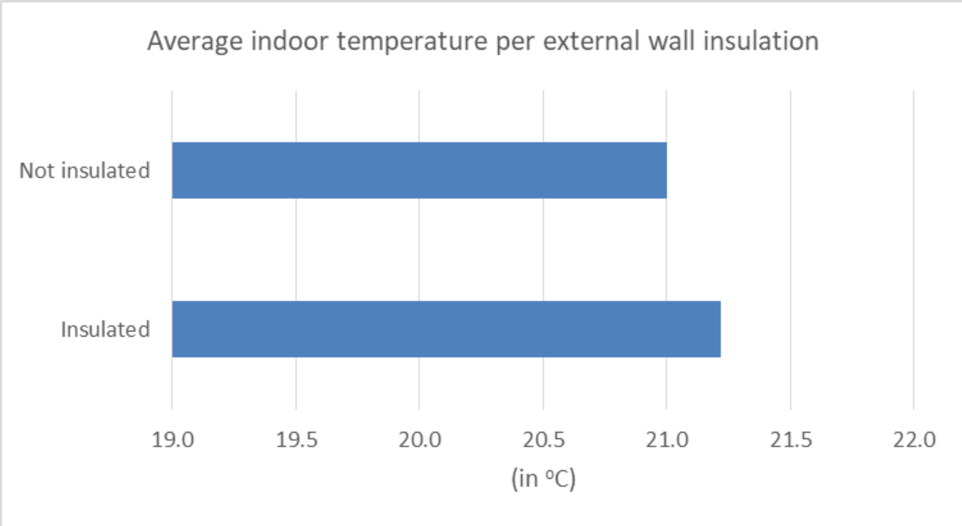

Figure 22: Average (stated) indoor temperature with respect to external wall insulation.

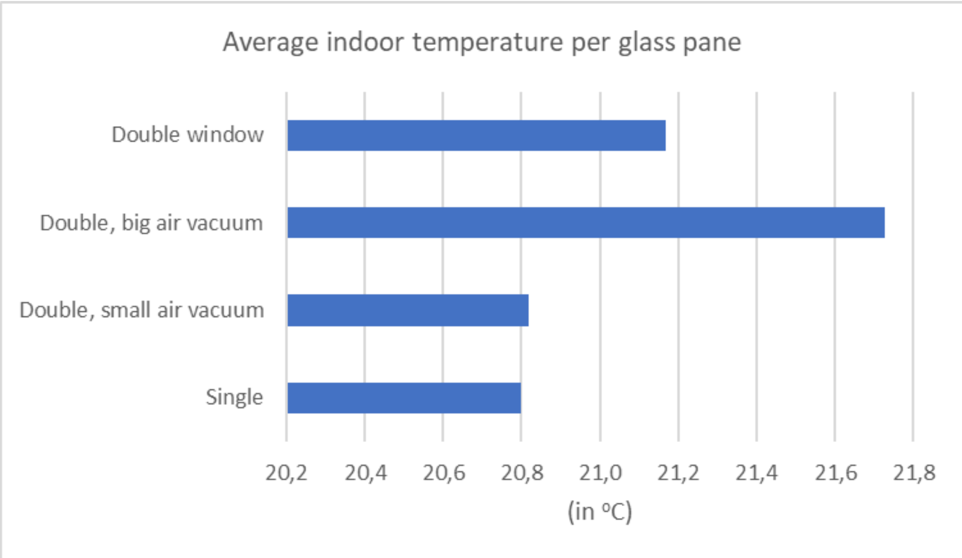

Figure 23: Average (stated) indoor temperature with respect to glass pane.

In the same direction, the average indoor temperature is not correlated with the size of the house (Kruskal–Wallis: χ^2=1.305, d.f.=3, p=0.728) (Figure 24) and the average daily usage of the heating system (Kruskal–Wallis: χ^2=3.025, d.f.=3, p=0.377) (Figure 22). However, it seems to be correlated with the comfort level inside the house (Figure 22), i.e. significantly higher indoor (stated) temperatures are shown for people who report feeling comfortable in the home.

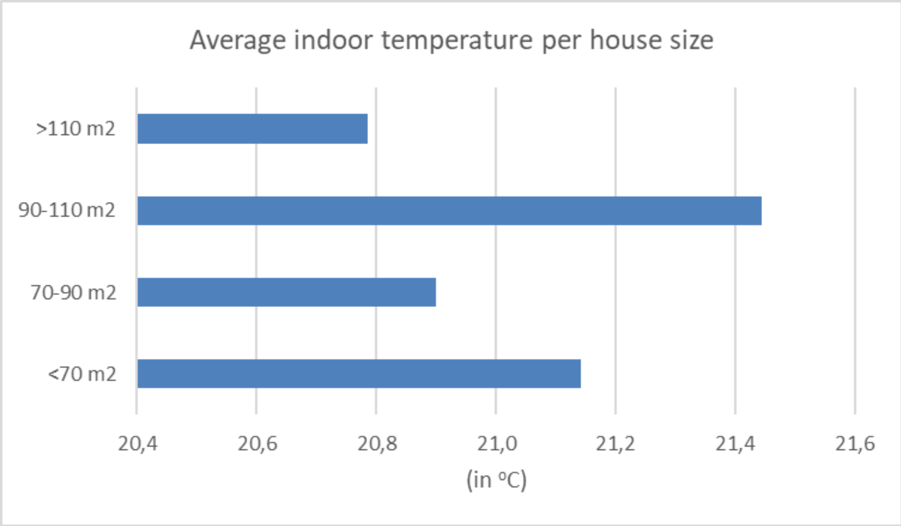

Figure 24: Average (stated) indoor temperature with respect to the size of the house.

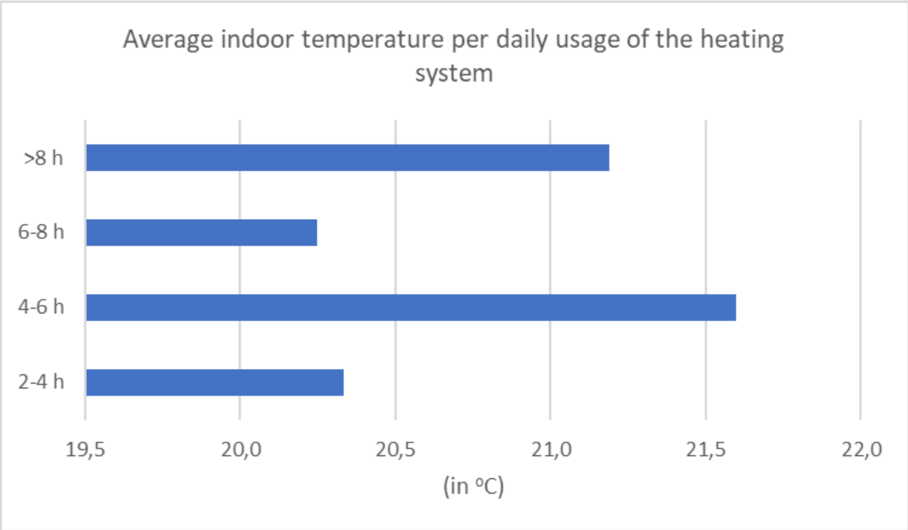

Figure 25: Average (stated) indoor temperature with respect to the use of the heating system (in hours).

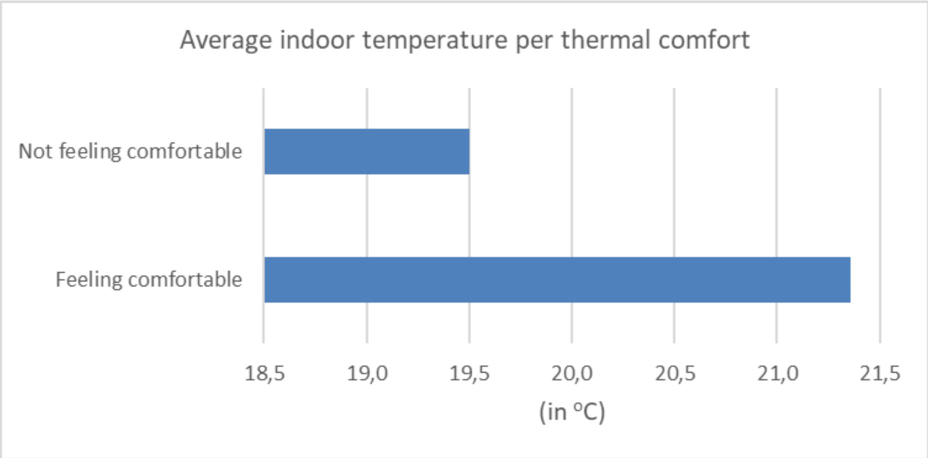

Figure 26: Average (stated) indoor temperature with respect to thermal comfort.

Finally, concerning the natural ventilation of the houses, 4% of the households reported that they do not open the windows at all during winter. The rest responded that they ventilate their homes mainly early in the morning (83%), before midday (4%) or at midday (12.5%). Considering that outdoor temperature is very low early in the morning, opening the windows at that time of the day allows the house to cool down quickly and, thus, requires more heating energy to restore the indoor temperature.

Energy spending on heating and electricity

On average, households spend 2,200 Euros per year on heating (std. dev: 915 Euros). More explicitly, about 6% spend less than 1,000 Euros per year, 48.5% spend between 1,000 and 2,000 Euros per year, 36% spend between 2,000 and 3,000 Euros per year, and the rest spend more than 3,000 Euros per year.

The (stated) average annual spending for heating seems to be affected by the building characteristics, i.e. the age (Figure 22), the size of the house (Figure 22), and the insulation of external walls (Figure 22). Nevertheless, the difference in the means is not statistically significant.

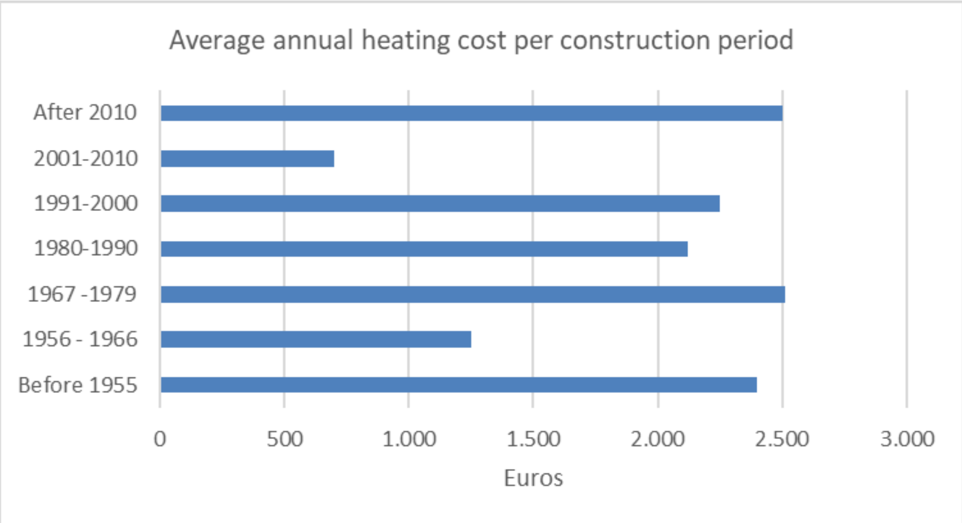

Figure 27: Average (stated) heating cost related to the construction period of the house.

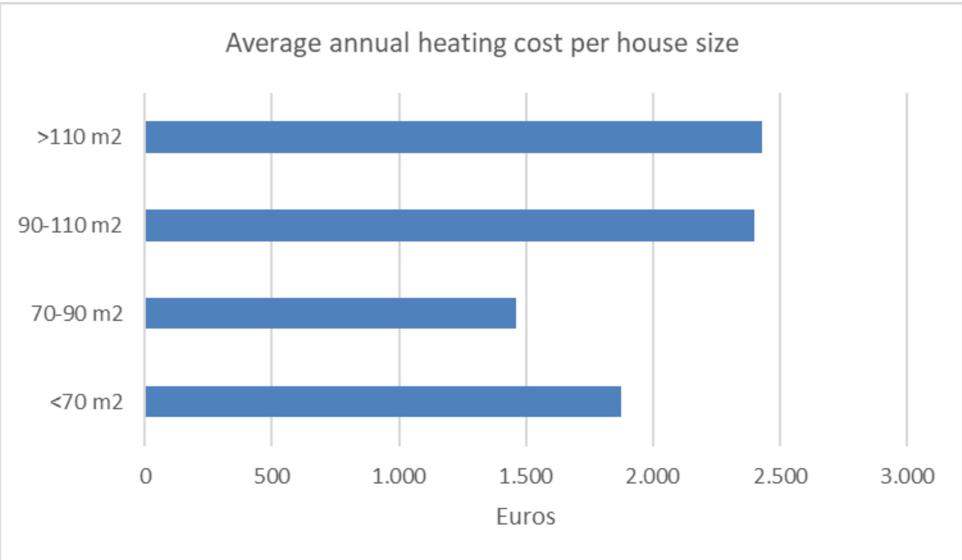

Figure 28: Average (stated) heating cost related to the size of the house.

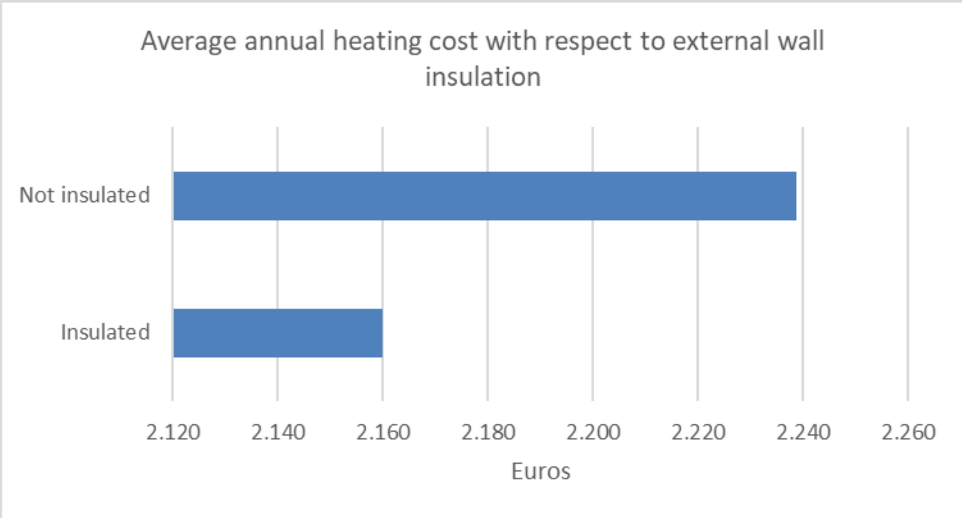

Figure 29: Average (stated) heating cost with respect to external wall insulation.

Seemingly, the annual heating cost is affected by the thermostat setting (Figure 22), the type of the primary heating system (Figure 22) and the daily usage of the heating system (Figure 22). However, there is no statistically significant relationship detected between heating cost and the above-mentioned variables.

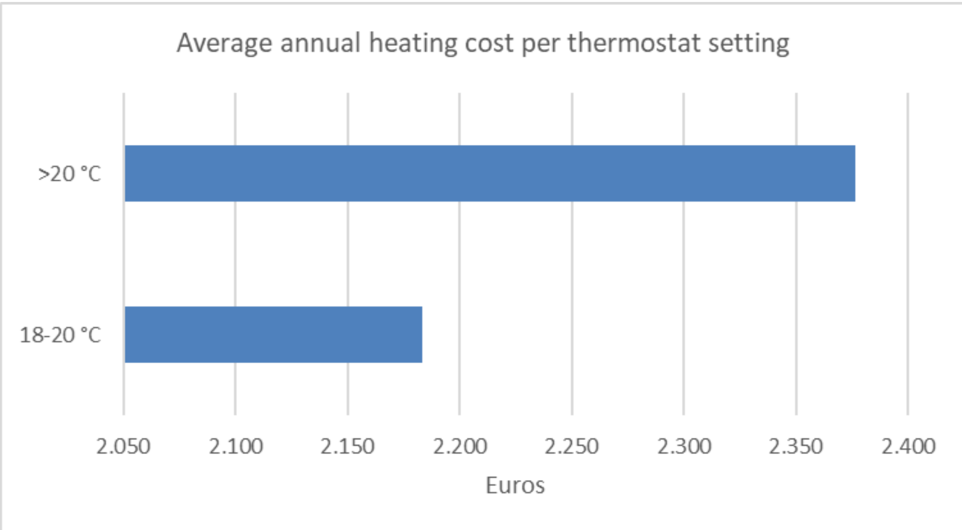

Figure 30: Average (stated) heating cost with respect to the thermostat setting.

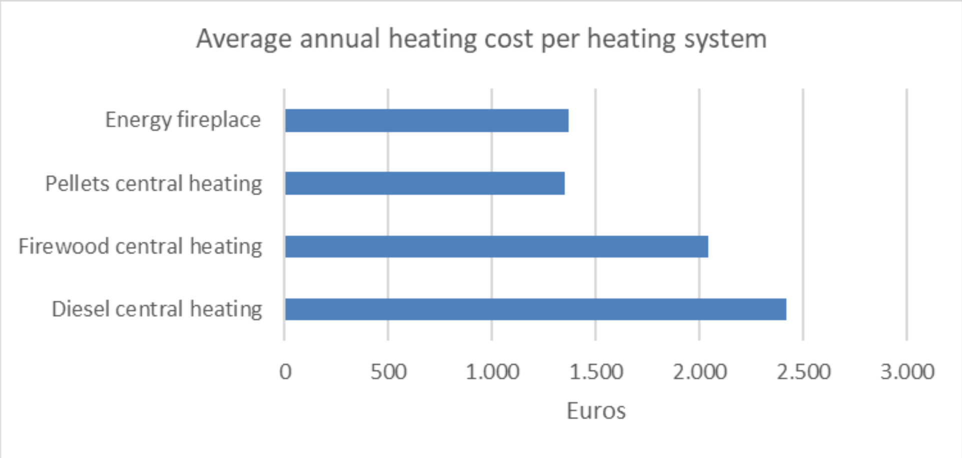

Figure 31: Average (stated) heating cost related to the type of the heating system.

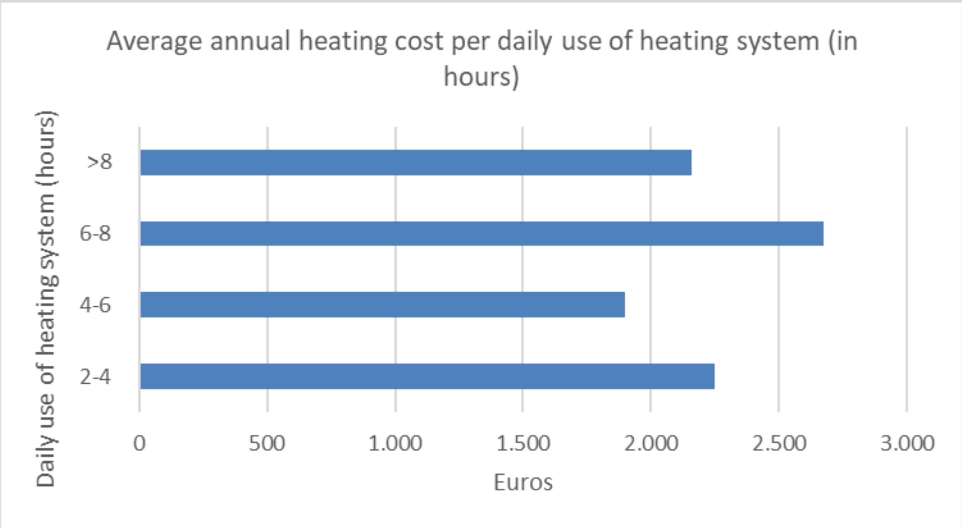

Figure 32: Average (stated) heating cost related to the use of the heating system.

The average (stated) annual electricity cost is around 930 Euros (std. dev: 421 Euros). More specifically, 30.5% of the households spend less than 600 Euros per year (i.e. 50 Euros per month), 28% spend between 600 and 900 Euros per year (i.e. 50-75 Euros per month), 22% spend between 900 and 1,200 Euros per year (i.e. 75-100 Euros per month), and the rest spend more than 1,200 Euros per year.

The annual electricity costs stated by the participants in the V2 operation of the LL vary to the size of the house (Figure 22) and the size of the household (annual costs increase as the household size increases) (Figure 22). Yet, differences between the groups are not statistically significant (Kruskal–Wallis: χ^2=1.623, d.f.=3, p=0.654 and χ^2=4.074, d.f.=2, p=0.130, respectively).

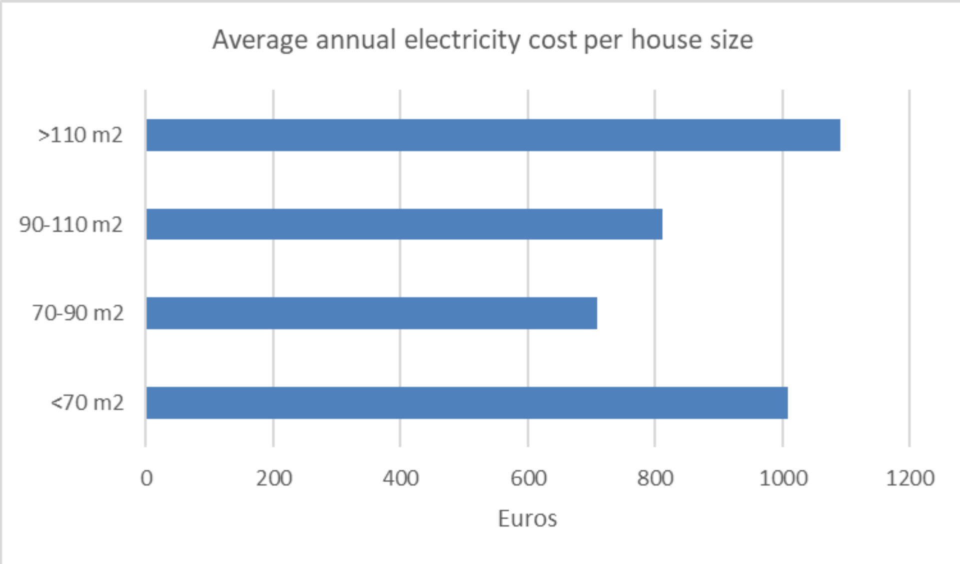

Figure 33: Average (stated) annual electricity cost related to the house size.

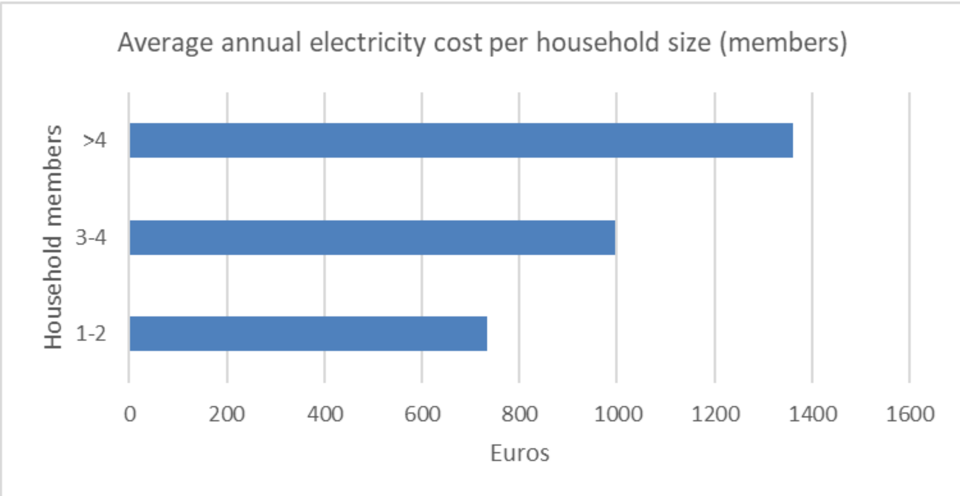

Figure 34: Average (stated) annual electricity cost related to the household size.

Similarly, the annual electricity cost varies to the presence of an electric hot water boiler (Figure 22) and the arrears on electricity bills (Figure 22), without a statistically significant relationship detected though (Mann-Whitney: U=57.5, p=0.461 and U=21.5, p=0.958, respectively).

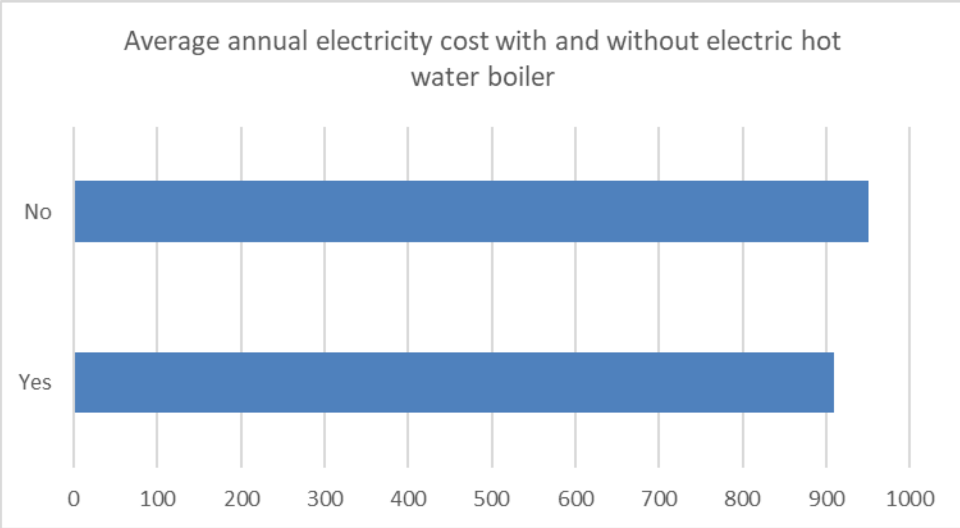

Figure 35: Average (stated) annual electricity cost with and without electric hot water boiler.

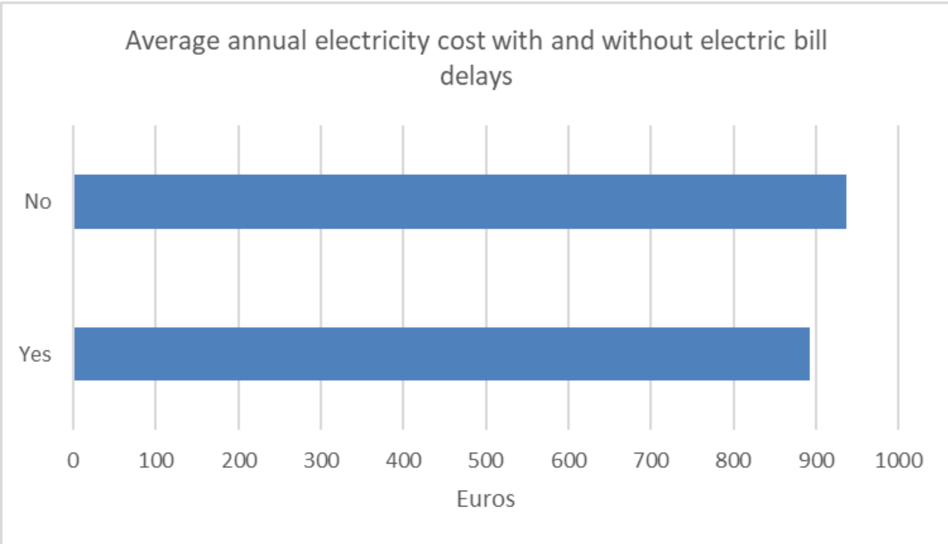

Figure 36: Average (stated) annual electricity cost with and without electric bill delays.

As regards special electricity tariffs, 18% of the households use the Residential Night Tariff, i.e. a tariff that includes two charging prices: the consumption within the peak period charged with the regular price and the consumption within the off-peak period charged with a reduced price. Nevertheless, as illustrated in Figure 22, households that enjoy lower electricity prices spend more on electricity, on an annual basis. This finding is worrisome, as it possibly indicates that these households consume significantly higher amounts of electricity or that their main consumption is within the peak period, thus not taking advantage of the lower price provided within the off-peak period.

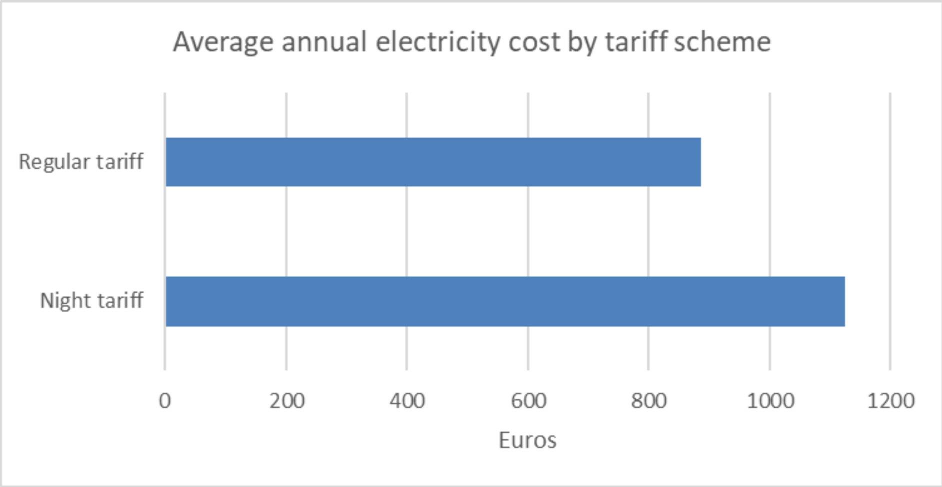

Figure 37: Average (stated) annual electricity cost by tariff scheme.

Energy vulnerability qualitative indicators

Three qualitative indicators were considered to measure energy vulnerability, namely: inability to keep optimal house temperature; housing condition (which includes problems with moisture/mould); and arrears in energy bills. As also in the V1 operation of the LL, cut back on essentials (e.g. food, lighting, etc.) was not taken into consideration, as the results of the baseline survey showed that it's not a major issue in the area of the LL. As shown in Figure 22, the most important issue is the presence of moisture/mould in the houses (30%), followed by thermal discomfort, i.e. the home is not warm enough (18%) and arrears in energy bills (10%).

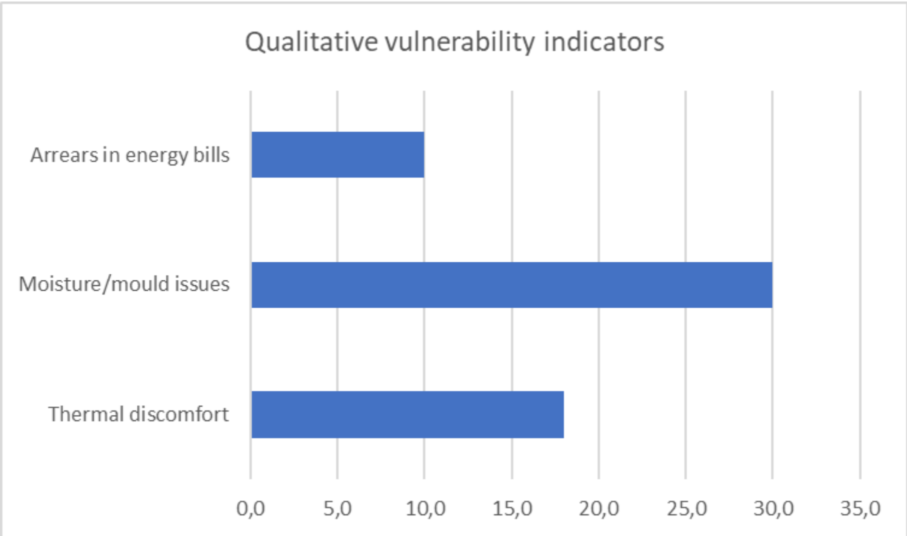

Figure 38: Percentage of energy-vulnerable households.

Using the three above indicators, an overall vulnerability index was constructed. The proposed index ranges between 0 (i.e. none of the above-mentioned issues is present, therefore the vulnerability risk is negligible) and 3 (i.e. all the problems described by the indicators are present, thus the vulnerability risk is very high). It is noted that this indicator was followed at the LL's households for comparability reasons with the V1 round. In the social survey, the above-mentioned indicators were used to construct a slightly different composite energy poverty index following Bouzarovski & Tirado Herrero (2017).

As presented in Figure 22, about 12% of the households face two or more of the above-mentioned problems.

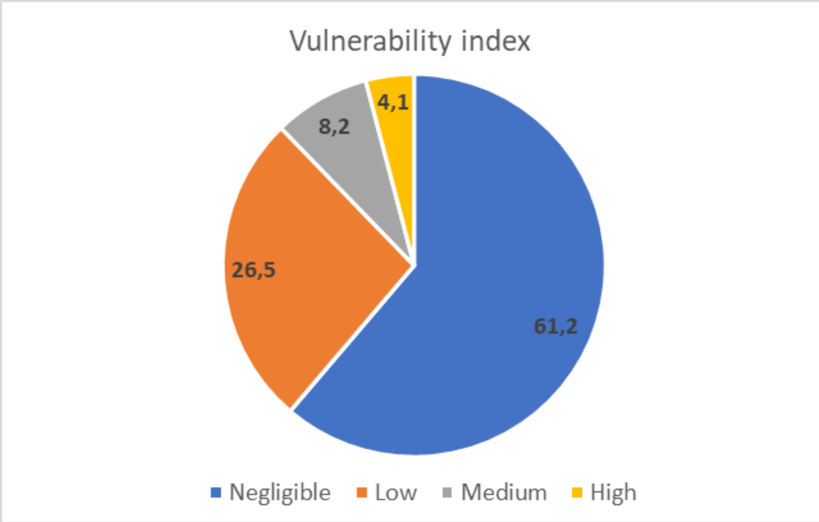

Figure 39: Overall vulnerability index.

As illustrated in Figure 22, those who spend more on heating face lower vulnerability risk (mainly because they face lower problems with moisture and mould), with no statistical differences arising though (Kruskal–Wallis: χ^2=2.682, d.f.=2, p=0.262). Electricity cost does not either present statistically significant differences between vulnerability classes (Kruskal–Wallis: χ^2=3.552, d.f.=3, p=0.314), i.e. those in negligible risk and those in high risk spend similar amounts of money on electricity, an outcome that confirms the complex nature of subjective indicators when combining them with objective data/indicators in the energy poverty problem. Similar conclusions have been reached in the literature (e.g. Price et al., 2007; DECC, 2009; Fahmy, 2011; Roberts et al., 2015), indicating that the relationship between objective and subjective indicators is not strong enough.

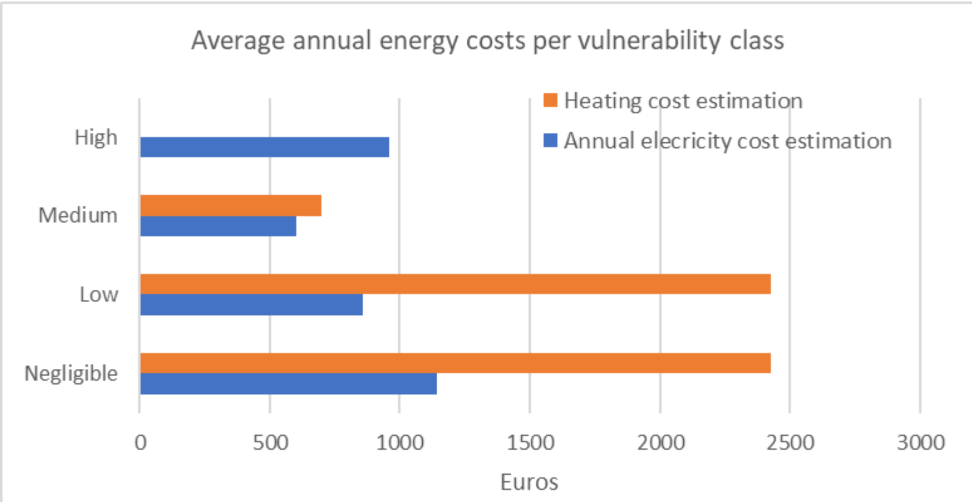

Figure 40: Annual energy costs in relation to vulnerability class.

4.2.2 Monitoring assessment

Indoor temperature and humidity

Thermal comfort is the condition of the mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation. Most people will feel comfortable at a room temperature of 20°C. The average indoor temperature in all the houses monitored was about 20°C for the period between November 2019 to May 2020 while the outdoor temperature in the same period ranged between -5°C and 22°C. More explicitly, 30% of the households had below 20°C of average temperature in their household and the rest 70% had above 20°C temperature.

As mentioned, however, only 13.3% of the households said that they suffer from thermal discomfort (practically households with average indoor temperature 18°C or less), as illustrated in Figure 41.

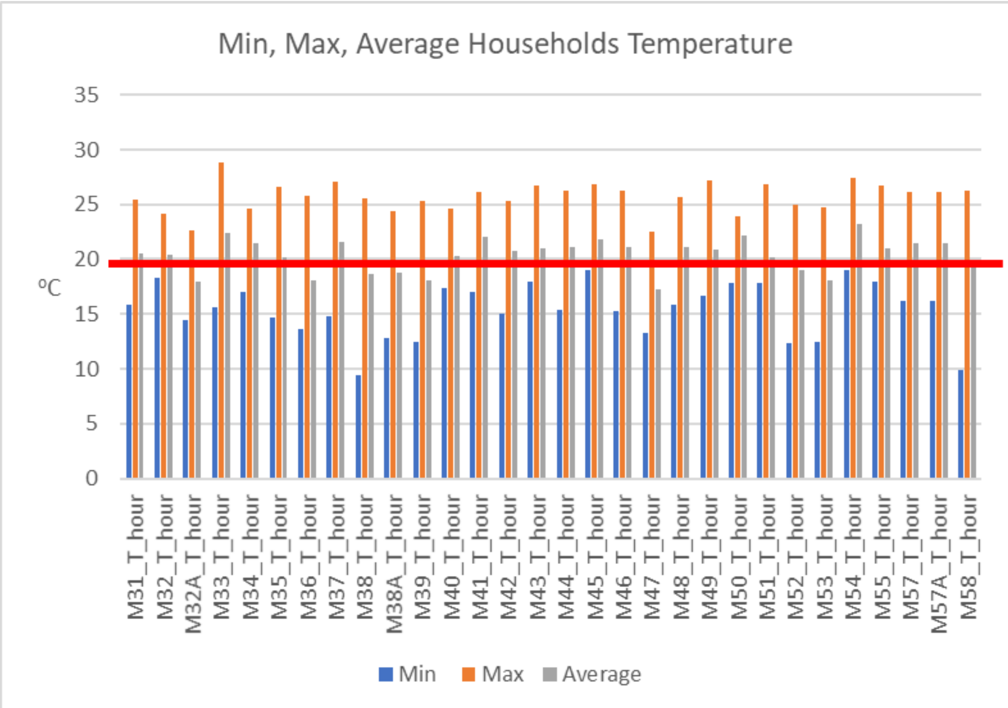

Figure 41: Min, max and average Households temperature.

Even though there exists a positive correlation between the measured and the stated temperature (r=0.121), the differences between them are in some cases significant. More explicitly, 46.6% of the households reported an average indoor temperature that had an absolute difference less than 1°C with the measured on, while 53.4% of the households reported an average indoor temperature that was significantly lower or higher than the measured on (i.e. between 1.11°C and 5.23°C). Yet, it has to be mentioned that people report indoor temperature during their stay at home, whereas measured temperature refers to a 24h average.

According to the temperature measurements taken by the monitoring equipment during the V2 operation of the LL, there is, in some houses, a significant difference between the comfortable temperature and the measured one (comparisons regarding thermal comfort are based on indoor measurement for November 2019 till May 2020, which is the last month where systematic use of heating is made). More explicitly, the average indoor temperature in about one-third of the houses (27%) was between 1°C and 2.75°C lower than the suggested temperature of 20°C, while in 43% of the houses (almost 1 out of 2) was over 20°C (from 1°C up to 3.2°C). In the rest of the houses the temperature was almost 20°C (ranged between 19°C to 21°C). Again, this finding should be considered with caution, as measured values include hours when people are not at home, at all. The average humidity was 44.6%, ranging from 35% up to 64%.

The mean temperature does not increase proportionally with the size of the property, implying that larger households face difficulties and spend more for heating purposes (Figure 42), the use of central heating systems (Figure 43), and the insulation of the external walls (by almost 0.8°C) (Figure 44). However, there is no statistically significant difference in any of these cases. Moreover, as shown in Figure 45, the average indoor temperature is higher for households that use fewer hours their heating system daily. This unexpected finding is related to the fact that households using central heating operate the system fewer hours compared with households that use local heating systems, such as electric devices, fireplaces, stoves, etc., as shown in Figure 46.

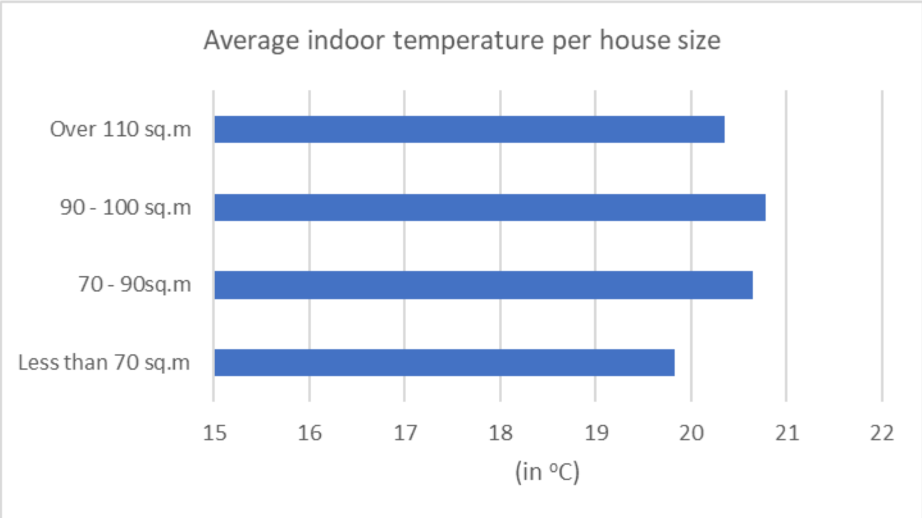

Figure 42: Average temperature related to house size.

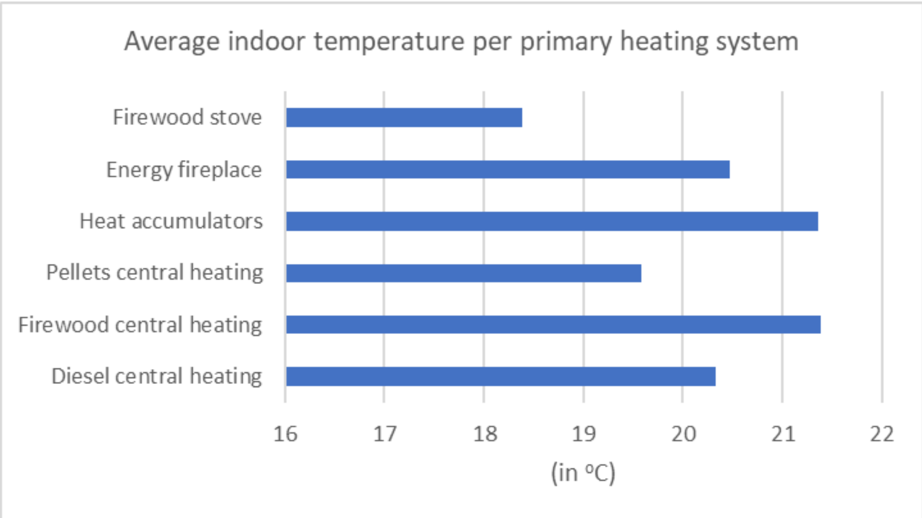

Figure 43: Average temperature per type of primary heating system.

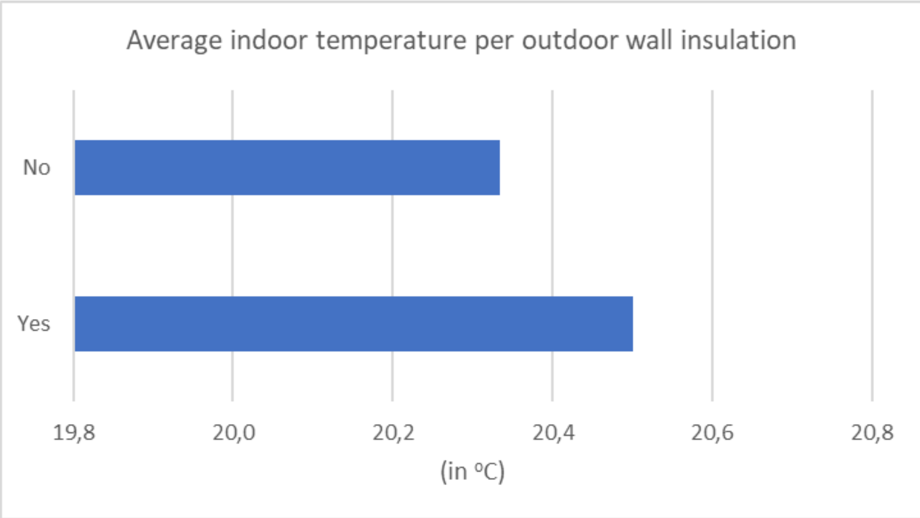

Figure 44: Average indoor temperature with and without external wall insulation.

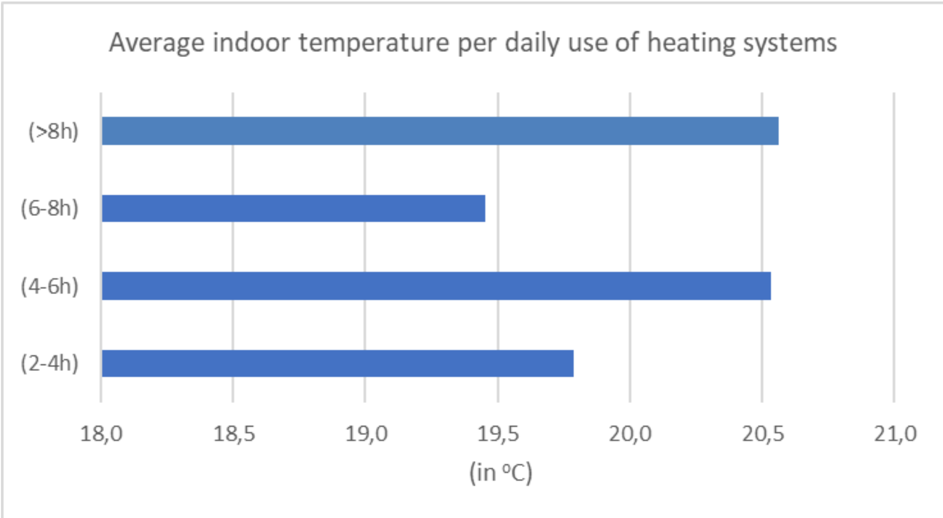

Figure 45: Average indoor temperature compared to the daily use of heating systems.

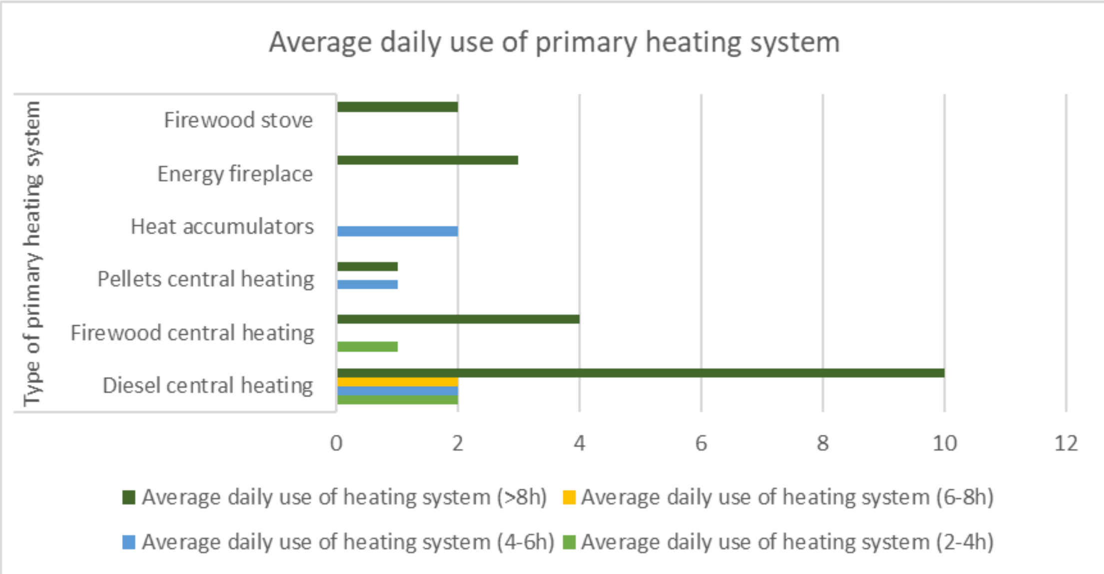

Figure 46: Average daily use of heating systems per type of heating.

It is worth mentioning that in certain cases significant differences were measured in the indoor temperature between rooms of the same house, which were attributed to the type of the heating system (i.e. local or central), to the orientation of the room or even to the fact that in some houses only a part of the house is being heated. For instance, Figure 47 and Figure 48 show the differences in the temperature between living rooms and bedrooms for houses that are partially heated or in which local heating systems are used.

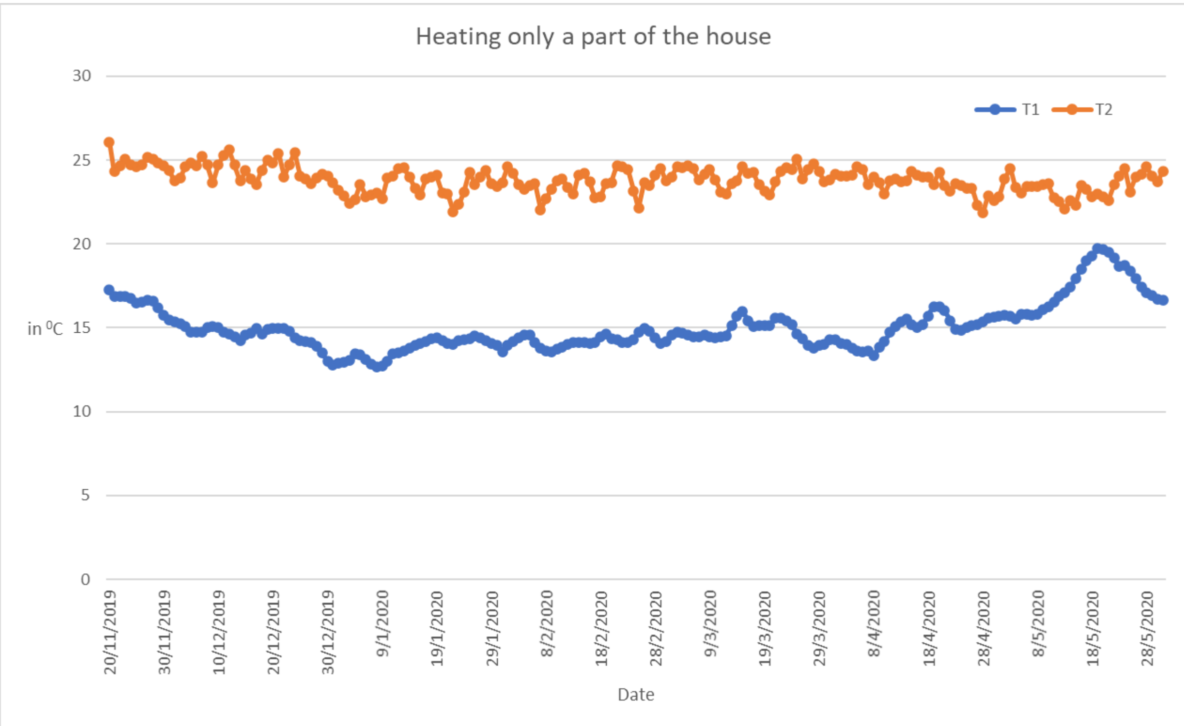

Figure 47: Indoor temperature differences in a partially heated house.

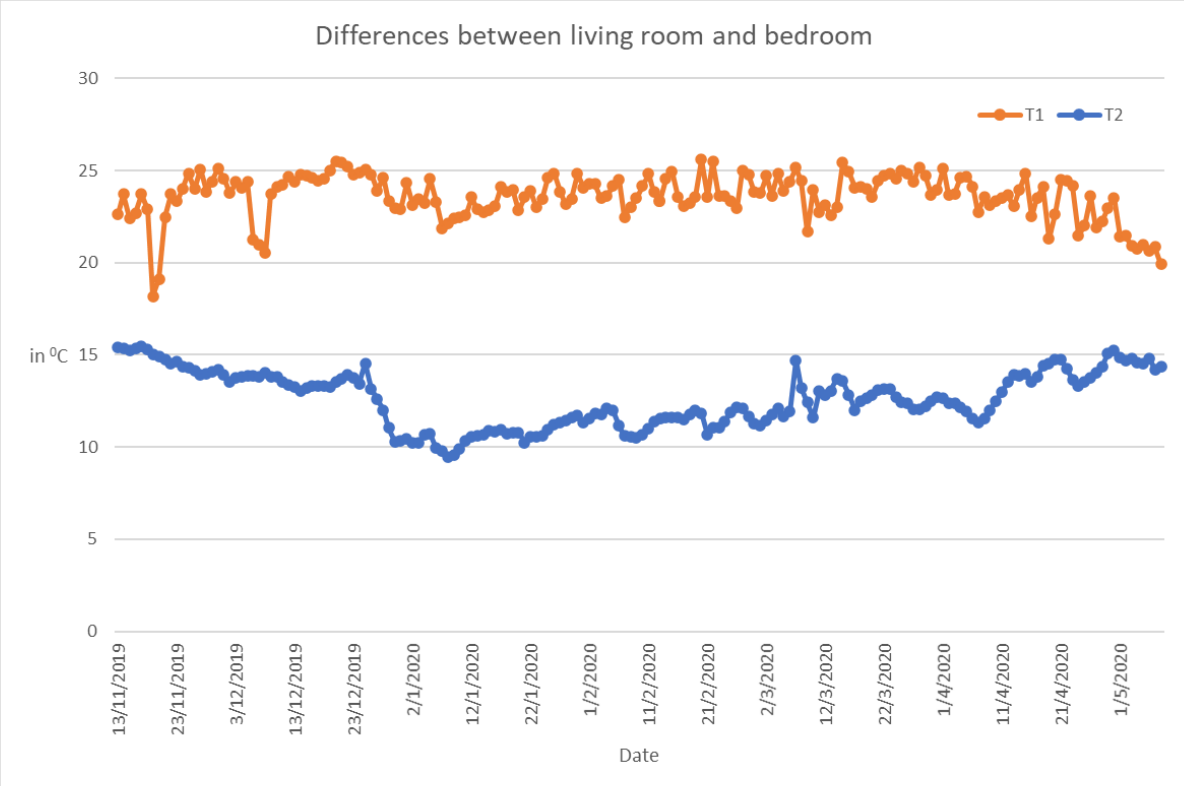

Figure 48: Indoor temperature differences in a house with local heating system (stove).

Heating energy consumption

To calculate the required energy consumption of the households with metering equipment, the following procedure was implemented:

- Creation of floor plans of the households, following measurements from Energy Advisors' visits
- Calculation of houses' heat transfer coefficient based on the floor plans and the data collected by questionnaires, as well as the heat permeability factors described in the Greek Regulation for Buildings' Energy Performance (KENAK)
- Calculation of thermal energy demand by combining the findings of the previous step and the Heating Degree Days (HDD) in Metsovo (base temperature for HDD 18°C, which practically corresponds to 20°C internal temperature).
- Estimation of thermal energy consumption, considering energy demand and the efficiency rations of the hating systems, as defined by KENAK.

Based on the modelling procedure, the total required thermal energy consumption of the households under consideration amounts to 879,054 kWh_{th}.

The calculation of the real heating energy consumption had to start from an assumption that is related to the period in which the V2 round of the LL took place. From November 2019 to May 2020, the average daily temperature varied and ranged, on average, from 1.7°C in January 2020 to 13.1°C in May 2020 as shown in Figure 49. The coldest month during the second cycle of the LL was January 2020 (Figure 50). More explicitly, the basic assumption made is that the average indoor temperature of each household from November 2019 to May 2020 reflects the average indoor temperature throughout the heating period. In Figure 51, the shares of households whose temperature is near, below and above the comfort levels (i.e. 20°C, as defined by KENAK and relevant standards) are presented. The measured average indoor temperature of the V2 round of the LL was then introduced into the energy consumption model and the real heating energy consumption was calculated.

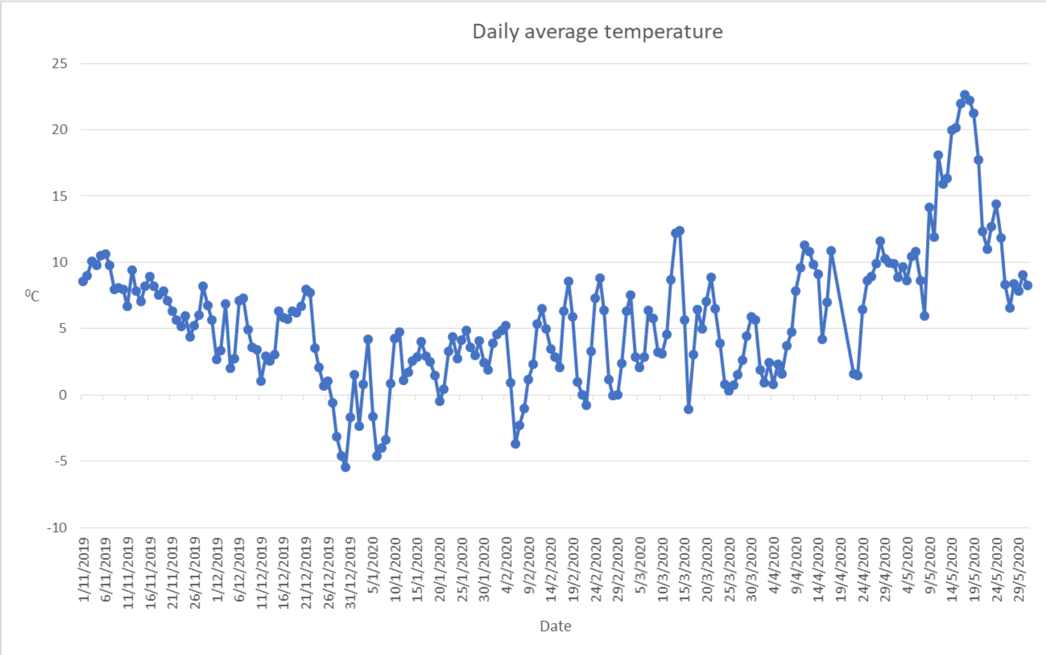

Figure 49: Daily average temperature during the V2 round of the LL.

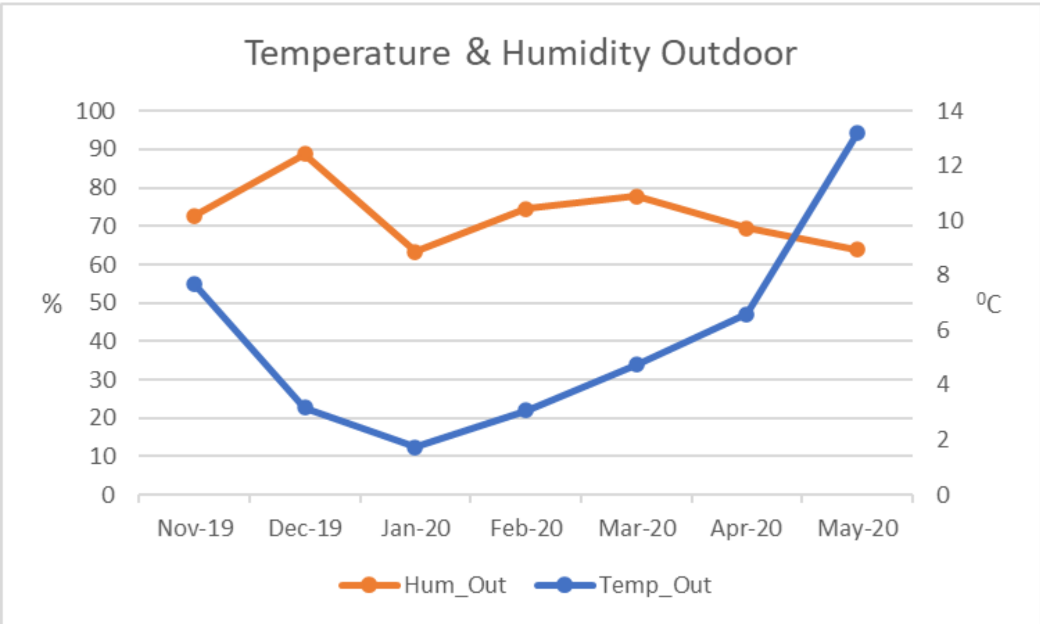

Figure 50: Outdoor temperature and humidity during the V2 round of LL.

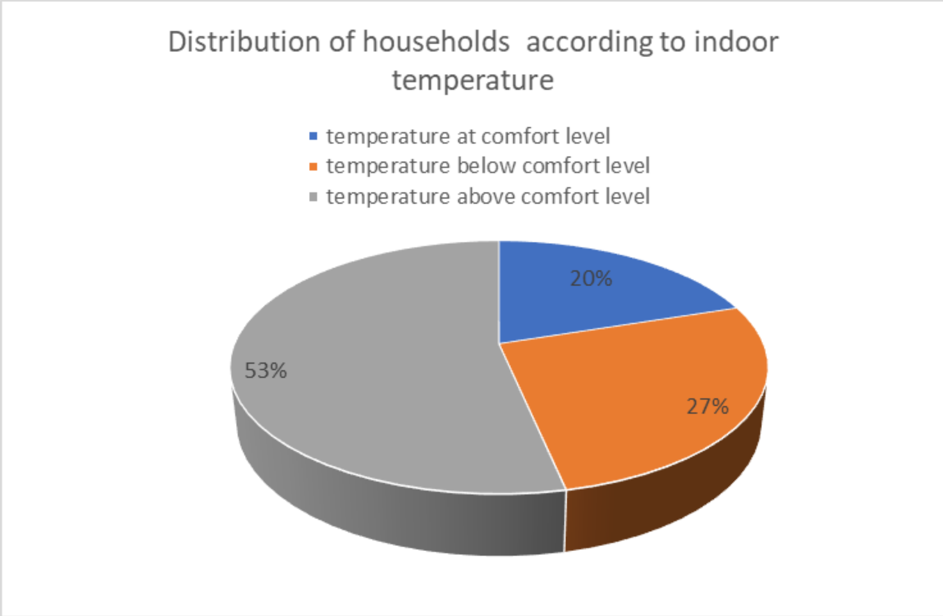

Figure 51: Comfort level of households under study during the heating period.

Following the methodology described, the total real heating energy consumption of the 30 households under study amounts to 806,538 kWh_{th}. The real heating energy consumption is lower than the required one (i.e. 879,054 kWh_{th}). The difference between them is about 8.2%. To gain a better view, the households that over-consume and under-consume energy were examined separately. Figure 52 contains the total required thermal energy consumption, as well as the actual thermal energy consumption of over- and under-consuming households. Households whose temperature is below comfort levels consume 25% less energy than required. In the cases where the temperature exceeds comfort level, the excess energy consumption is 17% greater than required.

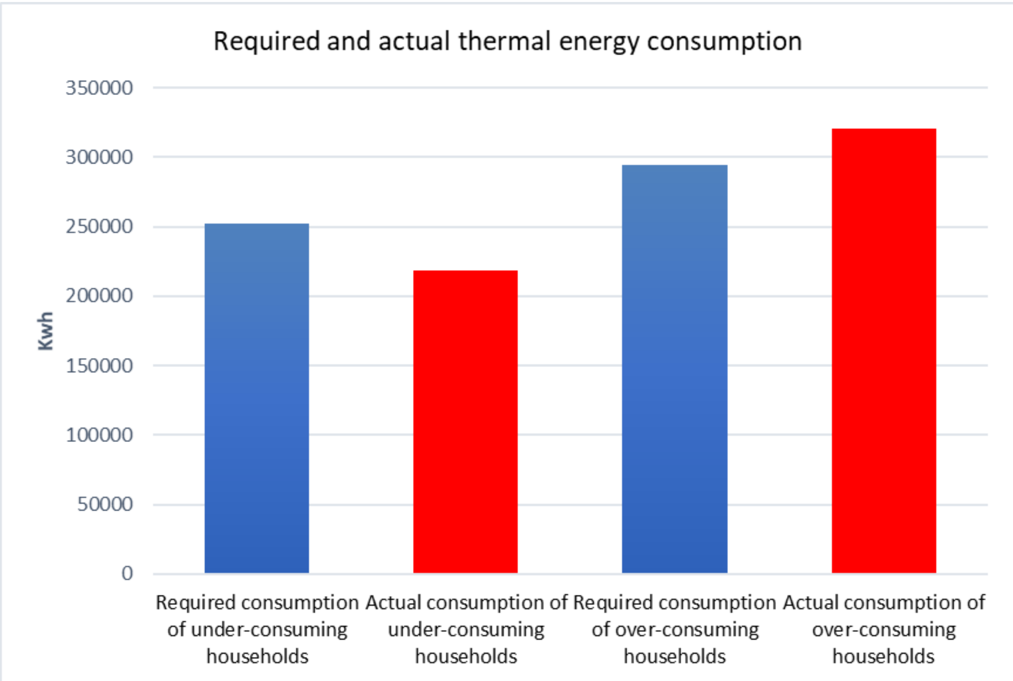

Figure 52: Required and actual thermal energy consumption of over- and under-consuming households under study.

Households whose residences have insulated external walls consume 6% less thermal energy (real consumption), as shown in Figure 53. This is an illustrative indicator of the positive effects of insulation on energy consumption.

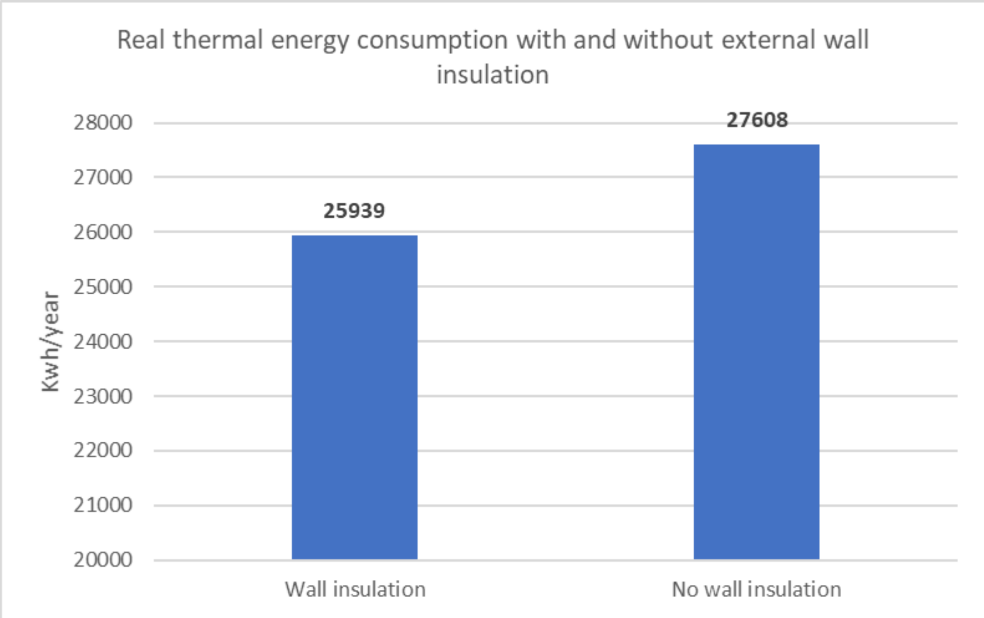

Figure 53: Real thermal energy consumption with respect to external wall insulation.

There is no special differentiation between households with temperature below, at or above comfort level. More specifically households with indoor temperature bellow comfort levels present, on average, 3% higher energy consumption than households with the indoor temperature at comfort levels and almost 2% higher energy consumption than households with an indoor temperature above comfort level (Figure 54). Although differences are minor, it is shown that more vulnerable households (i.e. those living in uninsulated houses) spend more money on heating without improving their comfort level.

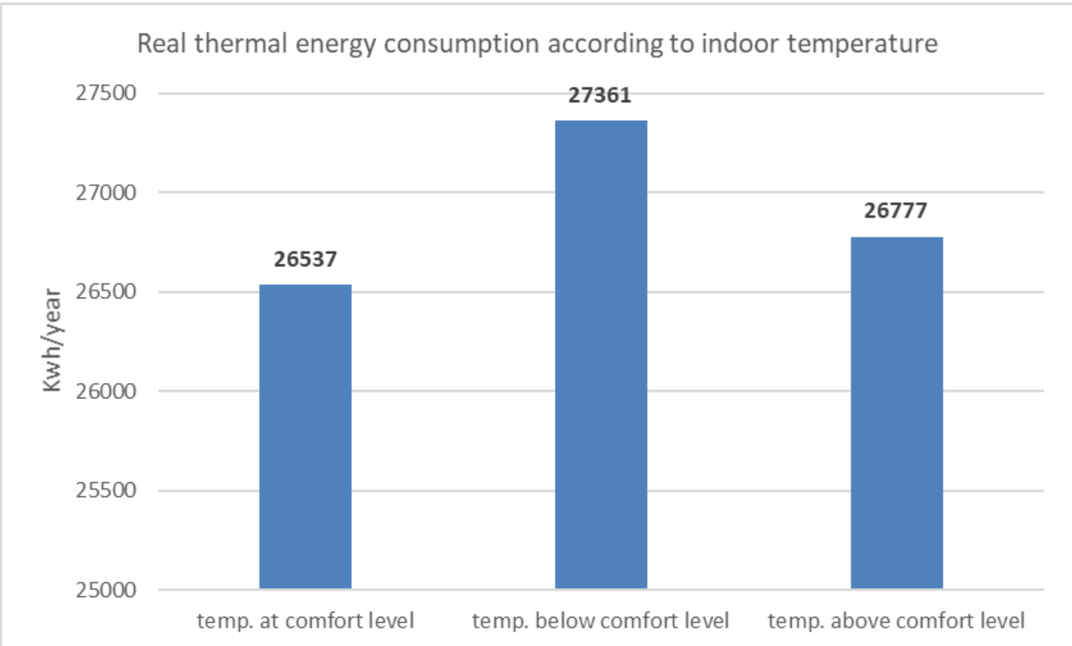

Figure 54: Real thermal energy consumption with respect to indoor temperature.

Electricity energy consumption

Given the sample of 30 households of the second round, there were three households that on average consume much more electricity than the others. In particular, two of them use heat accumulators for covering their thermal needs and one of them uses electricity for domestic and other purposes. Thus, the average annual electricity consumption has been calculated for the rest (twenty-seven) of the households and is around 3,684 kWh_{el} (std. dev: 1451$Kwh_{e)l}$ Based on Eurostat's data the final electricity consumption of all Greek households, in 2017, was about 19,628 GWh_{el}, which corresponds to approximately 4,700 kWh_{el} per household per year. More specifically, 17% of the households consume less than 2,000 kWh_{el} per year, 23% consume between 2,000 and 3,750 kWh_{el} per year 27% consume between 3,750 and 5,000 kWh_{el} per year, 23% consume between 5,500 and 7,250 kWh_{el} per year and the rest 10% (i.e. the three households that were excluded from the calculation of the mean value) consume more than 9,000 kWh_{el} per year.

The annual electricity consumption varies by the size of the property (Figure 55), although not proportionally. The differences between the property size groups are not statistically significant. In general, the annual electricity consumption increases proportionally to the household size (Figure 56). Yet, there is no statistically significant difference between the groups. Interestingly, the average annual consumption is higher for households that use special tariffs (e.g. night tariffs), as shown in Figure 57. This is attributed to the fact that there exist two households in the V2 round of the LL who use heat accumulators for heating and, thus, use electricity to cover their heating needs. According to Figure 58, households in arrears consume, on average, more electricity. The null hypothesis that the difference is not significant cannot be rejected. Nevertheless, it seems that those who are more vulnerable to arrears consume, in general, more electricity.

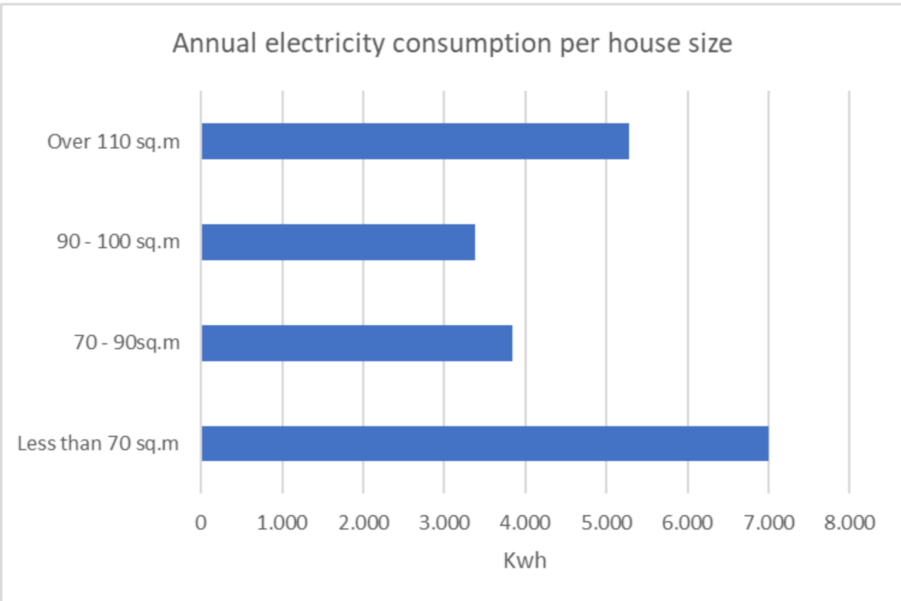

Figure 55: Average annual electricity consumption related to house size.

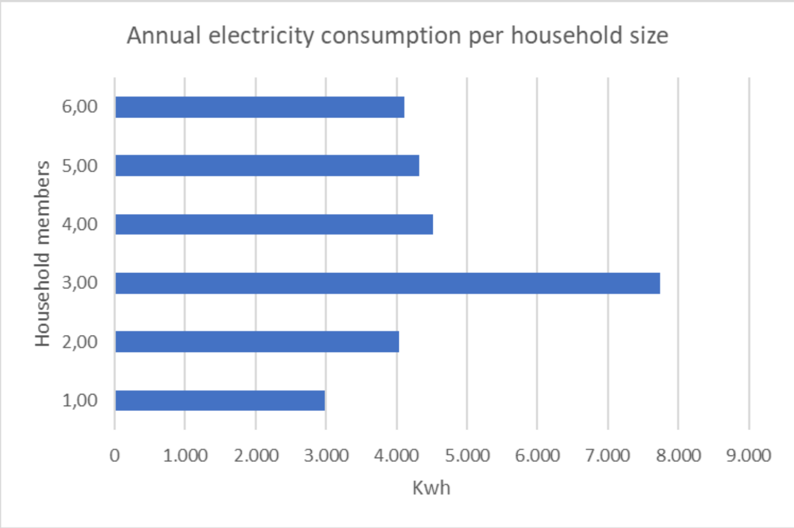

Figure 56: Average annual electricity consumption related to household size.

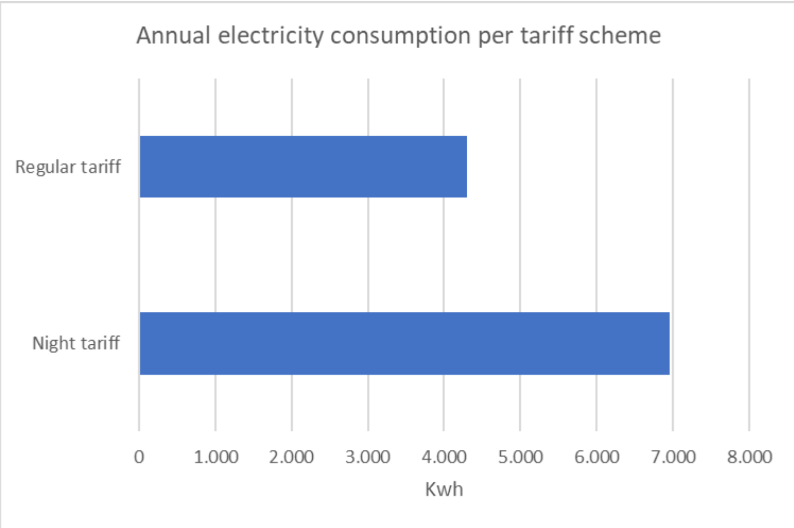

Figure 57: Average annual electricity consumption by tariff scheme.

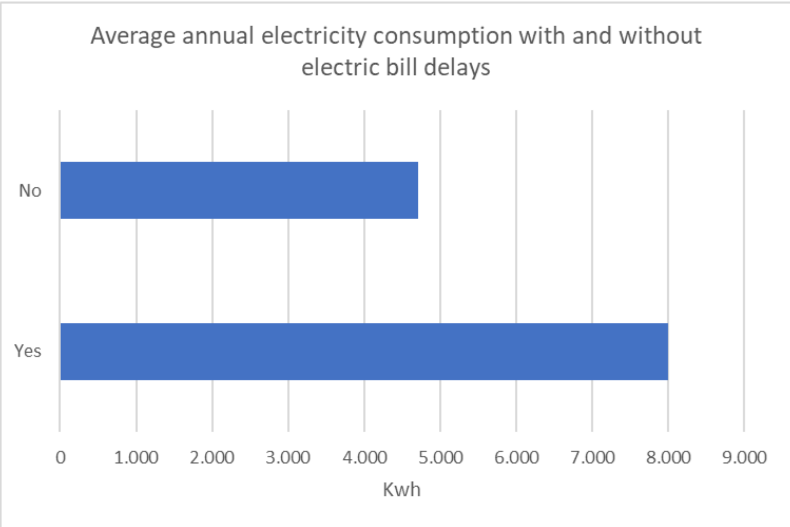

Figure 58: Average annual electricity consumption with and without electric bill delays.

On average, households that use electric hot water boilers consume approximately 1,320 kWh_{el} more electricity per year (Figure 59). Yet, the Mann-Whitney U test null hypothesis is not rejected (Mann-Whitney U=86, p=0.352). It is worth noting that the current legislation does not allow the installation of solar water heaters, to retain the vernacular architectural identity of the settlement. This results in higher energy consumption and, consequently spending (around 350-400 Euros per year). This is an issue that local and national policymakers and legislators should consider to reduce the energy expenses of local households.

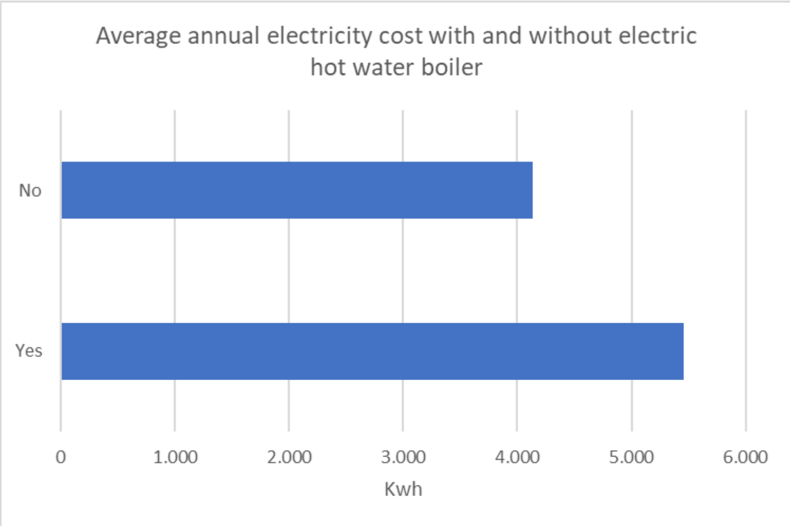

Figure 59: Average annual electricity consumption with and without electric hot water boiler.

Energy spending on heating and electricity

For covering the required thermal energy costs, the 30 households monitored would need to spend around 75,300 Euros per year. The average unit heating cost is 0.085 Euros per kWh_{th}. The real thermal energy costs are 66,300 Euros per year or 0.082 Euros per kWh_{th}. The majority of the households (60%) spend less money than required for covering adequately their heating energy needs. This may affect their ability to keep the indoor temperature at the comfort level (20°C). On the other hand, 20% of the households spend more money than required to have an acceptable thermal comfort level, i.e. the house temperature is more than 20°C (from 0.7 °C to 2.5 °C).

Compared to the required energy, the average under-spending is about 310 Euros per year, while the average over-spending is 485 Euros per year. The estimated required costs for an important part of the households (27%), present small differentiations with the real costs. So, this part of the households is considered to cover adequately their energy needs, without consuming more energy than required. In general, households in Metsovo seem to provide good estimations for their thermal energy costs. As regards the actual annual expenditure for heating, households with indoor temperature below comfort level spend 21% less than those with the indoor temperature at comfort levels, as depicted in Figure 60. The households with a temperature above comfort level spent only 5% more than those with temperature below comfort level and 16% less than the households with the temperature at the comfort level. This seemingly unexpected finding is related to the fact that households with a temperature above comfort level live usually in houses with wall and/or roof insulation and use more efficient heating systems. Based on the engineering models, it is found that the required heating costs of houses without wall insulation are significantly higher (32%) than the corresponding costs of houses with wall insulation (Figure 61).

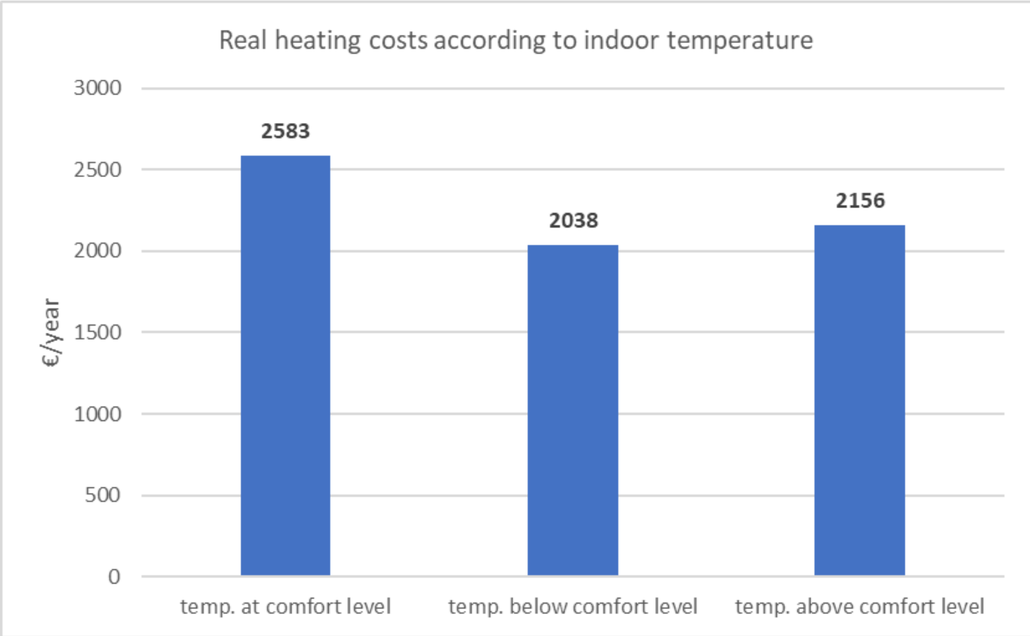

Figure 60: Real heating costs for households with respect to indoor temperature.

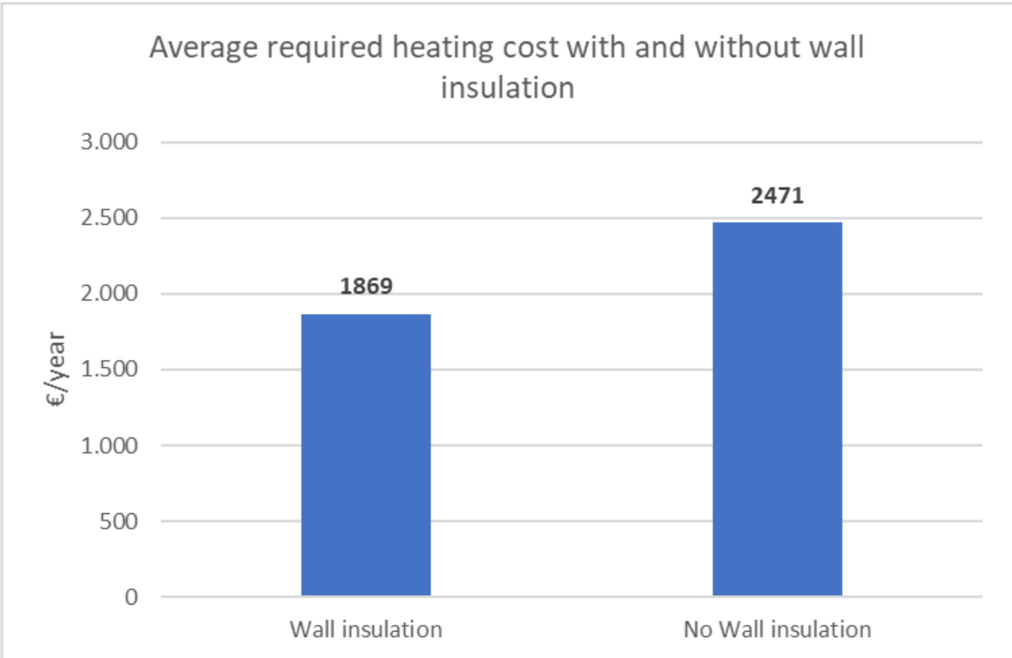

Figure 61: Required heating costs for households with and without wall insulation.

To wit, Figure 62 presents the average indoor temperature between two houses of similar size that use oil-fired central heating systems. The only difference is that one of the houses is insulated. The indoor average temperature is practically the same, almost 21ºC. Yet, the uninsulated house (H1) spends on heating approximately 3,000 Euros per year, whereas the insulated house (H2) spends roughly 2,000 Euros per year.

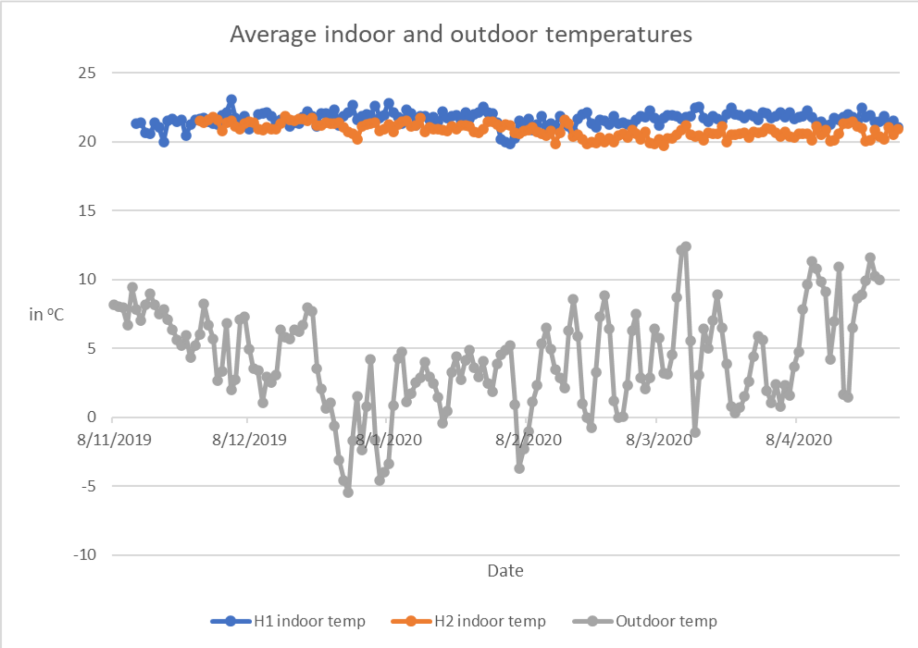

Figure 62: Average indoor temperatures in houses with oil-fired central heating system with and without insulation.

The households that use heating oil as the main fuel for heating spend more than the households that use a different fuel, especially when compared with those that use biomass (firewood and pellet). On average they spent more than 2,500 Euros as shown in Figure 63.

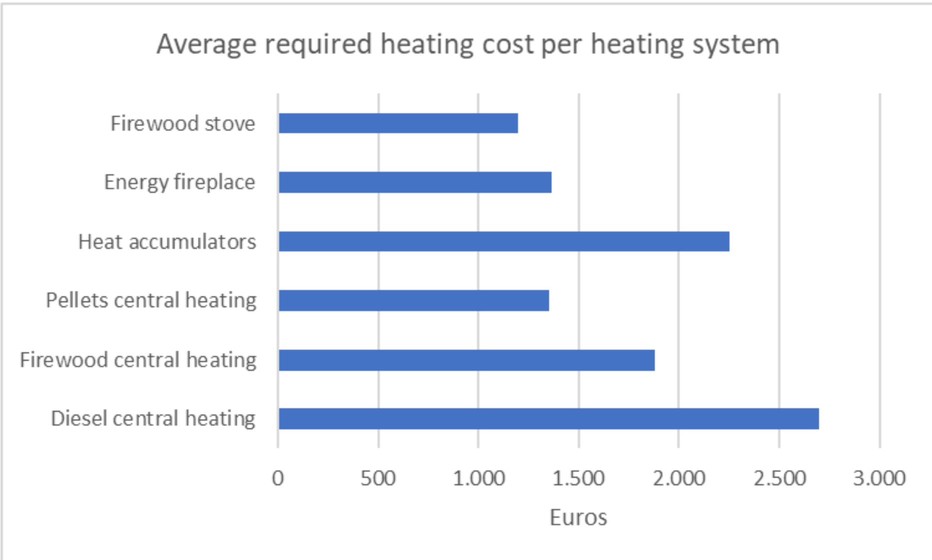

Figure 63: Average required heating cost per heating system.

As expected, the larger the house, the higher the amount of money needed for heating (Figure 64). Nevertheless, the area of the house is not always a decisive factor. As shown in Figure 64, houses with an area up to 70 m^2 show higher heating costs than those with an area between 70-90 m^2 because they are of a lower energy class or use less efficient heating systems.

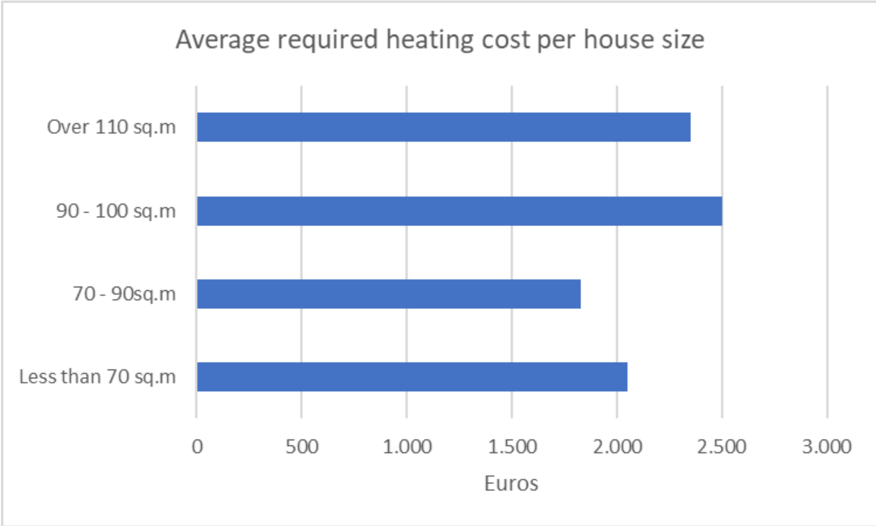

Figure 64: Average required heating cost per house size.

Energy diaries

During the V2 round of the LL, 30 energy diaries were distributed to the households. The diaries contained the basic household appliances and a timetable to record the operation of basic household appliances for two weeks. This type of insight was able to report to the specific activities that led to the use of power and, in particular, to the type of routines householders perform that consume energy, as shown in Figure 65.

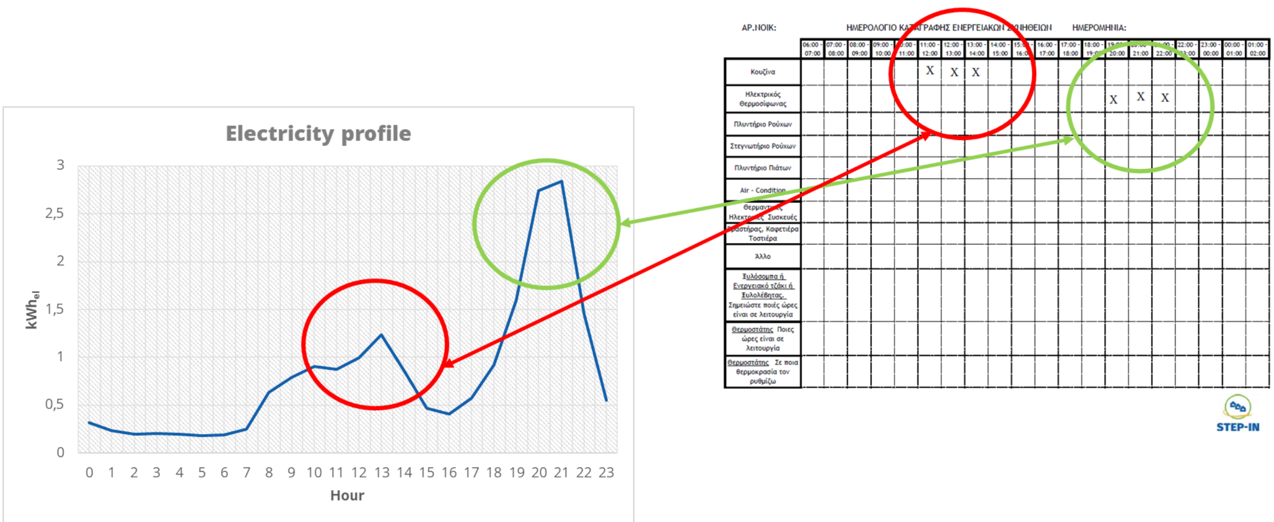

Figure 65: Connection of electricity profile and appliances usage according to the energy diaries.

Of the 30 households, less than half (i.e. 14) completed the diaries daily. For these households, it was easier to provide more accurate and tailored-made advices concerning simple and easy ways to reduce their energy expenses and/or improve their households comfort level. In general, however, energy diaries didn't seem to work well in the mountainous LL, as people were not committed to keeping the diaries.

4.2.3 Evaluation assessment

Acceptability of proposed energy interventions

Based on the data gathered by the questionnaires, the monitoring and the calculations conducted about the required and real energy consumption, each of the households in which metering equipment was installed received a leaflet (Annex IV). This leaflet offered tailor-cut information about heating energy and electricity consumption and "personalized" advice on how to reduce energy spending. Each proposed intervention had a short description, including an estimation of the investment cost and the annual savings. The rest of the households (i.e. those without metering equipment installed) were also provided with a bunch of energy intervention measures - common in all households - including Information on roughly estimated investment costs and annual savings.

During the evaluation phase, households were asked to rank the proposed energy intervention measures in terms of priority. As presented in Figure 66, the most acceptable measure is the change of windows frames, followed by the insulation of the external walls and the roof of the house. Yet, low-cost effective measures, such as maintenance of the heating system and installation of digital thermostats were also highly accepted.

Also, the households were asked to mention the most important barriers towards implementing the proposed energy efficiency investments. About half of them reported financial difficulties and the high implementation cost of the suggested measures. This was also apparent in a series of questions asked about the support of such investments by the State. About 86% of the participants said that they didn't apply in the past for the "Energy Saving at Home" – ESH programme. Yet, 60% are considering doing so if the programme opens again for applications. Further, more than 80% would prefer to receive a subsidy, instead of tax relief, to be able to invest in measures with high initial costs.

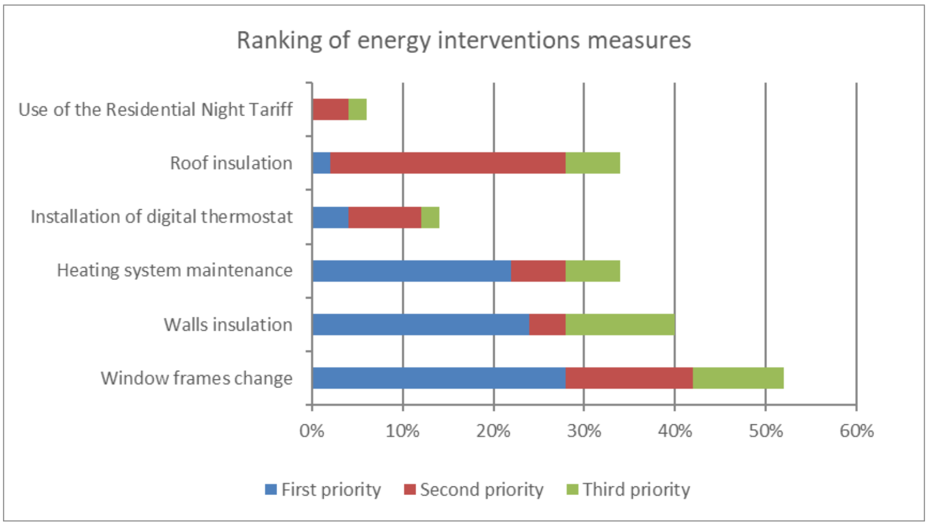

Figure 66: Ranking of proposed energy intervention measures.

Reduction in energy consumption and spending

Maintenance of oil central heating systems

During the V2 round of the LL, twelve diesel oil – fired central heating systems were checked. Exhaust gases and burner efficiency ratios were measured. Three diesel oil – fired central heating systems underperformed and were therefore maintained according to the Legislation and the Standards, applied in Greece. The aims of this action were the following:

- Inform household owners about the necessity and the benefits of the regular maintenance of central heating systems, in an experiential way.

- Contribute to energy efficiency and energy saving in the town of Metsovo, and consequently to a reduction in gaseous emissions.

In particular, three households had efficiency ratios that were lower by more than 3% from the 90% limit, which is considered to be the acceptable efficiency ratio for diesel oil-fired burners. In total, almost 5,280 kWh_{th} and 581€ were saved as shown in Table 2.

Table 2: Energy savings and reduction in energy costs, due to maintenance of central heating systems in the V2 round of Metsovo living lab.

No.	Increase in Burner Efficiency (%)	Thermal Energy consumption (kWh/year)	Energy Savings[1] (kWh/year)	Reduction in energy costs (€/year)
1	3.8	46060	2042	225
2	3.6	40000	1688	186
3	2.9	45970	1550	171
AVERAGE			**1760**	**194**
TOTAL			**5280**	**581**

Replacement of analogue thermostats with digital ones

An easy and low-cost way measure to reduce heating energy consumption in houses were heated by central heating systems is the replacement of analogue thermostats by digital ones. According to the relevant literature, the energy consumption may be reduced by 5% up to 8% because there are less guesswork and higher accuracy in adjusting the temperature to the right setting.

During the V2 round of the LL in Metsovo, twelve old and in many cases malfunctioned analogue thermostats were replaced by digital ones. Correspondingly, the estimated reduction in energy consumption and the savings in heating cost are estimated at 20,456 kWk_{th} and 1,911€, respectively, as shown in Table 3.

[1] Calculated on the basis of each household's specific energy consumption, as estimated by the energy advisors.

Table 3: Energy savings and reduction in energy costs, due to replacement of analogue thermostats by digital in the V2 round of Metsovo living lab.

No.	Thermal energy consumption (kWh/year)	Thermal Energy cost (€/year)	Thermal energy saving (kWh/year)	Reduction in heating costs (€/year)
1	40040	4100	2002	205
2	27800	3100	1390	155
3	46060	3020	2303	151
4	31240	2900	1562	145
5	40000	3700	2000	185
6	32180	2500	1609	125
7	33670	3800	1684	190
8	27433	2500	1372	125
9	36320	2170	1816	109
10	45970	4975	2299	249
11	28250	3180	1413	159
12	20150	2270	1008	114
AVERAGE			**1705**	**159**
TOTAL			**20456**	**1911**

In the following tables, the average, maximum, minimum and standard deviation values of indoor temperature have been calculated for the period before and after the replacement of the analogue thermostats. In particular, Table 4 and Table 5 provide the results for houses in which the thermostat was replaced on January 15 and February 12, respectively.

Table 4: Indoor temperature statistics for thermostat replacement on January 15

	HH1	HH5	HH7	HH10
	Before the change of the thermostat			
Average	19.99	18.65	21.65	18.22
Maximum	20.28	19.44	21.95	18.56
Minimum	19.82	18.04	21.22	17.86
St. dev.	0.21	0.59	0.31	0.29
	After the change of the thermostat			
Average	20.59	17.22	21.68	19.08
Maximum	20.83	17.81	21.92	19.57
Minimum	20.46	16.43	21.25	17.99
St. dev.	0.15	0.50	0.26	0.63

Table 5: Indoor temperature statistics for thermostat replacement on February 12

	HH2	HH3	HH4	HH6	HH8	HH9	HH11	HH12
	Before the change of the thermostat							
Average	20.51	21.44	21.22	21.04	20.60	20.09	18.32	21.20
Maximum	20.62	22.48	21.38	21.12	20.70	20.41	18.63	21.60
Minimum	20.34	20.05	21.07	20.91	20.49	19.80	17.90	20.88
St. dev.	0.10	0.92	0.11	0.08	0.08	0.24	0.28	0.27
	After the change of the thermostat							
Average	20.12	23.34	21.56	20.89	21.18	20.83	17.36	20.51
Maximum	20.31	23.50	22.20	21.05	21.32	22.08	17.75	20.66
Minimum	19.99	23.02	20.74	20.75	20.95	19.71	16.94	20.40
St. dev.	0.13	0.22	0.61	0.12	0.17	0.97	0.33	0.11

As shown in these tables, the range between the minimum and maximum temperature values (and consequently the variance) is not always reduced. However, it should be taken into consideration that these estimates are affected by behavioural factors (e.g. operating hours of the heating system) as well as the fact that the "after the replacement" period extends within the coronavirus outbreak and the corresponding lockdown measures. According to the evaluation survey, households claim that after the replacement of the thermostat, the temperature is more stable. Also, they mentioned that they estimated a reduction in the oil-diesel consumption of about 5%-10%, which conforms to the relevant literature.

Several households in which metering equipment was installed, stated that they are interested in implementing energy-saving interventions soon, following the specialised advice provided by the Energy Advisors. Specifically, five households stated that they may insulate the wall of their homes. Considering the existing energy consumption and assuming energy savings of 30%, the total annual energy savings are estimated at 46,760 kWh_{th}. Further, two households reported that they will replace old electrical appliances with new efficient ones. In particular, the first household is willing to replace an old refrigerator. This is estimated to produce annual electricity energy savings of 330 kWh_{el}, which correspond to about 64 Euros per year. The second household wishes to change an old electric stove. The total electricity energy annual savings are estimated at 865 kWh_{el} or 165 Euros.

As far as households without metering equipment are concerned, four of them mentioned that they are going to maintain their heating system. This is estimated to produce annual heating savings of 5% or about 3,850 kWh_{th} (in this case the current heating consumption is based on the stated heating costs, the calorific value of the fuel and an assumed efficiency ratio). The energy costs are expected to be reduced, on average, by 525 Euros.

All in all, the LL activities reduced the thermal energy consumption by about 77,350 kWh_{th} and the electricity consumption by 1,200 kWh_{el}. It should be also mentioned that these energy savings are expected to continue throughout the lockdown period because they come from improvements in the efficiency of the heating systems.

Improvement in the quality of life

In total, 70% of those who participated in the LL's activities said that the project was useful to them. More specifically, according to the responses given to the evaluation questionnaire (Figure 67), approximately 28.5% changed everyday habits, 22% were helped to gain a better understanding of electricity bills, 16.5% maintained their heating system (primarily oil-fired central heating systems), 13.5% claimed that they learned how to use their heating system more efficiently, 7.5% decided to implement insulation measures, 6% started using the Residential Night Tariff and 6% switched electricity provider. It is also interesting to note that the majority of households of both categories, either equipped with monitoring equipment or not, stated that STEP-IN was useful to them, with the percentage being higher for the households equipped with monitoring equipment (77% vs 60%, respectively).

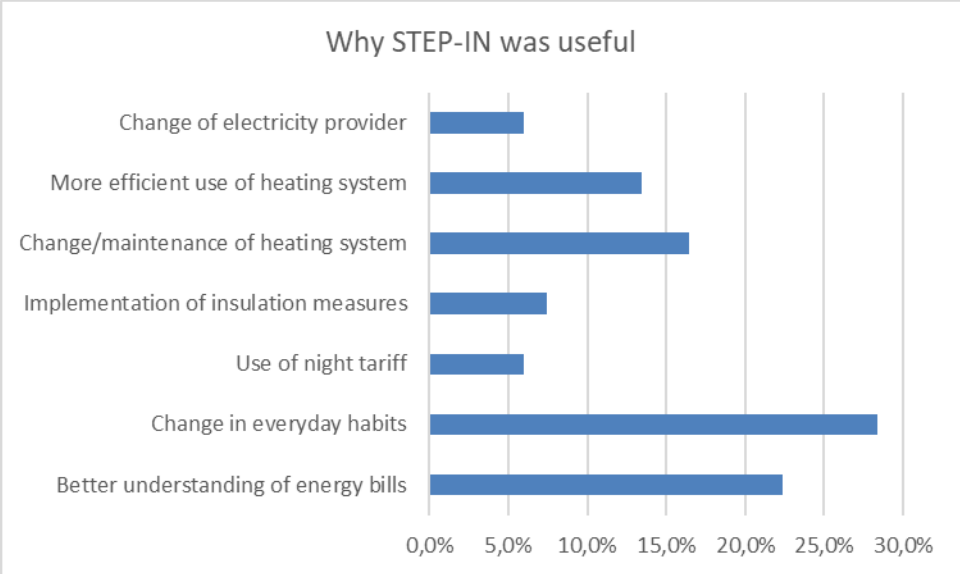

Figure 67: Why participating households find STEP-IN useful.

Focusing on the houses in which equipment was installed, approximately 67% of the owners said that they used the app to check their electricity consumption (27% of them said that they did so several times per week or at least once per day) and almost all the households (97%) said that they were reading the indications of the meteorological station, i.e. the indoor temperature and humidity (about 57% of them were reading the indications several times per week or at least once per day).

About 87% of these households said that the sensors helped them in taking energy efficiency decisions. As far as these decisions are concerned, the households mentioned maintenance of the heating system (17%), change of analogue thermostats (15%), the examination of insulation measures, change of light bulbs and better natural ventilation (at equal proportions, about 13.5% each), change of time-of-use of home appliances (8%), change of habits/reduction in consumption (8%), purchase of an energy-efficient appliance (4%), reduction of thermostat setting (4%), service of energy-consuming appliances (4%) and purchase of a dehumidifier (2%) (Figure 68).

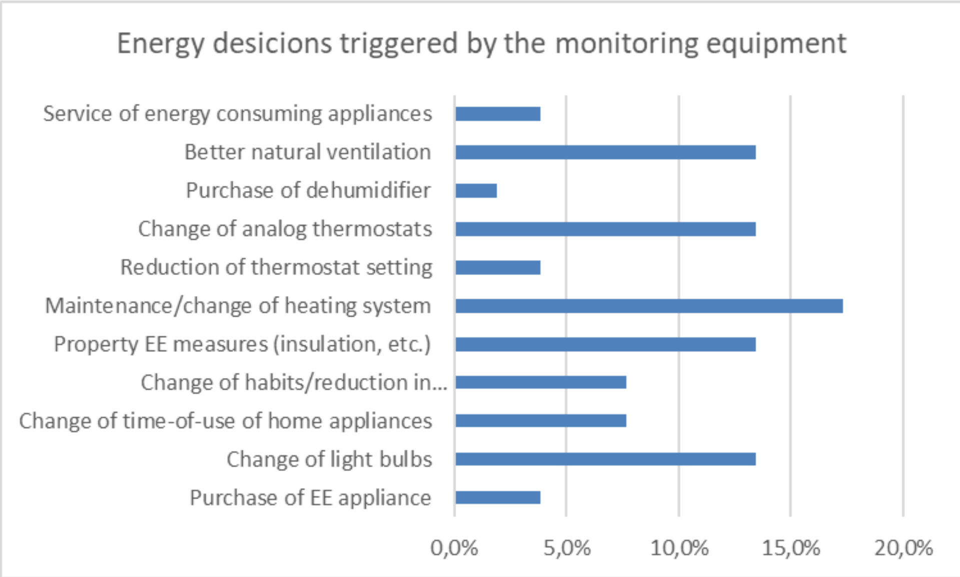

Figure 68: Energy decisions triggered by the monitoring equipment.

Around 54% of the total households said that they saw an improvement in their quality of life during the V2 operation of the LL. The majority (i.e. 58%) of those who responded affirmatively to this question mentioned a better level of thermal comfort at home, 29% mentioned that they noticed a reduction in their energy cost and 13% claimed that they faced less moisture/mould issues (Figure 69). It is also interesting to note that a significantly higher percentage of households equipped with monitoring equipment stated an improvement in their quality of life versus that of households without monitoring equipment (70% vs 30%).

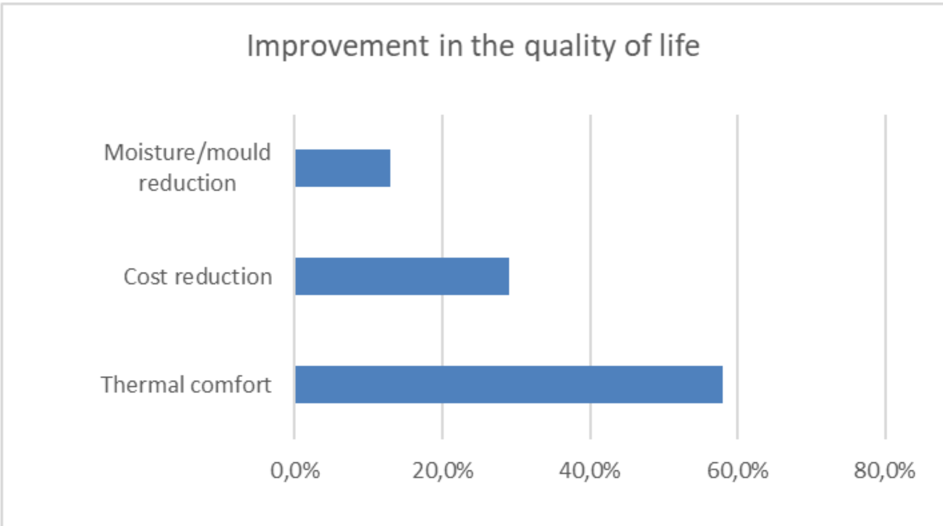

Figure 69: Improvements in the quality of life.

Finally, as arising by the evaluation stage, about 50% of the households stated that they are planning to apply energy efficiency actions in the near future. In more detail, 73% of households with monitoring equipment reported plans regarding energy efficiency measures, instead of 10% of households without equipment.

Besides improvements in the quality of life, STEP-IN actions bring also environmental benefits. Based on the energy mix of Metsovo and the CO_2 emission factors as defined by KENAK, it is calculated that 0.227 kg CO_2 are produced per kWh_{th} of thermal energy consumed in the area. Hence, the potential reduction in CO_2 emission can be up to 17.3 tn per year.

4.3 Results of Round V3

4.3.1 Initial assessment

Housing characteristics

The sample of the V3 round also includes 50 houses, 22% of which are detached houses, 4% are maisonettes and 74% are apartments. About 16% are less than 70 m^2, 20% are between 70-90 m^2, 36% are between 90-110 m^2 and the rest are over 110 m^2. Further, 64% have two or fewer bedrooms, 30% have three bedrooms and 6% have more than three bedrooms. As far as the age of the houses is concerned, 51% were built before 1980, 42% were built between 1980 and 2000 and just 7% were built after 2000.

As regards residences' energy efficiency, 44% have insulated external walls and 42% have insulated roof. Moreover, 48% have double glazing windows. Finally, 36% of houses have a good air insulation level, 46% have medium air insulation level and 18% present bad air insulation.

Heating system characteristics

About 82% of the V3 households stated that the total area of their house is heated. As regards the primary heating system, 72% use central heating systems. The choices of fuel used in central heating systems are shared between diesel oil (about 34%) and firewood (34%), with the rest of houses mainly using firewood stoves (20%). Moreover, 38% of households use secondary heating systems as well, with no special type prevailing though.

As regards automation/control systems in cases of central heating systems, 42% of households reported some automation system (30% use thermostats to control heating systems and 12% use thermostats along with installed thermostatic vanes in the radiators), while also 20% use digital thermostats.

Domestic hot water production system

Diesel oil boiler and wood boilers are mainly used for domestic hot water production, at the same rates (36% each), followed by electrical boilers (22%), pellets boilers (2%), LPG boilers (2%) and heat pump boilers (2%). Moreover, 1 out of 3 households uses an extra solar heater boiler for hot water production.

Electrical loads

Practically all households own electrical appliances with heavy power consumption, such as electric cooker (typical power: 2,000W – 6,000W), washing machine (typical power 500W – 750W), refrigerator (typical power 200W - 250W), etc.

As far as lighting is concerned, 50% of households use Light Emitting Diode (LED) bulbs, 12% use old type bulbs and the rest use Compact Fluorescent Lamps (CFLs).

Energy-related behavioural aspects

According to the answers provided at the beginning of the V3 operation of the LL, 2% of the households use the heating system 4 to 6 hours every day, 10% use it 6 to 8 hours every day and the rest (i.e. 88%) use it more than 8 hours every day.

Among those who have thermostats (either analogue or digital), 2.6% reported that they set the thermostat below 18°C, 23.7% said that the thermostat is set between 18°C and 20°C, and the rest (i.e. 73.7%) claimed that they set the thermostat to over 20°C.

As regards the stated indoor temperature, about 93% of the households stated an average temperature over 18°C during the winter period. Specifically, 41% stated an average temperature in their home more than 20°C, 52% an average temperature between 18°C and 20°C, and the rest an average temperature below 18°C (Figure 70).

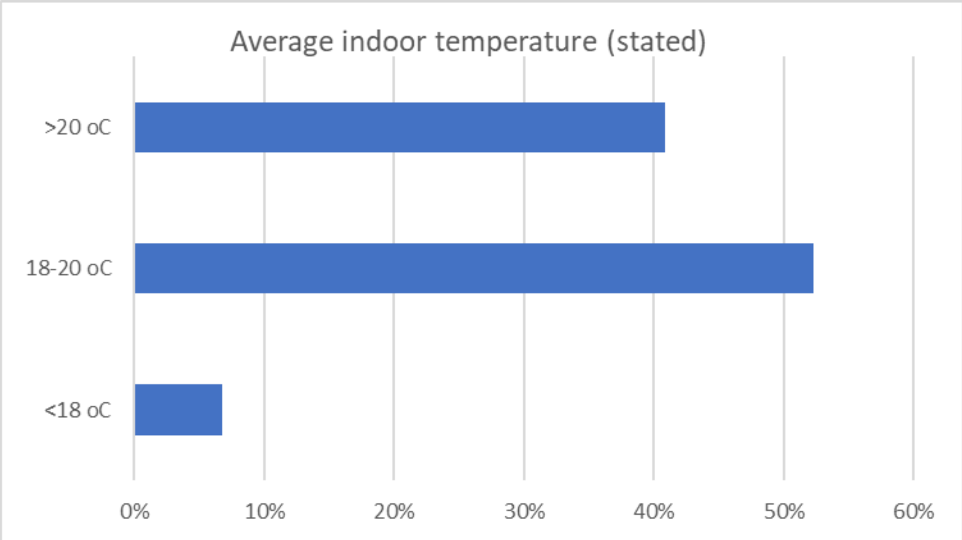

Figure 70: Average (stated) indoor temperature in the LL homes.

As expected, the average (stated) indoor temperature is correlated with the temperature set to the thermostat. The null hypothesis for the non-parametric Kruskal–Wallis test is rejected (χ^2=6.807, d.f.=2, p=0.033) (Figure 71).

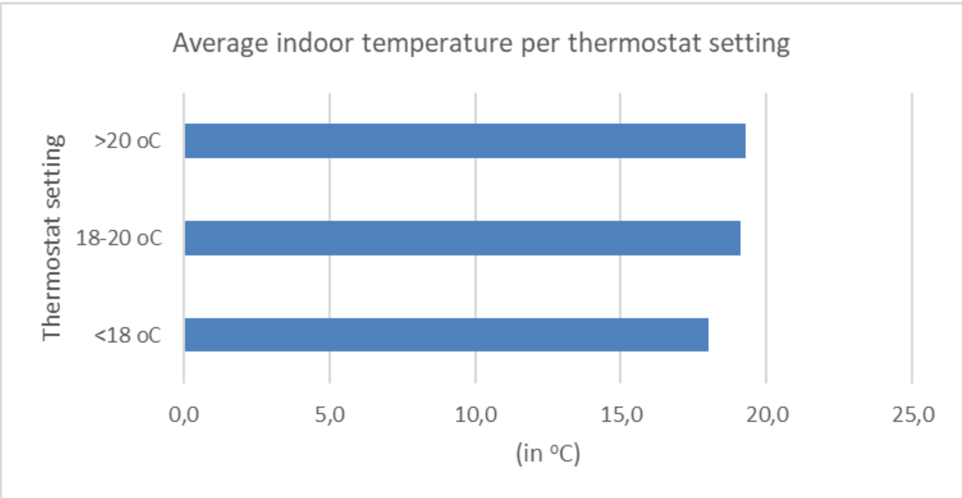

Figure 71: Average (stated) indoor temperature with respect to the thermostat setting.

By examining technical/building characteristics, it arises that the average indoor temperature is not correlated with the construction period of the house (Kruskal–Wallis: χ^2=4.268, d.f.=5, p=0.511) (Figure 72), the insulation of the external walls (Mann-Whitney U=229.5, p=0.800) (Figure 73), or the use of double glazing windows (Kruskal–Wallis: χ^2=1.214, d.f.=3, p=0.750) (Figure 74). As mentioned before, this is associated with the fact that heating is an "inelastic" need in Metsovo due to the cold climatic conditions.

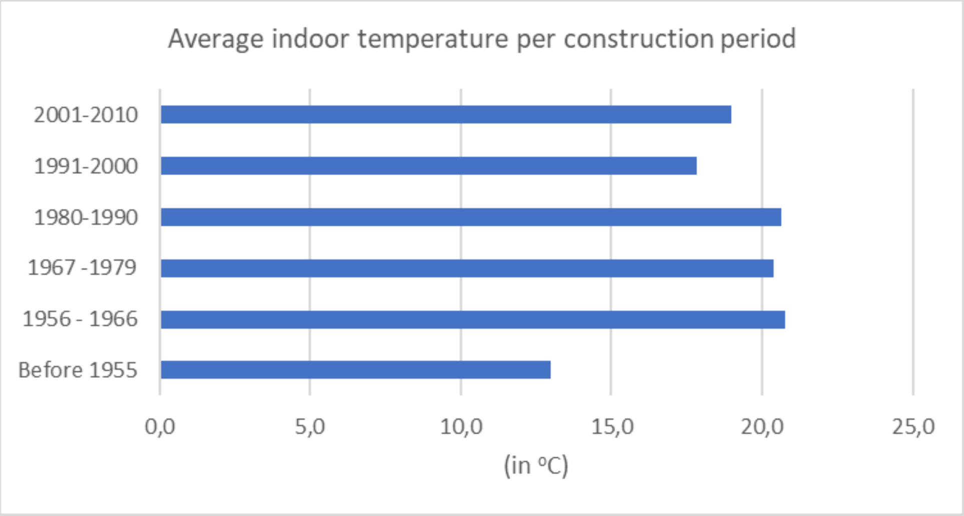

Figure 72: Average (stated) indoor temperature with respect to the construction period.

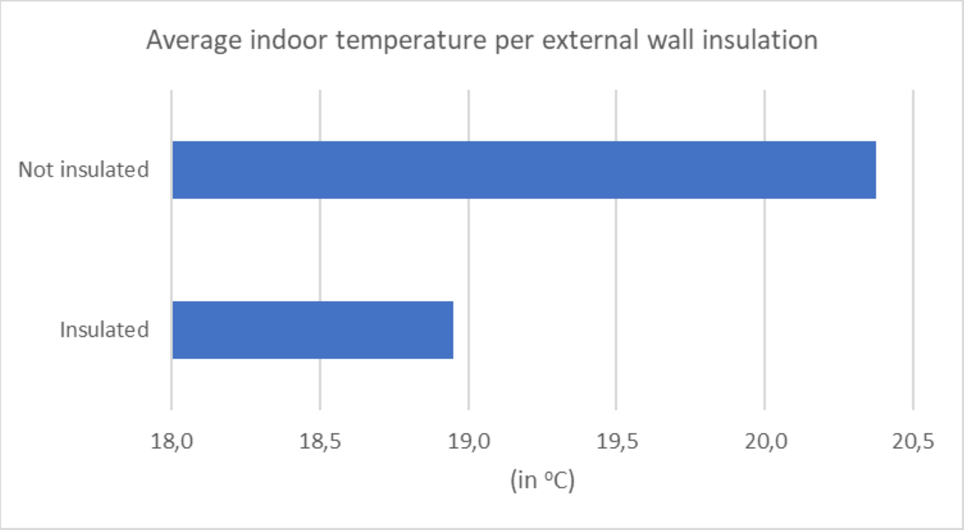

Figure 73: Average (stated) indoor temperature with respect to external wall insulation.

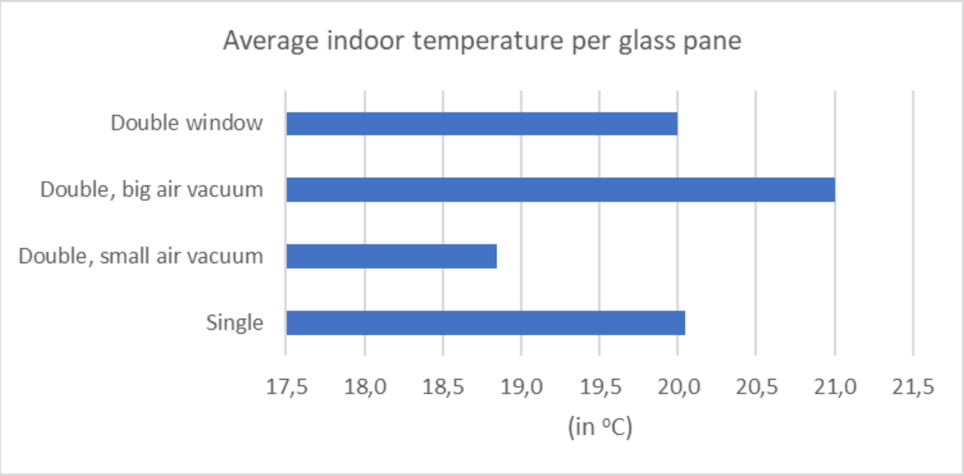

Figure 74: Average (stated) indoor temperature with respect to glass pane.

In the same direction, the average indoor temperature is not correlated with the size of the house (Kruskal–Wallis: $\chi^2=0.098$, d.f.=3, p=0.992) (Figure 75) or the average daily usage of the heating system

(Kruskal–Wallis: χ^2=0.508, d.f.=2, p=0.776) (Figure 76). Yet, it is mentioned that the operating hours of the heating system are also associated with the performance of the heating system and the housing characteristics.

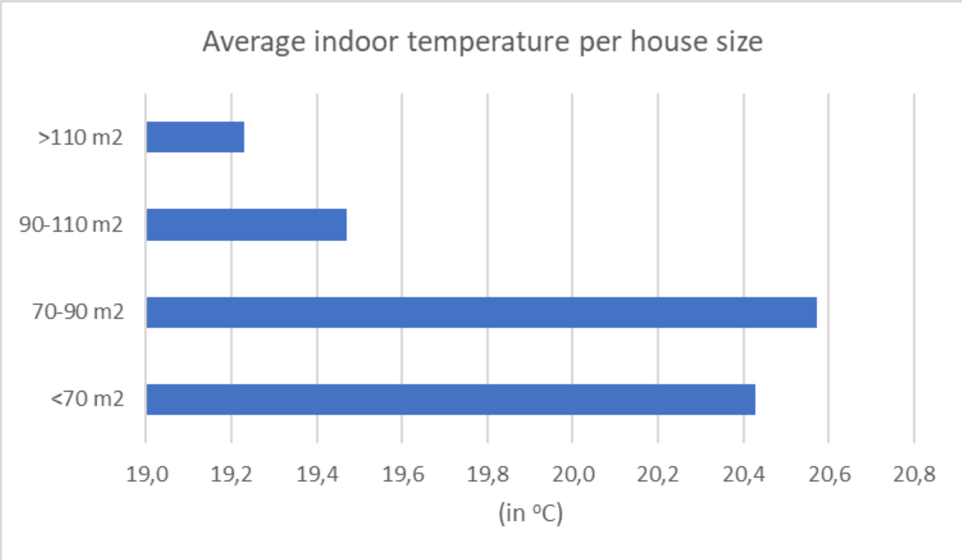

Figure 75: Average (stated) indoor temperature with respect to the size of the house.

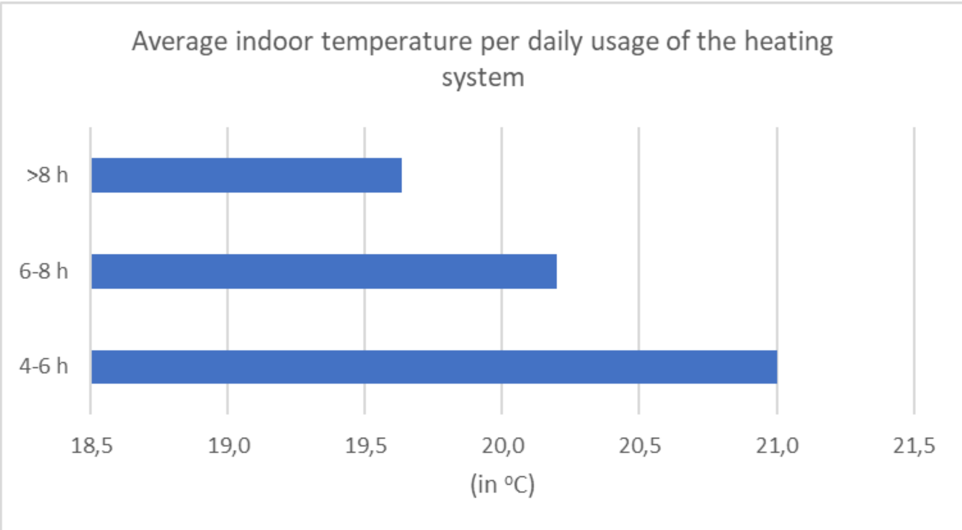

Figure 76: Average (stated) indoor temperature with respect to the use of the heating system (in hours).

The average indoor temperature seems to be correlated with the comfort level inside the house (Figure 77).

Finally, concerning the natural ventilation of the houses, 8% of the households reported that they don't open the windows at all during winter. The rest responded that they ventilate their homes mainly early in the morning (58%), before midday (18%) or at midday (24%). Considering that outdoor temperature is very low early in the morning, opening the windows at that time of the day allows the house to cool down quickly and, thus, requires more heating energy to restore the indoor temperature.

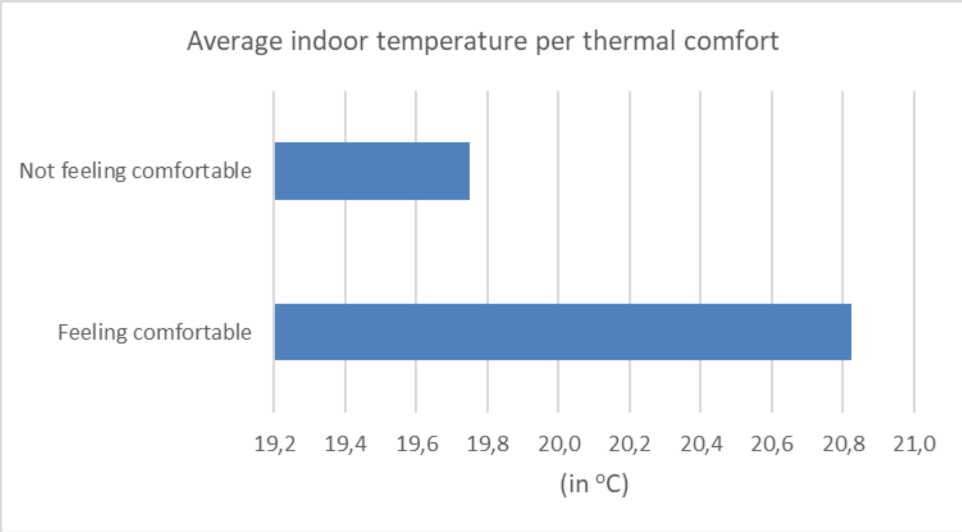

Figure 77: Average (stated) indoor temperature with respect to thermal comfort.

Energy spending on heating and electricity

On average, households spend 1,785 Euros per year on heating (std. dev: 718 Euros). More explicitly, about 15% spend less than 1,000 Euros per year, 59% spend between 1,000 and 2,000 Euros per year, 23.5% spend between 2,000 and 3,000 Euros per year, and the rest spend more than 3,000 Euros per year.

The (stated) average annual spending for heating seems to be affected by the building characteristics, i.e. the age of the house (Figure 78), the size of the house (Figure 79) and the insulation of external walls (Figure 80). Nevertheless, the difference in the means proves to be statistically significant only for the size of the house (Kruskal–Wallis: χ^2=8.375, d.f.=3, p=0.039).

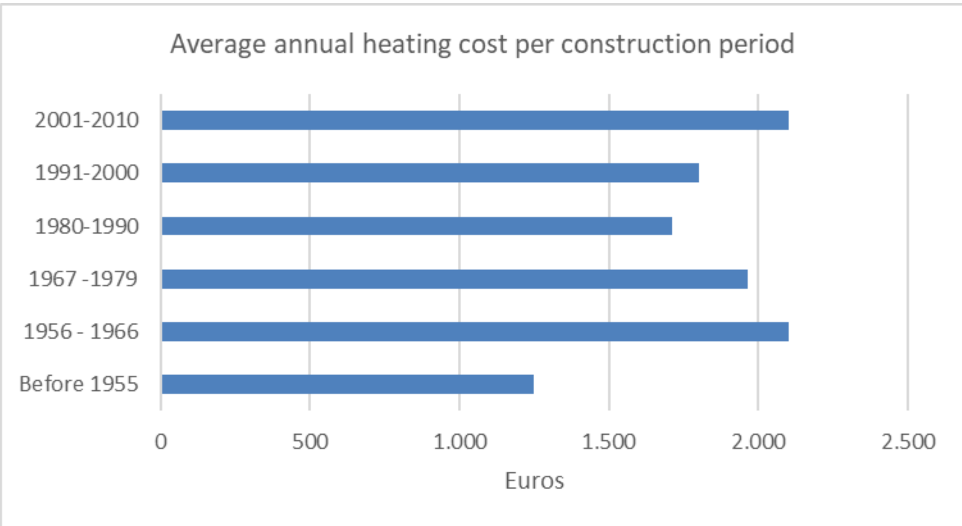

Figure 78: Average (stated) heating cost related to the construction period of the house.

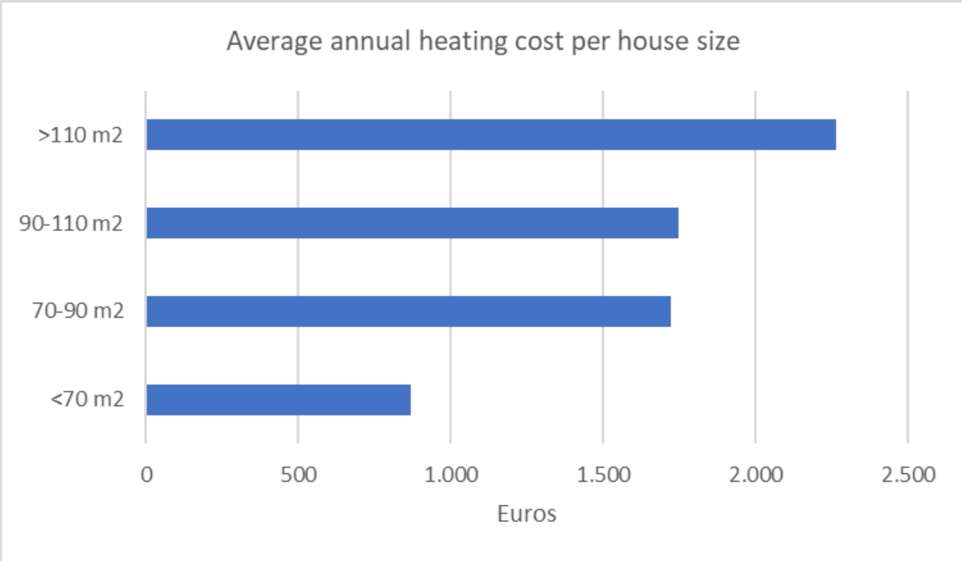

Figure 79: Average (stated) heating cost related to the size of the house.

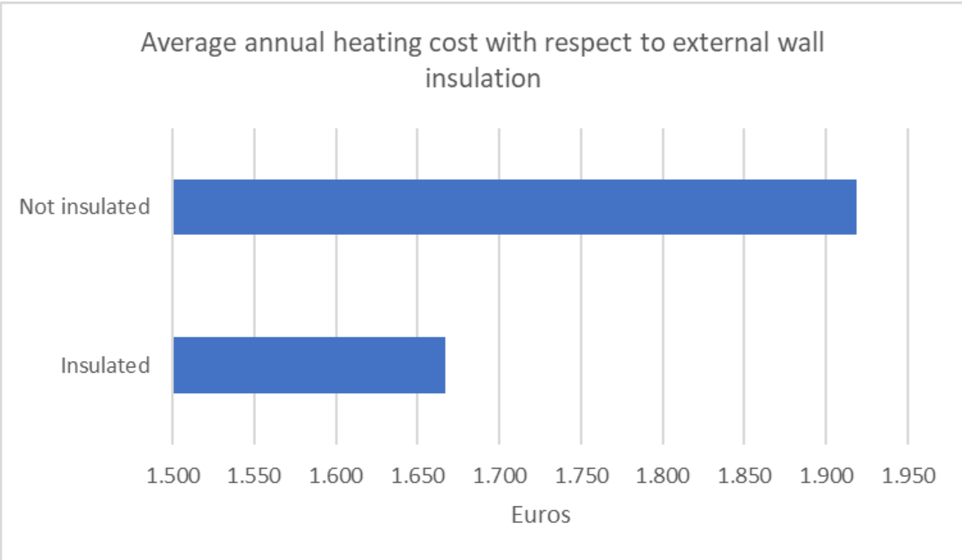

Figure 80: Average (stated) heating cost with respect to external wall insulation.

Tthe annual heating cost is affected by the thermostat setting (Figure 81), the type of the primary heating system (Figure 82) and the daily usage of the heating system (Figure 83). However, there is no statistically significant relationship detected between heating cost and the above variables.

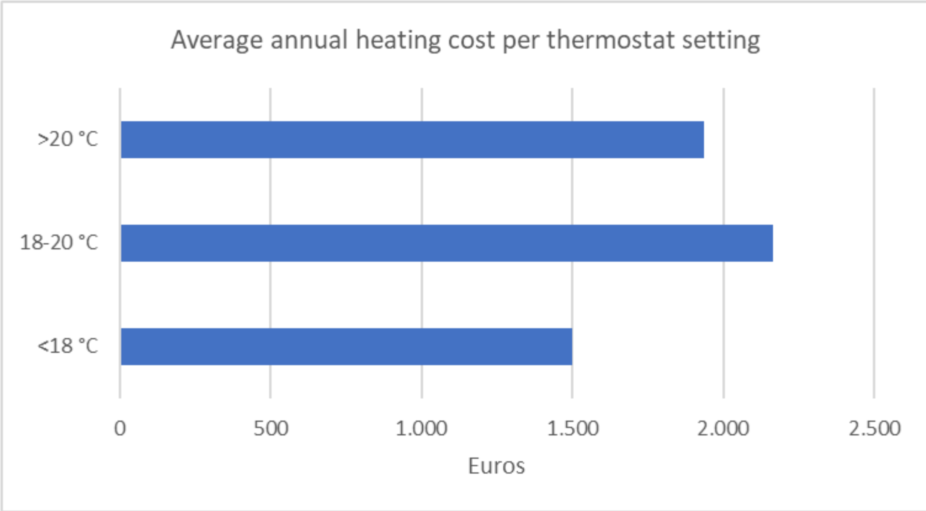

Figure 81: Average (stated) heating cost with respect to the thermostat setting.

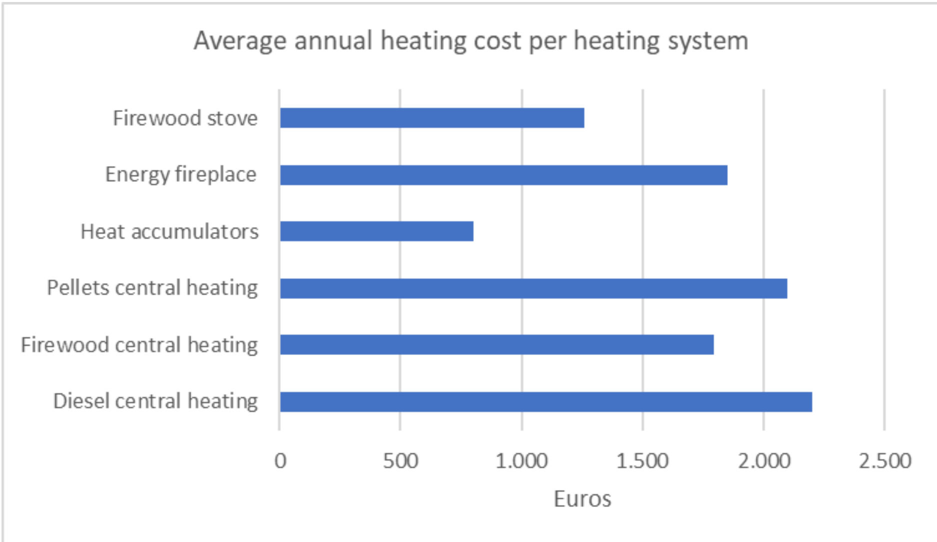

Figure 82: Average (stated) heating cost related to the type of heating system.

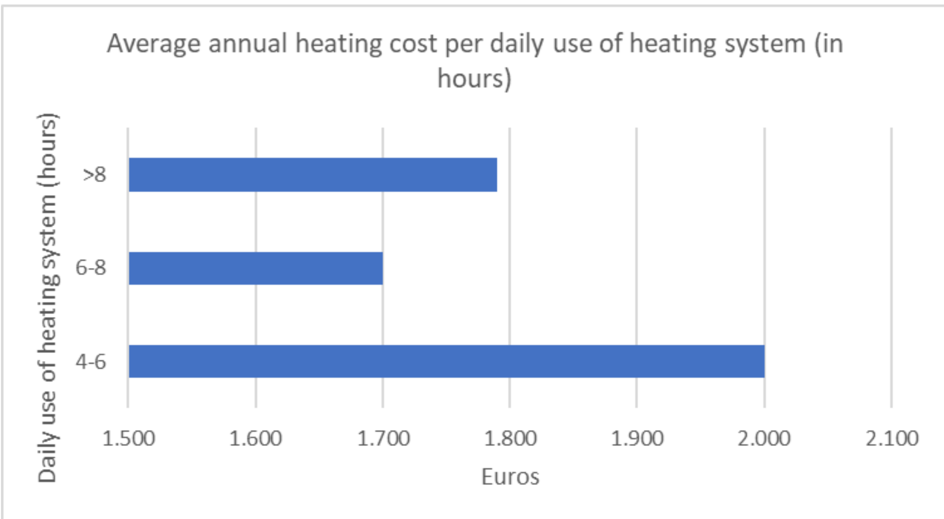

Figure 83: Average (stated) heating cost related to the use of the heating system.

The average (stated) annual electricity cost is around 800 Euros (std. dev: 469 Euros). More specifically, 44% of the households spend less than 600 Euros per year (i.e. 50 Euros per month), 44% spend between 600 and 900 Euros per year (i.e. 50-75 Euros per month) and about 12% spend higher amounts of money on electricity (over 900 Euros per year).

The annual electricity costs stated by the participants in the V3 operation of the LL vary to the size of the house and the size of the household, i.e. annual costs increase along with the increase in the house size and the household size (Figure 84 Figure 85). In both cases, the non-parametric Kruskal–Wallis test is rejected (χ^2=14.426, d.f.=3, p=0.002 and χ^2=7.589, d.f.=2, p=0.022, respectively), indicating statistically significant differences in the electricity cost between the groups of house and household sizes.

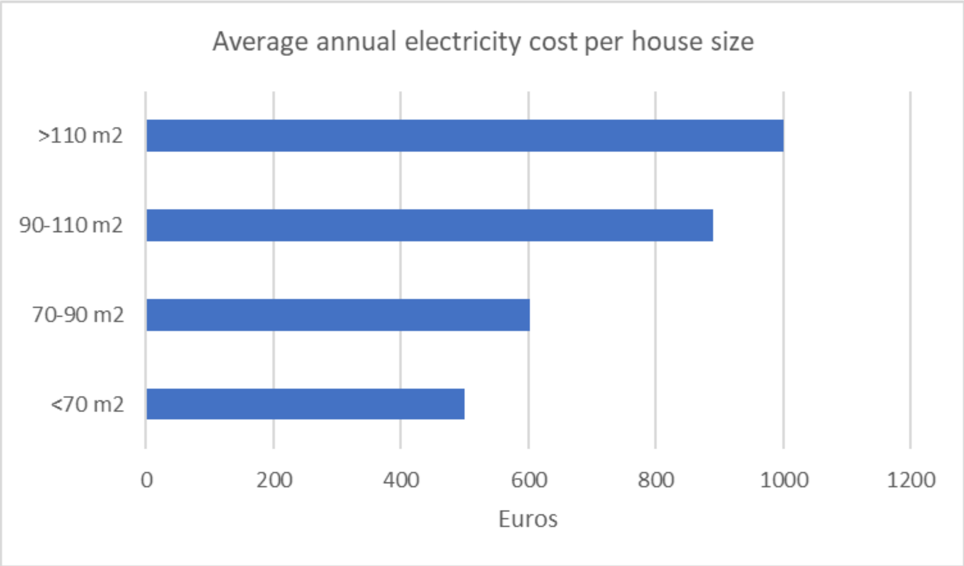

Figure 84: Average (stated) annual electricity cost related to house size.

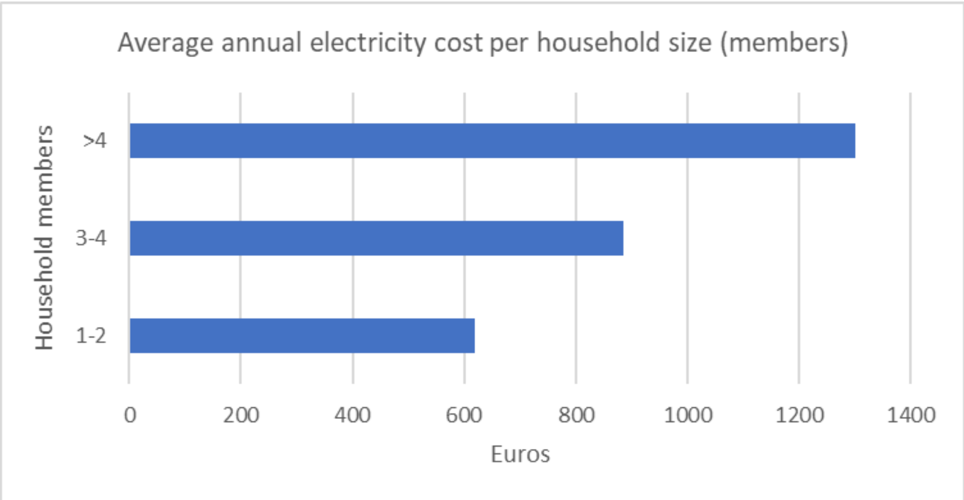

Figure 85: Average (stated) annual electricity cost related to the household size.

Also, the annual electricity costs vary to the presence of an electric hot water boiler and arrears on electricity bills (Figure 86 Figure 87). Yet, differences between the groups are not statistically significant, according to the Mann-Whitney test (U=108,0 p=0.860 and U=40.5, p=0.294, respectively).

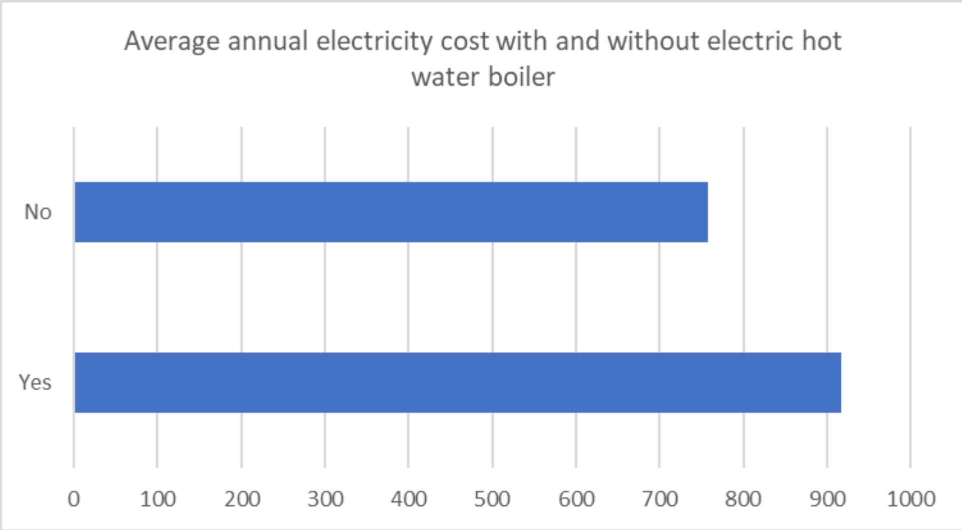

Figure 86: Average (stated) annual electricity cost with and without electric hot water boiler.

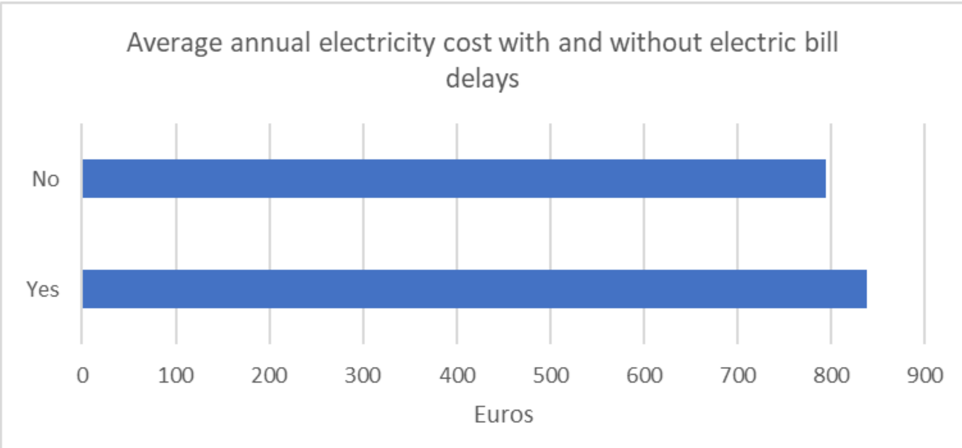

Figure 87: Average (stated) annual electricity cost with and without electric bill delays.

As regards special electricity tariffs, 4% of the households use the Residential Night Tariff and 6% use the Social Residential Tariff. Nevertheless, as illustrated in Figure 88, households that enjoy lower electricity prices using the Residential Night Tariff seem to spend significantly more on electricity, on an annual basis. Although the number of households using the night tariff is small, this finding is worrisome because it was noticed also in the previous LL rounds. This fact possibly indicates that that the main electricity consumption of the households is within the peak period and, thus, do not take advantage of the lower price provided within the off-peak period.

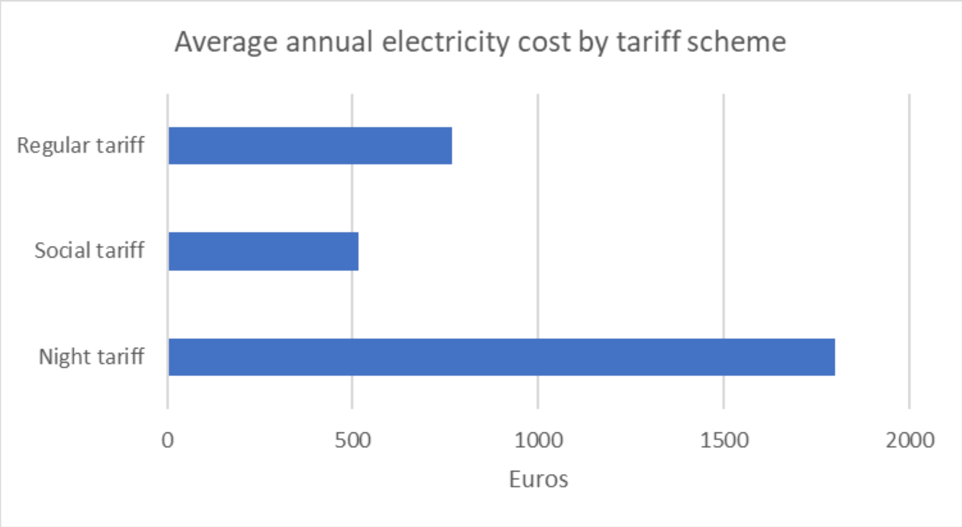

Figure 88: Average (stated) annual electricity cost by tariff scheme.

Energy vulnerability qualitative indicators

Again, the three qualitative indicators (i.e. inability to keep optimal house temperature, problems with moisture/mould and arrears in energy bills) were considered to measure energy vulnerability. As also in the V1 and V2 operation of the LL, cut back on essentials (e.g. food, lighting, etc.) was not taken into consideration, as the results of the baseline survey showed that it's not a major issue in the area of the LL. As shown in Figure 89, the most important issue is, once more, the presence of moisture/mould in the houses (22%), followed by thermal discomfort, i.e. the home is not warm enough (10%) and arrears in energy bills (10%).

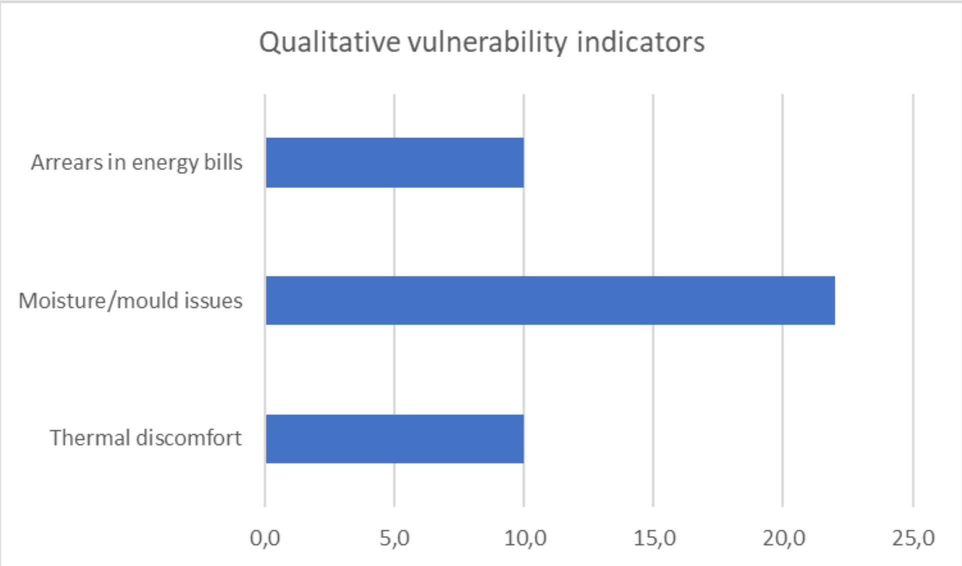

Figure 89: Percentage of energy-vulnerable households.

Using the three above indicators, an overall vulnerability index was constructed ranging between 0 (i.e. none of the above-mentioned issues is present, therefore the vulnerability risk is negligible) and 3 (i.e. all the problems described by the indicators are present, thus the vulnerability risk is very high). As presented in Figure 90, 24% face one of the above-mentioned problems and about 8% face two or more of them.

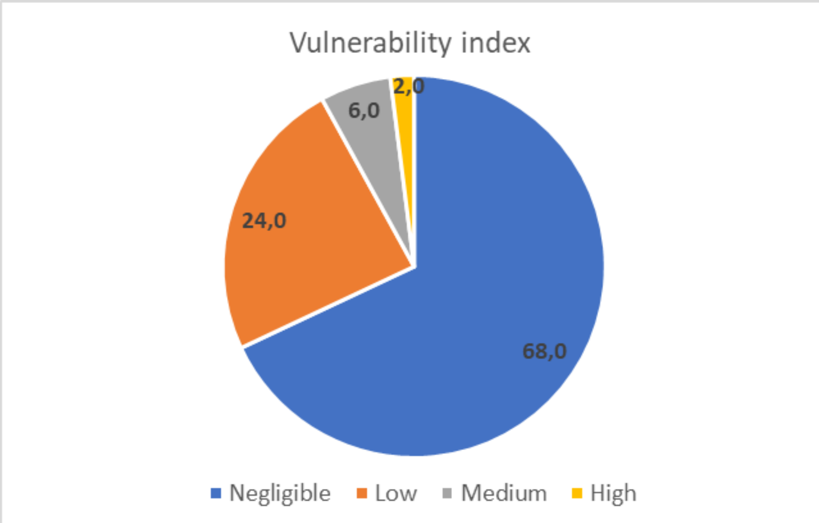

Figure 90: Overall vulnerability index.

As illustrated in Figure 91, those who spend more on heating face relatively lower vulnerability risk, mainly because they face lower problems with moisture and mould, with no statistical differences arising though (Kruskal–Wallis: χ^2=2.113, d.f.=3, p=0.549). Electricity cost does not present statistically significant differences between vulnerability classes (Kruskal–Wallis: χ^2=3.193, d.f.=3, p=0.363), i.e. those in low risk and those in high risk spend similar amounts of money on electricity, an outcome that confirms the complex nature of subjective indicators when combining them with objective data/indicators in the energy poverty problem.

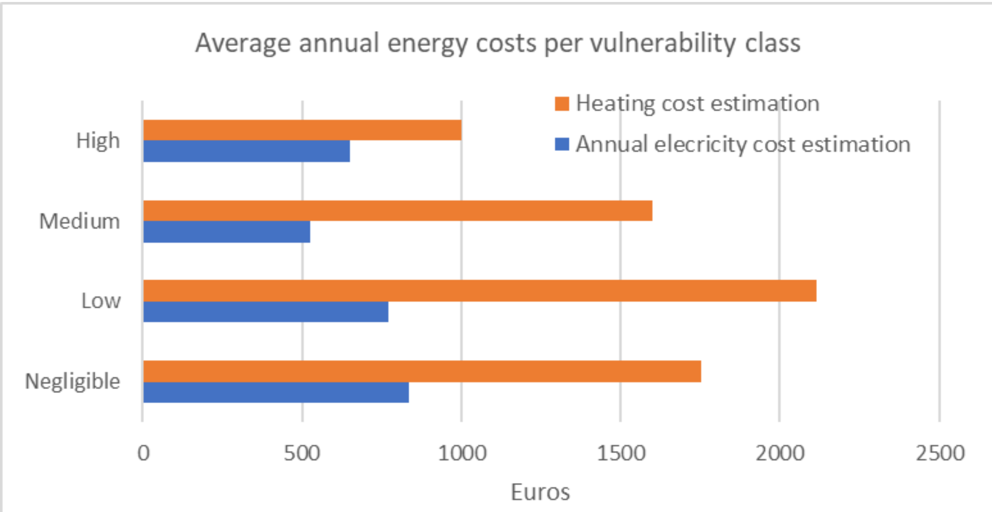

Figure 91: Annual energy costs in relation to vulnerability class.

4.3.2 Evaluation assessment

Acceptability of proposed energy interventions

As described in the methodological approach (Section 3), the V3 operation of the LL didn't include monitoring equipment and analysis, because the monitoring equipment stayed at the V2 round households to measure the impact of the coronavirus-related restrictive measures. Nevertheless, during the V3 round, the participating households were provided with a bunch of energy intervention measures based on the information received by the initial survey. The proposed measures included, similarly to the two previous rounds, information on roughly estimated investment costs and annual savings.

At the evaluation survey, the households were asked, first, to rank the proposed energy intervention measures in terms of priority. As presented in Figure 92, the most acceptable measure is the insulation of the external walls of the house, followed by a change of windows frames and roof insulation. Low-cost measures, such as the installation of digital thermostats and maintenance of the heating system were also reported at a lower degree, however. The discrepancy in the figures between the V3 round and the two previous rounds concerning the low-cost measures may be associated with the absence of the monitoring equipment. It is reminded that in the V2 round about 87% of the households with equipment installed in their houses said that the sensors helped them in taking energy efficiency decisions.

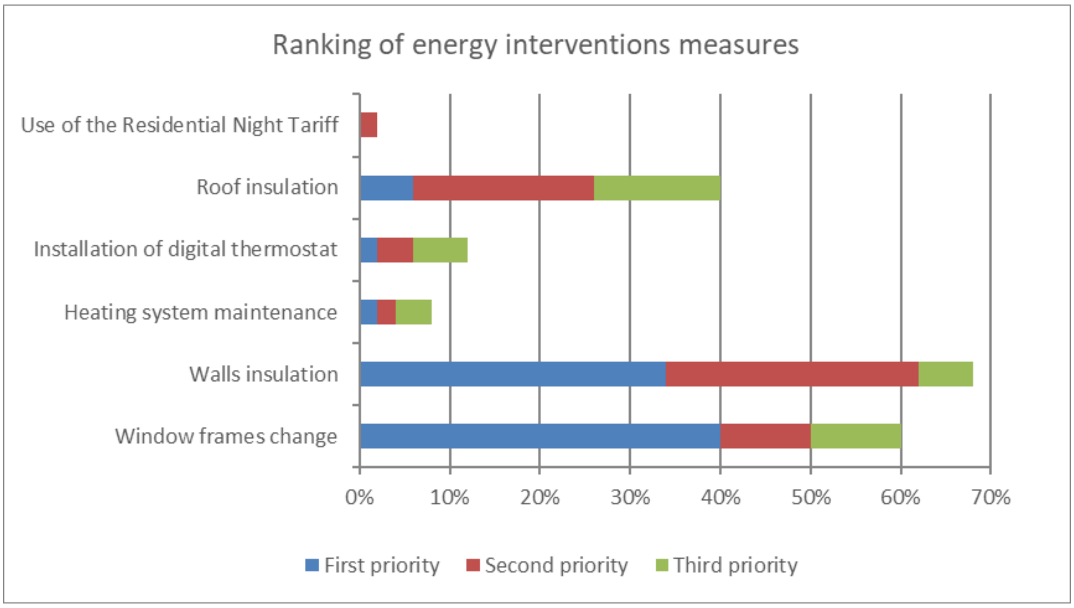

Figure 92: Ranking of proposed energy intervention measures.

The households were then asked to mention the most important barriers towards implementing the proposed energy efficiency investments. About half of them reported financial difficulties and the high implementation cost of the suggested measures. This was also apparent in a series of questions asked about the support of such investments by the State. About 94% of the participants said that they didn't apply in the past for the "Energy Saving at Home" – ESH programme. Yet, 36% are considering doing so if the programme opens again for applications. Further, about 90% would prefer to receive a subsidy, instead of tax relief, to be able to invest in measures with high initial costs.

Reduction in energy consumption and spending

During the V3 round of the LL, six households stated that they are interested in implementing energy-saving interventions in the near future. Five households mentioned that they are planning to replace old window frames and one is planning to insulate the external walls. Taking into account the characteristics of the houses and their heating expenses, the following energy and cost savings are estimated:

- Thermal energy savings: 26,782 kWh_{th}
- Reduction in heating costs: 2,340 Euros per year.

Moreover, six more households declared that they maintained their oil-fired central heating system. The annual thermal energy savings are calculated to 4,256 $kWht_h$ (or 468 Euros). Two households stated that they replaced their old analogue thermostats with digital ones. Correspondingly, the estimated reduction in energy consumption and the savings in heating cost are estimated at 6,000 kWh_{th} and

560 Euros, respectively. Ten more households placed air insulation adhesive foam tape (aero stop) in their old window frames. The total thermal energy saving has been calculated to 6,678 kWh_{th} and 735 Euros (assuming 2% savings).

Concerning the potential savings, nine households stated that are willing to change their old thermostats. The total potential thermal energy saving has been calculated to 13,980 kWh_{th} (corresponding to 1537 Euros). Two more households are willing to place air insulation adhesive foam tape, saving 1,352 kWh_{th} of thermal energy (or 148 Euros).

So far, considering the households who have already implemented energy-saving interventions and those who are willing to do so soon, the LL activities resulted in a reduction of the thermal energy consumption by 59,050 kWh_{th} or 6,375 Euros. It should be also mentioned that these energy savings are expected to continue throughout the lockdown period because they come from improvements in the efficiency of the heating systems.

Improvement in the quality of life

In total, 78% of those who participated in the LL's activities said that the project was useful to them. More specifically, according to the responses given to the evaluation questionnaire (Figure 93), approximately 47% changed everyday habits, 23% were helped to gain a better understanding of electricity bills, 19% learned how to use their heating system more efficiently and 9% maintained their heating system (primarily oil-fired central heating systems).

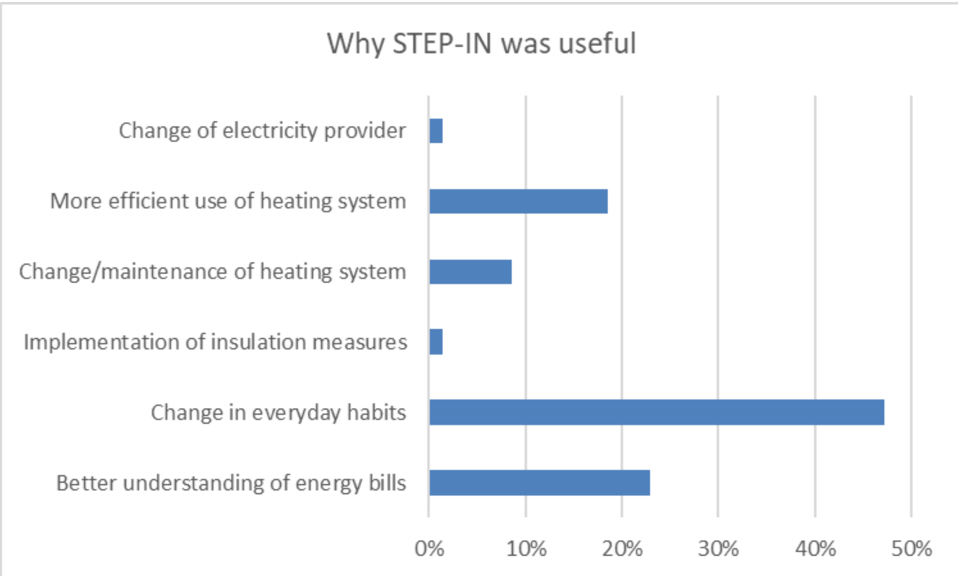

Figure 93: Why participating households find STEP-IN useful.

Almost half of the households (48%) reported that they have already implemented some of the suggested advice from the Energy Advisors, while 78% stated that they are planning to do so shortly. Regarding energy efficiency measures, about 15% of the households stated that they are planning to apply energy efficiency actions in the near future (almost all plans concern the change of windows frames).

Overall, as arising by the evaluation stage, around 32% of the households said that they saw an improvement in the quality of their lives during the V3 operation of the LL. Half of these households mentioned a better lever of thermal comfort at home and the other half claimed that they faced less moisture/mould issues. The percentage of the households with improved quality of life coincides with the results of the two previous rounds for those households without monitoring equipment.

Besides improvements in the quality of life, STEP-IN actions bring also environmental benefits. Considering the energy mix of Metsovo and the CO_2 emission factors as defined by KENAK, it is calculated that 0.227 kg CO_2 are produced per kWh_{th} of thermal energy consumed in the area. Hence, for the V3 round, houses the potential reduction in CO_2 emission can be up to 13.4 tn per year.

4.4 Dissemination Activities

During the V2 and V3 rounds of the LL, several dissemination actions took place beyond the local scale, as a means to create knowledge for sustaining and scaling up these benefits at both national and European levels. More specifically:

- The project and its objectives and results as well as its activities appeared in a widely online energy portal (energypress.gr) in Greece
  - https://energypress.gr/news/protoporiako-ereynitiko-ergo-gia-tin-katapolemisi-tis-energeiakis-ftoheias-apo-rae-kai-emp
  - https://energypress.gr/news/step-exypnes-symvoyles-gia-tin-exoikonomisi-energeias
  - https://energypress.gr/news/stis-19-noemvrioy-1o-diadiktyako-synedrio-gia-tin-energeiaki-ftoheia-apo-rae-kai-emp
  - https://energypress.gr/news/ena-sta-tria-noikokyria-thermainetai-me-xyla-pellets-kai-koyvertes-ti-deihnoyn-ta-apotelesmata
  - https://energypress.gr/news/rae-emp-treis-vasikes-prokliseis-gia-tin-antimetopisi-tis-energeiakis-ftoheias-stin-ellada
- Three scientific papers were published in international peer-reviewed scientific journals:
  - L. Papada, A. Balaskas, N. Katsoulakos D. Kaliampakos and D. Damigos (2021). Fighting energy poverty using user-driven approaches in mountainous Greece: Lessons learnt from a Living Lab. Energies, 14(6), 1525. https://doi.org/10.3390/en14061525
  - D. Damigos, C. Kaliampakou, A. Balaskas and L. Papada (2021). Does energy poverty affect energy efficiency investment decisions? First evidence from a stated choice experiment. Energies,14(6), 1698; https://doi.org/10.3390/en14061698
  - A. Balaskas, L. Papada, N. Katsoulakos, D. Damigos and D. Kaliampakos (2021). Energy poverty in the mountainous town of Metsovo, Greece. Journal of Mountain Science (accepted after revisions – currently under second review)
- One presentation was given at the Conference of the "Twinning Project for Service Quality and Smart Metering in Georgia":
  - L. Papada (2019). Tackling energy poverty in Greece: The participation of RAE in the research European project "STEP-IN", Twinning Project "Development of incentive-based regulation for service quality and regulatory strategy to support roll-out of smart metering", Tbilisi, Georgia, November 27-28, 2019.
- One presentation was made in the 5th HAEE Energy Transition Symposium "GLOBAL AND LOCAL PERSPECTIVES":
  - N. Katsoulakos, L. Papada, A. Balaskas, I. Doulos, D. Kaliampakos and D. Damigos (2020). Supporting households against energy poverty using the Living Lab approach: First evidence from the STEP-IN project, 5th HAEE Energy Transition Symposium "GLOBAL AND LOCAL PERSPECTIVES", September 30 –October 2, 2020 (online event).
- Seven presentations were made at the 1st National Energy Poverty Web Conference:
  - A. Balaskas and M. Kofinas (2020). The energy profile of mountainous areas, 1st National Energy Poverty Web Conference, November 19, 2020.
  - D. Damigos and A. Balaskas (2020). The impact of the coronavirus-related restriction on households' energy consumption, 1st National Energy Poverty Web Conference, November 19, 2020.
  - D. Kaliampakos and L. Papada (2020). Energy poverty in Greece: An obscure and erosive form of poverty, 1st National Energy Poverty Web Conference, November 19, 2020.

   - C. Kaliampakou and D. Damigos (2020). The role of 'irrational' behaviour in energy poverty, 1st National Energy Poverty Web Conference, November 19, 2020.
   - N. Katsouakos and D. Damigos (2020). Experiences and lessons learnt from an attempt to address energy poverty through living labs, 1st National Energy Poverty Web Conference, November 19, 2020.
   - G. Panagiotopoulos and N. Katsoulakos (2020). The use of IT tools in tackling energy poverty, 1st National Energy Poverty Web Conference, November 19, 2020.
   - L. Papada and A. Balaskas (2020). The profile of energy poverty in mountainous areas: The case of Metsovo, 1st National Energy Poverty Web Conference, November 19, 2020.
- An online app was developed that helps users to calculate the cost required to meet their heat and electricity energy needs. Further, users have the ability, by changing the parameters (e.g. type of windows, the existence of thermal insulation, type of fuel, etc.) to see the possibilities of reducing their energy expenses.
- Six animated videos were created for social media to provide advice to local and national households. Each of these videos focused on a different subject, namely correct set-up of thermostats, benefits of regular maintenance of heating systems, advantages of digital thermostats, efficient use of fireplaces, advices about saving energy in the kitchen and during laundry.
- A new energy advice booklet targeting mountain households was prepared. The leaflet includes information and advice on energy efficiency and consumption, refurbishment schemes, subsidy programmes, energy labelling schemes, etc. The booklet was distributed by RAE to all 13 Regional and 331 Municipal Authorities, the Ministry of Environment and Energy and the "Center for Renewable Energy Sources and Saving – CRES". A quick Google search for the title of the booklet returns over 700 results. Moreover, the booklet will be sent to all Metsovo households by the Municipality of Metsovo (this was delayed due to the COVID-19 pandemic, but the booklet is available on the Municipality's website).
- An online consultation round table entitled "Energy Poverty in Greece: Quantification, Monitoring and Alleviation Policies" was organised on June 18, 2020, with 20 Greek experts in the field of energy poverty from universities, research centres, governmental authorities and consumer unions. The round table was conducted for discussing the Greek National Strategy against Energy Poverty (NSEP), which is part of the National Energy Efficiency Action Plan (NEEAP) and of the National Energy & Climate Plan (NECP).
- A summer school (the second STEP-IN Summer School) was from July 6 to 7, 2020, with the support of NTUA and RAE as an online event with 32 participants. The main objective was to provide those working in the fields of energy efficiency, building renovation, energy policy, and land-use planning with information about the energy poverty challenges based on the experiences of the mountainous LL.
- A national conference co-organised by the NTUA and RAE as Web Conference on November 19, 2020. The conference was a great success, especially considering the COVID-19 situation, with over 220 participants. Also, a quick Google search returns over 10,000 results for the title of the conference. Further, around ten interviews at radio stations and the TV about the energy poverty conference were given.

As far as social media are concerned, the Greek Facebook page of the mountainous LL had 495 unique users (i.e. Daily Page Engaged Users), while it attracted 2,392 unique people (i.e. "Daily Total Reach". Further, the number of times any content from the page entered a person's screen ("Daily Total Impressions) was 3,471.

4.5 Lessons learned from the three LL rounds

The LL activities during the three rounds run, in general, as planned. Nevertheless, as described in Section 3.2.10 certain modifications were made in the last round because of the COVID-19 outbreak.

First, the coronavirus pandemic and the associated measures adopted to control the COVID-19 spread resulted in the suspension of LL activities from March 18 until May 1st, 2020. Some face-to-face LL activities started again at the beginning of June 2020. Yet, all the activities of the V3 round were conducted remotely due to the continuation of social distancing measures. In this direction, certain actions were taken to support those households participating in mountainous LL activities, such as the following:

- The last energy café was organised as a webinar via an online meeting platform.
- The 50 households recruited in the last round were provided with information and feedback on energy-related issues remotely, via phone and/or web-based video conferencing. Also, initial and evaluation questionnaires were collected remotely.
- A web app was developed to support consumers in estimating their energy expenditures. In addition, six short videos were created with energy advice that were communicated via social media.
- An energy advice booklet was prepared, available in paper and electronic format, with information and advice on energy efficiency and consumption, refurbishment schemes, subsidy programmes, energy labelling schemes, etc.
- The personal interviews for the second social survey (app. 300 households) were completed remotely via web-based video conferencing.

This unforeseeable situation, as mentioned, created new scientific, methodological, and ethical challenges for the LL and the project, in general. On the other hand, it offered an opportunity to study the impact of the pandemic outbreak on energy consumption and the socio-economic status of the households and, eventually, on energy vulnerability. Further, it allowed testing the effectiveness of the remote provision of advice and assistance (e.g. via energy café webinars, online information campaigns, personal communication via phone, email or online chat, etc.). The impact of the COVID-19 pandemic on households' energy vulnerability is discussed in Section 6. This section focuses primarily on the methodological findings concerning the operation of the LL.

As regards the general context of the LL, the following remarks can be made:

- Even when there is a great interest in the local community on how to reduce energy consumption and spending, or how to improve the thermal comfort in their homes, it is not easy to engage households committed to the activities of the LL. Paying long and often visits for collecting the energy data or assigning tasks, such as keeping a complete energy diary for the use of heating and electrical appliances daily, is not possible without causing annoyance (or even withdrawal). Thus, a "compromise" between what is planned and what is acceptable from the local community needs to be found.
- Towards gaining the local community's trust and support, it is more than useful to involve local people in the LL activities. For instance, people who seemed reluctant to let the Energy Advisors install the monitoring equipment to the electric switchboard were appeased when local electricians were hired and paid visits together with the Energy Advisors.
- Discussing the benefits of the project is simply not enough. It is more than important to undertake promoting actions to motivate the local community. For example, in the case of the mountainous LL servicing for free oil-fired heating systems was strongly discussed among the members of the local community and promoted a sense of ownership of the LL actions.
- Relying on questionnaires for collecting information about the estimated heating and electricity consumption and spending is inevitable. Yet, in some cases, the estimated and measured figures do not fully coincide. This stands particularly for the electricity costs, as the electricity bills in Greece include charges for local taxes and public TV licence.
- People seem to be more convinced to get involved in energy conservation and to adopt the advices provided by the Energy Advisors when presented with actual measurements, as discussed later on. For example, less than 30% of those who did not have monitoring equipment installed said that they noticed an improvement in their quality of life, whereas around 60% of those who had monitoring equipment installed said that they noticed an improvement in their quality of life. Further, 80% of the participants who had monitoring

equipment installed said that the installation of electricity consumption meters motivated them to check regularly their electricity consumption and almost all of the participants with temperature and humidity monitoring equipment said that they were helped in taking energy efficiency decisions, i.e. replacement of thermostat, purchase of a dehumidifier, etc.

- Using monitoring equipment is not only helpful towards convincing people to implement energy-saving measures (either technological or behavioural) but also useful towards identifying problems in the operation of malfunctioned appliances. In one case, in the mountainous LL, a defective appliance, namely a refrigerator, was found and replaced, saving hundreds of Euros per year. Moreover, temperature and humidity sensors revealed significant differences within certain residences that use non-central heating systems or are unable to heat the total house area.
- The Information Centre did not seem to work well, at least at the mountainous LL. This suggests that it is not always easy to inform energy vulnerable households because they need to be proactive to change their status quo. This problem is not unprecedented. As referred to in DellaValle, (2019), in Malta, there was a scheme to support energy vulnerable households. Every year, €500,000 vouchers were not claimed. Hence, the government changed the scheme without changing the eligibility criteria. More specifically, households identified as vulnerable categories were automatically enrolled in the voucher program and receive a credit to their bill through their service provider. Also, the Italian Regulatory Authority for Energy, Networks and Environment has advanced a proposal to automatically enrol energy vulnerable households automatically in subsidy programs. In the same direction, during the first energy café which was held at the premises of NTUA, the participants said that moving closer to the Metsovo's centre could attract more people. Thus, it was decided to move the next energy cafés to a more familiar place, either to the Municipality Hall or a local café. Indeed, the second energy café was held at the Municipality Hall. Unfortunately, the third energy café was organised as an online event to respect the social distancing measures in force.
- Finally, it seems that the remote operation of the LL cannot fully replace face-to-face LL activities. For instance, remote advice and assistance on energy issues are feasible on a one-to-one basis. Yet, participatory actions, such as energy cafés, at least in the mountainous LL didn't work well. As mentioned in Section 3.2.2, the participants' involvement in the online event was not the same as in the face-to-face events. This was probably due to the fact that the advisors are 'faceless' in the online event and, thus, people feel uncomfortable in asking questions and initiating a conversation. Moreover, it is possible that some energy vulnerable households were not unable to attend the online event due to lack of internet access. The same remark stands for the remote assistance and advice, i.e. it may not reach the most vulnerable citizens who may not have internet access (or even telephone access in many cases). This is also reflected in the achieved energy savings in the three rounds. More specifically, the energy savings in the V1, V2 and V3 rounds were 9.2%, 5.4% and 3.9% of the total energy consumed by the households.

As far as the mountainous LL is concerned, the main conclusions drawn are the following:

- The main problem faced by the local people in the mountainous LL is the excess cost of heating. Thus, they usually tend to underestimate the burden of electricity costs. The LL measurements, however, showed that important reductions in energy bills may be gained from reducing electricity consumption (e.g. when replacing old, energy-consuming, appliances). Thus, further attention needs to be paid to electricity conservation measures. In the same direction, a solution needs to be found regarding the use of solar water heaters in the settlement. As has been mentioned before, the use of solar panels is not allowed today. Yet, the estimates showed that households using electric water heaters spend on electricity around 350-400 Euros per year more than those without electric boilers.
- Thermal insulation is important in Metsovo because the area experiences a high number of heating degree-days. Based on the stated heating expenses and the engineering model calculations, the presence of thermal insulation leads to 30% lower heating expenses, on average.

- The LL activities revealed that many diesel-fired heating systems had a low-efficiency ratio (even lower than 84% compared to 90% which is the proper rate). The maintenance of the oil burner led to an average increase in the efficiency ratio of 4% (even up to 7%). Regular maintenance of the heating system is a low-cost and effective measure for reducing heating expenses.
- In some cases, zero-cost behavioural changes, like setting the thermostat to the right temperature, may result in a significant reduction in the heating cost. For example, it was shown that if the indoor temperature exceeds 20°C, heating expenses can increase even by 1,000 €/year. This is another reason why replacing old analogue thermostats with digital ones is a useful and cost-efficient measure.

Considering the total number of households that took place in the three LL rounds, i.e. 150 or 442 people, the following benefits are estimated:

- STEP-IN helped 335 people
  - Better understanding of energy bills: 75 people
  - Change in everyday habits: 96 people
  - Change/maintenance of the heating system: 56 people (19 houses)
  - More efficient use of the heating system: 53 people
  - Motivated to implement insulation measures: 28 people (10 houses)
  - Change of electricity provider: 9 people (3 households)
  - Use of night tariff: 11 people (4 households)
- STEP-IN improved the quality of life of 170 people
  - Improved thermal comfort: 74 people
  - Energy cost reduction: 41 people
  - Moisture/mould reduction: 46 people
  - Payment of utility bills on time: 10 people
  - Replaced defective appliance/insulate the house: 5 people (2 houses)
- Actual and potential heating energy savings achieved during the project (on an annual basis):
  - Heating energy savings due to heating system maintenance: 19,640 kWh_{th}
  - Heating energy savings due to replacement of thermostats: 52,840 kWh_{th}
  - Heating energy savings due to insulation: 220,260 kWh_{th}
  - Electricity energy savings due to the replacement of old appliances: 3,200 kWh_{el}
- Potential reduction in CO_2 emissions: 66.4 tn per year

5. Ex-post evaluation survey

5.1 Sample characteristics

5.1.1 Demographics

The settlement of Metsovo, where the Living Lab is located, has a total of 2503 residents consisting of 888 households, according to the last census of the country that took place in 2012 (Hellenic Statistical Authority - ELSTAT, 2012).

Towards collecting the necessary information for the survey, a stated preference approach was used based on personal interviews. However, due to the Covid-19 pandemic-related distancing measures, the households participated in the survey through online platform interviews.

A total number of 303 households participated in the second socioeconomic survey (ex-post assessment survey) most of which 59.3% include three or more persons, 24.5% of them include two persons and 12.6% of them consist of single-person households (Figure 94).

The sample consists of 65% men and 35% women. Figure 95 illustrates the distribution of the sample by age group. The share of the elderly people (i.e. over 65 years old) is 21.6%. About 67% of the population is aged between 30 and 64 years old and the rest are between 18 and 29 years. As regards the marital status, the majority (62.6 %) are married or cohabitate with a partner, 23.8% are unmarried, 8.6% are widowed and the rest declare separated, divorced, or living with a friend/ relative.

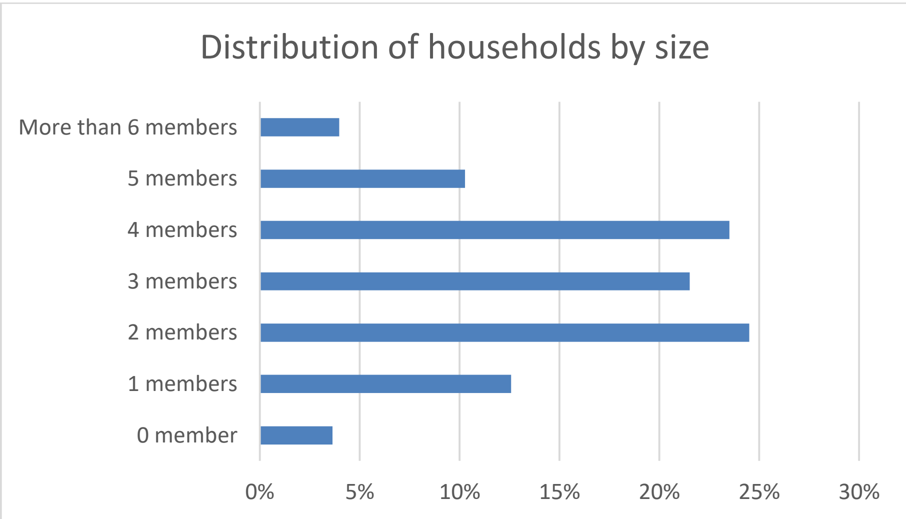

Figure 94: Households by size (STEP-IN ex-post survey).

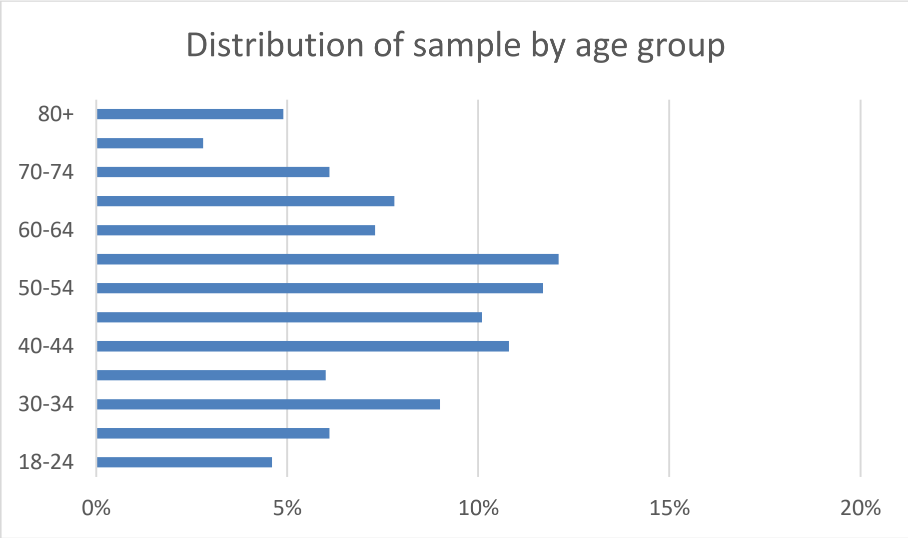

Figure 95: Participants by age (STEP-IN ex-post survey).

As far as the educational level is concerned (Figure 96), about half of the participants (44.9%) had access to Tertiary Education. About 15% have not reached high school, 26% have stopped their education at the end of senior high school, 14.5% have finished a 2-year vocational degree, 37% have a three-, four- or five-year degree and about 10% have an MSc or a PhD degree. As regards the employment status, 64.4% are employed (31.9% are full-time and 32.5% are part-time employees) and 32.5% are retired.

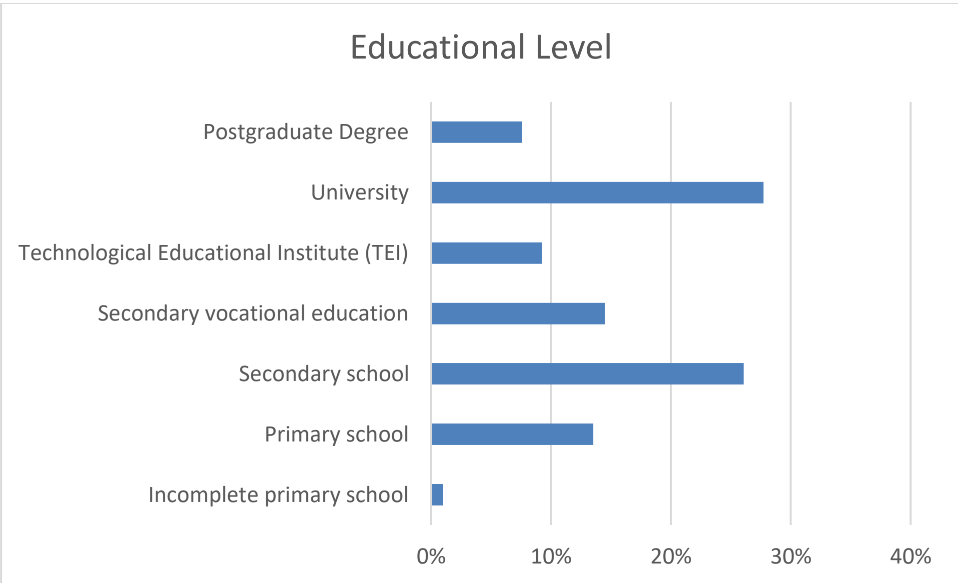

Figure 96: Educational Level (STEP-IN ex-post survey).

The average annual income per household is 16,560 euros (std. dev.: 8,600). As presented in Figure 97, 54.5% of the interviewees manage to make ends meet on current income, 15.5% live comfortably but 9.4% are struggling to cope with current income.

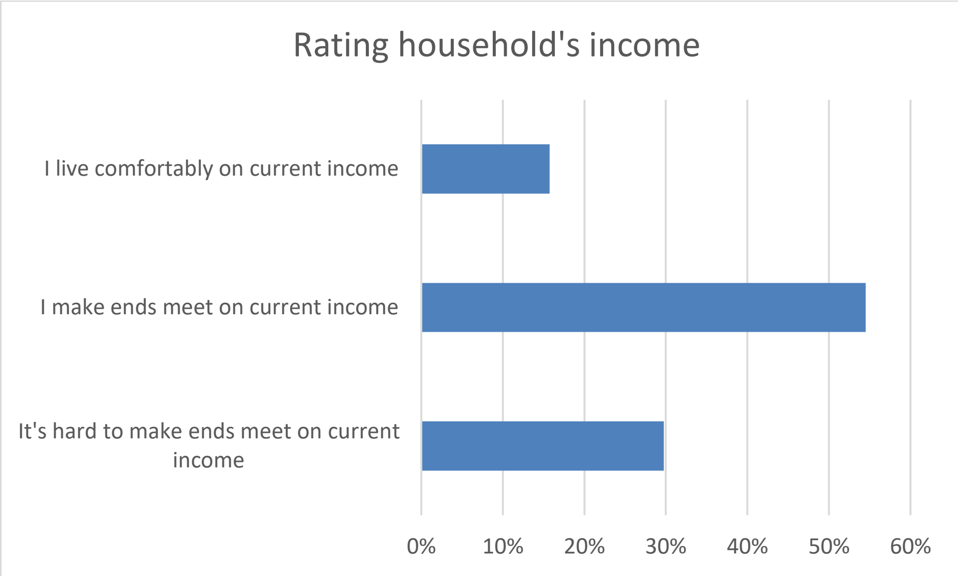

Figure 97: Rating of household income (STEP-IN ex-post survey).

5.1.2 Housing characteristics

The majority of residences (around 55%) are apartments, 37% are detached houses, and the rest are maisonettes. Regarding the total floor area, about 87% of the residences, are less than 120 m^2, 10.3% of the residences are between 121-160 m^2, and the rest 2.07% are over 160 m^2 (Figure 98). Further, nearly 6% have two rooms or less, 13% have three rooms, 60.9% have four to five rooms, and the rest have more than five rooms, except bathrooms and storage rooms. Finally, the vast majority of houses (91.7%) have up to two floors and 63.3% of the participants live on the first floor.

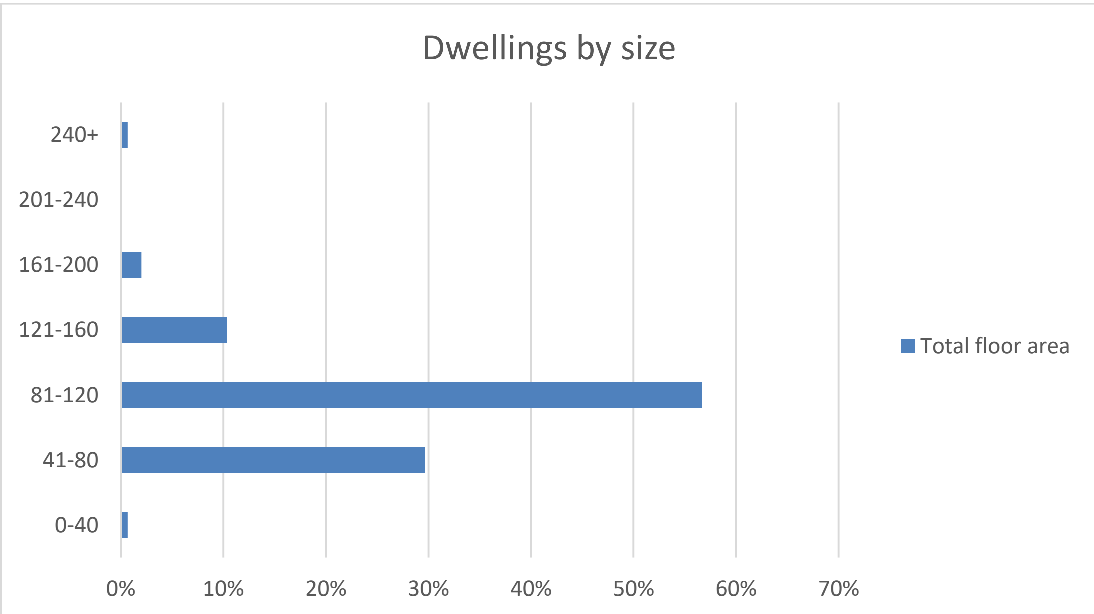

Figure 98: Distribution of dwellings by size in Metsovo settlement (STEP-IN baseline survey).

As shown in Figure 99, above half (i.e. 58.7%) of the dwellings were constructed before 1980, 21.8% were built between 1980 and 1990 and the rest after 1990 (about 5.9% during the last 20 years). Taking into account that the first Insulation Regulation in Greece was practically implemented in 1980, it appears that the lack of basic insulation standards of the building stock is a basic problem in the Municipality of Metsovo (almost 60% of the dwellings were built before 1980).

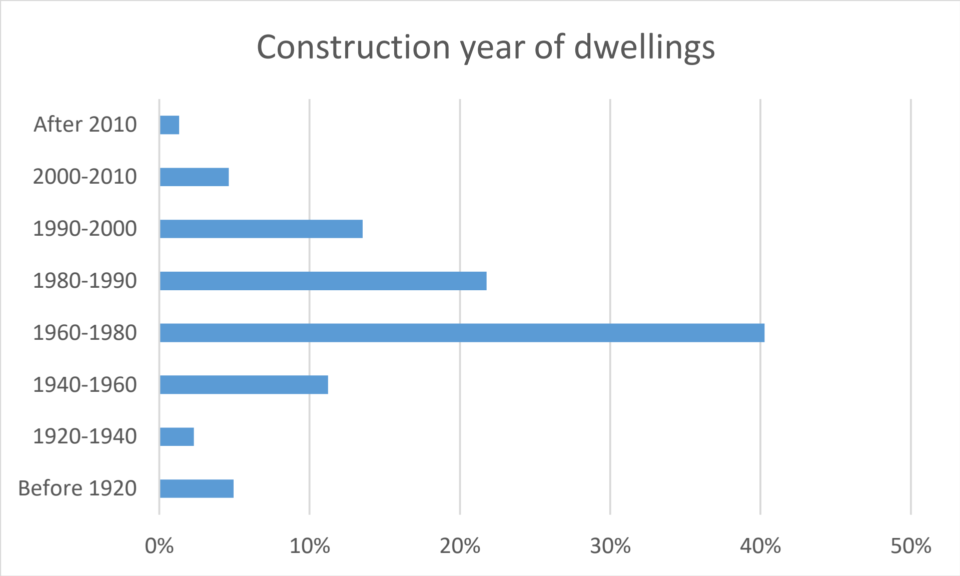

Figure 99: Construction year of dwellings in Metsovo settlement (STEP-IN baseline survey).

5.1.3 Heating system characteristics

Among the households that took part in the survey, two are the dominant fuels used for heating, diesel oil and woods/pellets, at 42% and 35%, respectively (Figure 100). In detail, 42% of the households use oil-fired central heating systems, 35% use firewood and pellets central heating systems, 18% use wood or pellet-fired stoves, and the rest of the households use other systems (e.g. air-conditioning units, heat accumulators and fireplaces) (Figure 101).

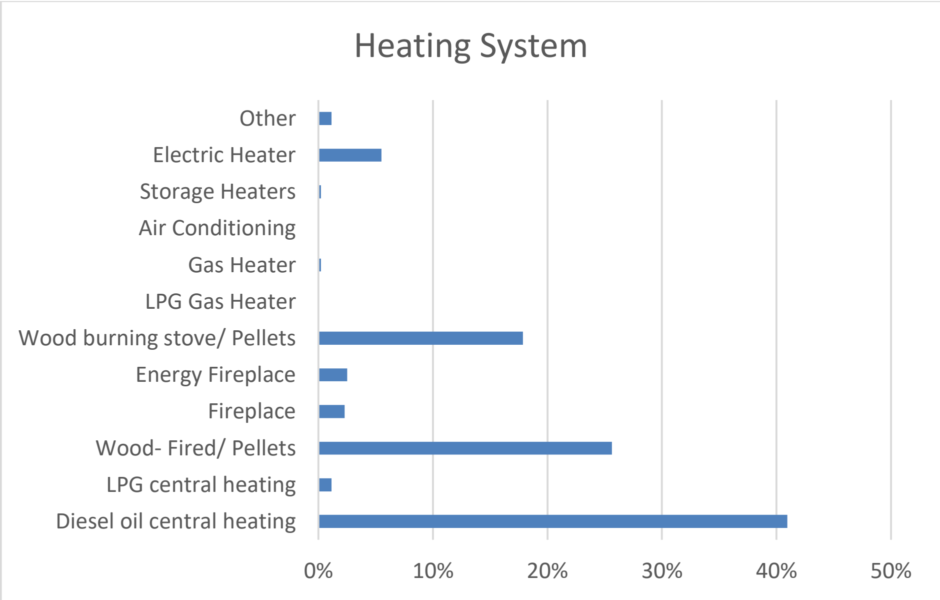

Figure 100: Heating systems used in Metsovo (STEP-IN ex-post survey).

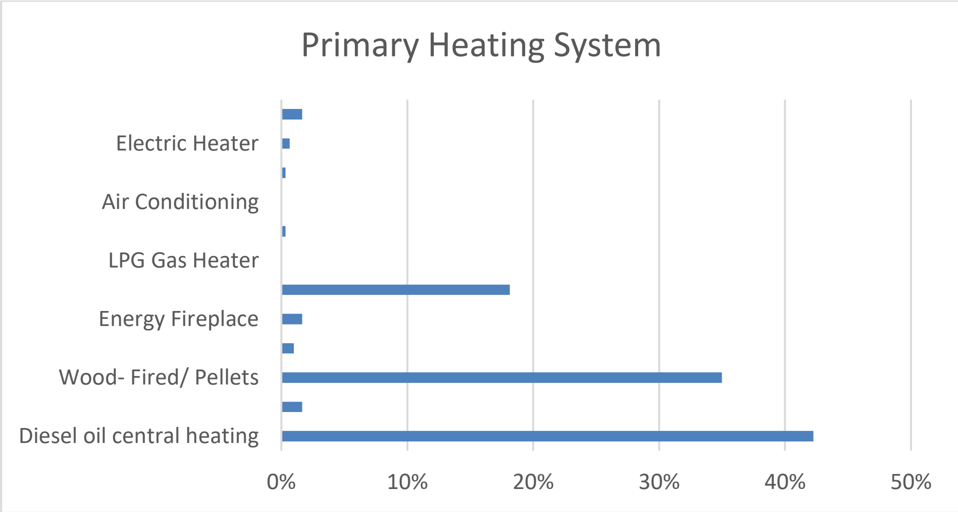

Figure 101: Primary Heating systems used in Metsovo (STEP-IN ex-post survey).

Another issue of concern regarding Metsovo's heating systems is that energy systems (mainly diesel oil central heating systems) are old. The average age is 20.5 years. This factor affects negatively energy efficiency and fuel use. However, the respondents stated that they regularly maintain their heating systems. To wit, 76.5% of them stated that they maintain their heating systems on an annual basis or, if needed, more often. However, about 30% of interviewees stated that their house does not feel warm and comfortable during winter and about 35% reported the appearance of moisture or mould in their houses, on walls ceilings or floors. These important problems affect negatively energy efficiency and energy costs and were thoroughly investigated during the LL operation in the area.

5.1.4 Energy costs

The second social survey provided additional findings regarding energy expenditure in the settlement of Metsovo. Heating holds the greatest part of energy costs because of the harsh climatic conditions. Heating costs represent about 69.5% of the total annual energy costs, while the rest 30.5% corresponds to electricity costs. More specifically, the average energy costs per household are summarized below:

- Average annual energy cost for heating per household: around €2,000
- Average annual energy cost for electricity per household: around €890

In total, the average annual energy cost for heating and electricity is approximately €2,860 per household.

More explicitly, 51% spend between €1,000 and €2,000 per year, 29% spend between €2,000 and €3,000, and smaller portions spend less (< €1,000 per year) or more (> €3,000 per year) on heating, 9% and 11%, respectively.

Another useful finding has to do with the energy expenses categorised concerning the kind of fuel used for heating. Due to high taxation, diesel oil remains the most expensive fuel for heating, although oil prices are lower nowadays compared to 2012-2013.

- Average annual expenses for oil- fired central heating system: €3,300
- Average annual expenses for wood-fired central heating system/pellets: €2,700
- Average annual expenses for LPG central heating system: €2,500
- Average annual expenses for wood-burning stove/pellets: €2,100
- Average annual expenses for electric heater: €4,800
- Average annual expenses for accumulators: €6,500

- Average annual expenses for fireplace: €900
- Average annual expenses for energy fireplace: €2,650

5.2 Attitudes towards energy efficiency and energy vulnerability

5.2.1 Energy efficiency

Considering energy efficiency interventions, about 25% of the interviewees stated that are planning to apply some energy-saving interventions in the near future. About 31.8% of the households are planning to proceed to thermal insulation of walls and/ or roofs, 33% are planning to invest in the replacement of window frames and glazing, 14.5% are thinking of proceeding to the installation of thermal solar panels for water heating, and 15.9%, in total, are planning to upgrade their heating system (Figure 102). Thermal insulation is the most effective intervention for reducing heating costs. However, it demands higher investment costs and, thus, it is difficult for households to proceed to such energy upgrades. Nevertheless, negative responses, meaning that the households are not planning to apply energy efficiency interventions, are high (75%) and this raises issues of concern.

It should be noted that the current legislation does not allow the installation of solar panels, to retain the vernacular architectural identity of the settlement. However, the high-energy consumption of households has driven people to overcome this legislative prohibition, to reduce energy expenses.

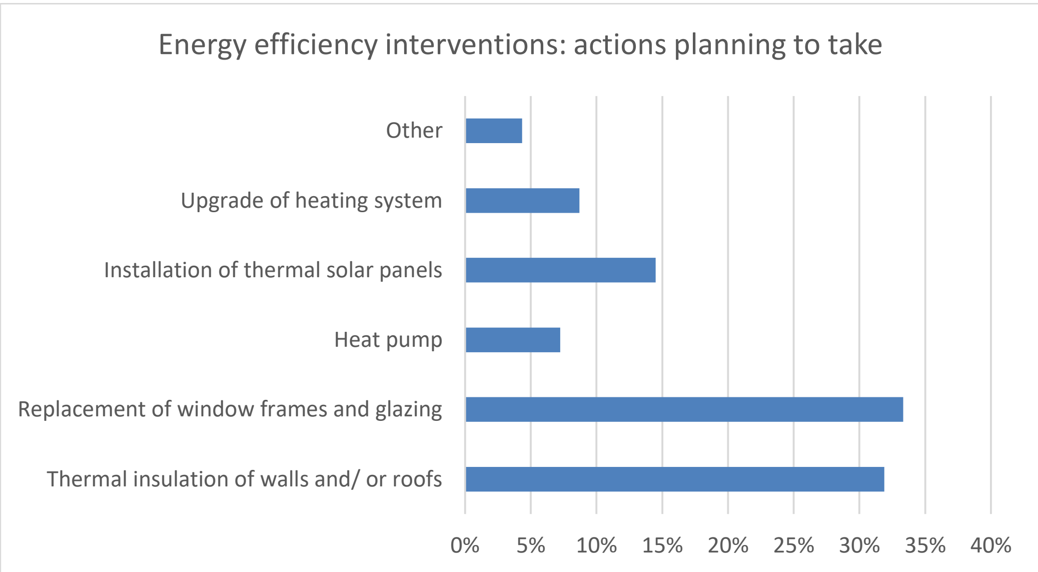

Figure 102: Energy-saving actions that household's in Metsovo are planning to take.

As previously mentioned, the majority of Metsovo's households (75%) claimed that are not willing to take energy efficiency actions shortly. Excluding those who have already improved the energy efficiency of their homes, the main reason for the negative answers is undoubtedly financial barriers, as about 73.2% of the households stated so (Figure 103). Also, 16.7% stated that there is no necessity for home improvement.

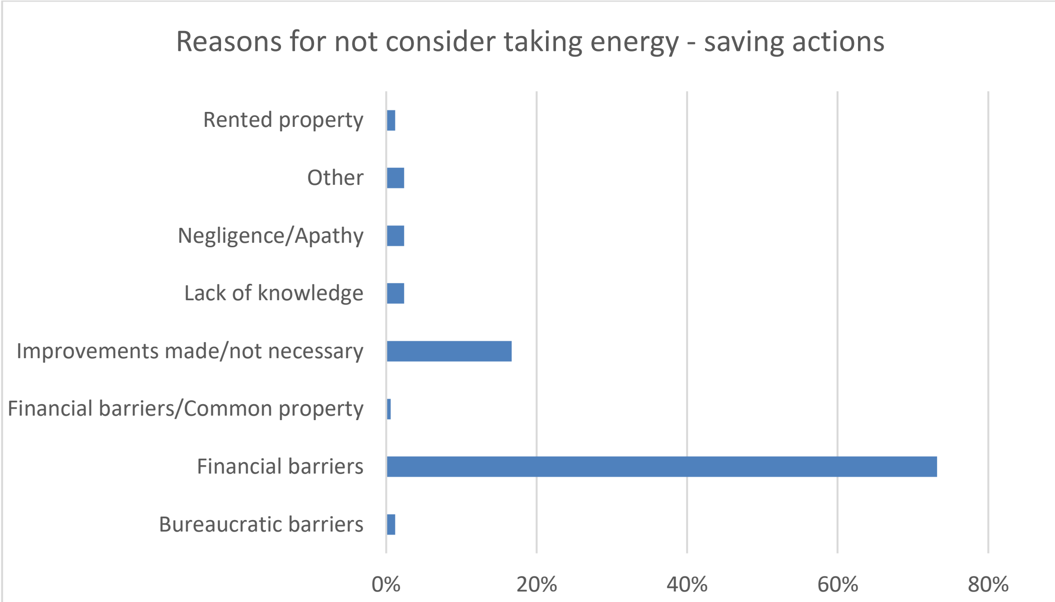

Figure 103: Reasons why households in Metsovo are not willing to apply energy efficiency interventions.

When asked which are the main actions that could help households apply energy efficiency interventions, the vast majority (81%) suggested subsidy for such interventions and about 10% recommended deduction from income tax for saving expenses (Figure 104). The data seem to suggest that households believe that the State should do more to support those that cannot pay for energy.

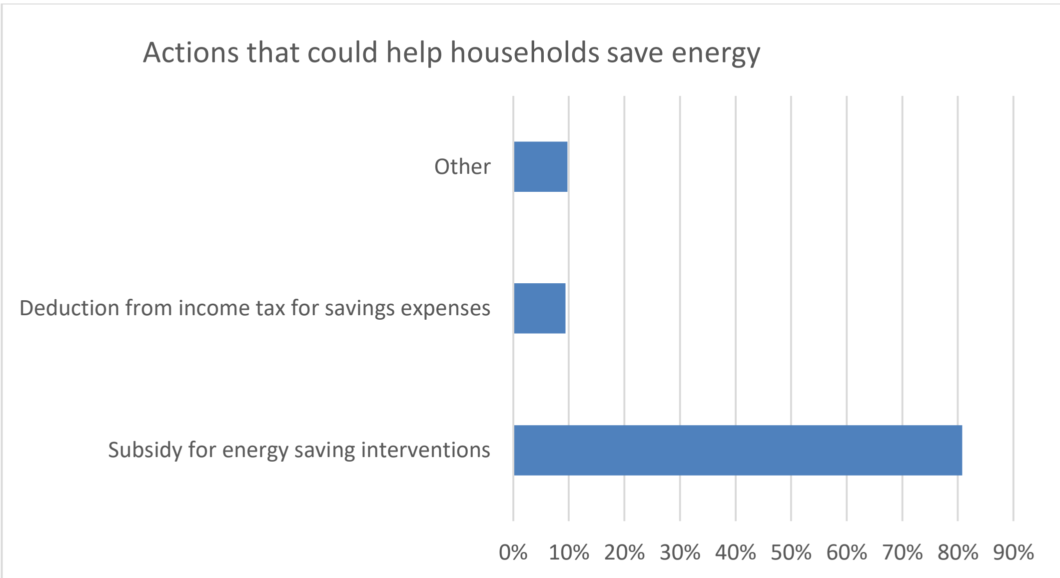

Figure 104: Suggested actions that could help households save energy.

5.2.2 Energy vulnerability

Towards exploring the energy vulnerability in Metsovo, apart from the 'Ten-Percent-Rule', which is commonly used in Greece by researchers working in the field, some basic qualitative indicators suggested in the relevant literature were examined. More specifically, three qualitative indicators were used to measure energy vulnerability:

(a) Thermal discomfort or inability to keep home adequately warm,

(b) Housing condition, including moisture/mould problems and

(c) Arrears in energy bills (electricity and heating bills) over the last 24 months.

The answers provided by the households participated in the baseline survey are illustrated in Figure 105, approximately 30% of the households claimed that they cannot keep their house adequately warm in winter, exceeding by far the Greek average at country level (17.9%) according to EU-SILC survey latest data (Eurostat, 2020). It is useful to note that in the previous STEP IN survey, almost 64% of the respondents stated that the ideal temperature in the house during winter is more than 21°C. This is a rather high value, which also reflects the importance of adequate heating in a particularly cold area. Following the findings of the survey, 70% of the households manage to keep their house warm and comfortable during the winter. Moisture/ mould problems are reported by 34% of the households, which again exceed by far the Greek average at the country level (12.5%) (Eurostat, 2020). The percentage of households who reported arrears in energy bills is rather low (10%). However, it should be taken into account that the fuels for heating purposes (diesel, wood, LPG) are always paid in cash, otherwise the suppliers do not provide fuel.

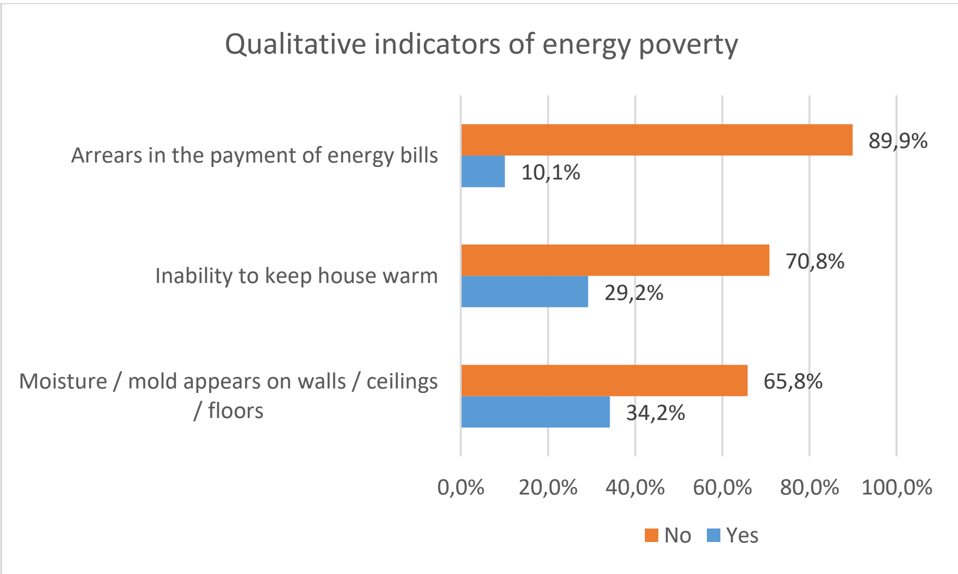

Figure 105: Energy poverty qualitative indicators in Metsovo (STEP-IN baseline survey).

Using the above-mentioned indicators, a composite energy poverty index was calculated as follows (Bouzarovski & Tirado Herrero, 2017):

$$Energy\ poverty\ index = (0.5 \times Inability + 0.25 \times Arrears + 0.25 \times Housing\ faults) \times 100$$

The proposed index ranges between 0 (i.e. none of the above-mentioned issues is present, therefore the energy poverty risk is negligible) and 100 (i.e. all the problems described by the indicators are present, thus the energy poverty risk is very high). The results of the analysis are presented in Figure 106. Approximately 50% of the households are at zero risk of energy poverty (EP composite index=0%), 18.6% are at low risk (EP composite index=25%), 15.5% are at medium risk (EP composite index =50%), 13.9% are at high risk (EP=75%) and the rest, i.e. around 3% are in excess energy poverty risk (EP composite index=100%).

Finally, using the 'Ten-Percent-Rule' approximately 83.5% of the households (based on 236 valid observations) are characterised as energy poor. The mean 'energy cost-to-income' ratio is 21.3% (5% trimmed mean: 20.7%; std. dev.: 12.3%) and the median 18.9%. Figure 107 presents the Kernel density estimate of the 'energy cost-to-income' ratio. Compared to the baseline survey, the mean 'energy cost-to-income' ratio is slightly lower (i.e. by 2%).

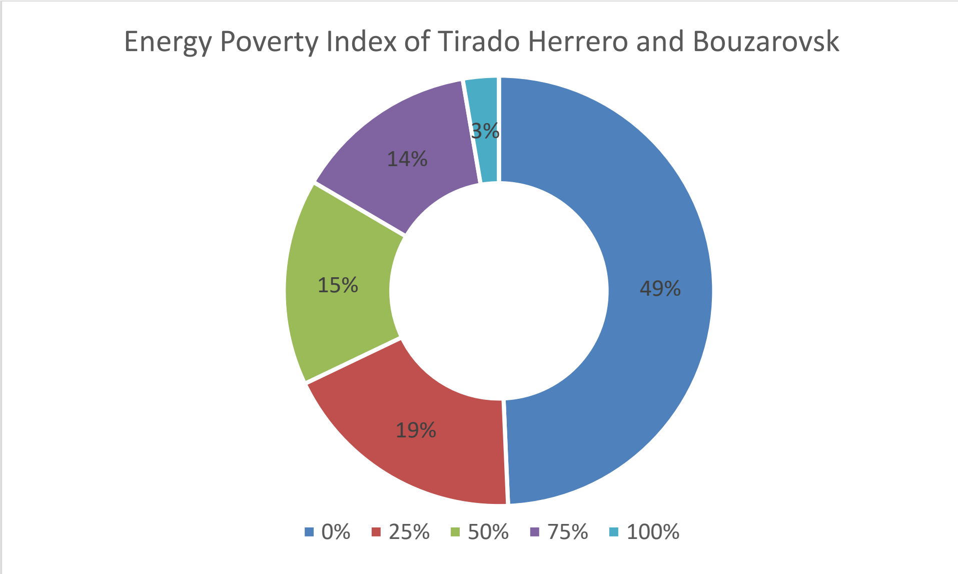

Figure 106: Composite energy poverty risk index.

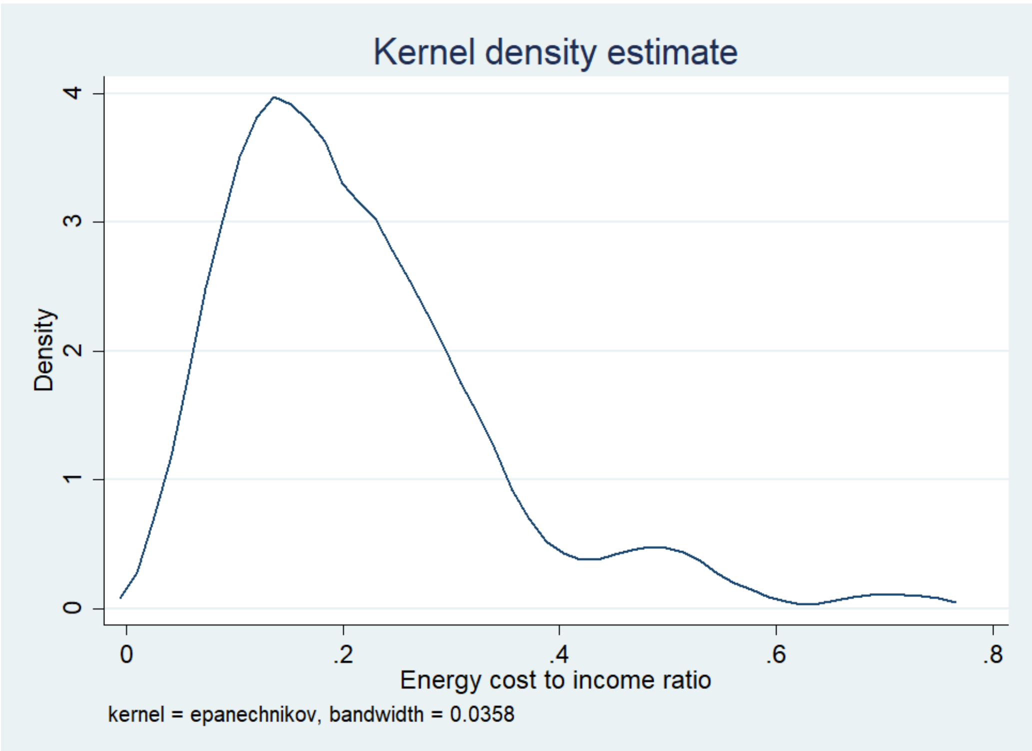

Figure 107: Kernel density histogram of energy expenditure to income ratio.

5.3 Energy vulnerability and behavioural perspectives

A phenomenon that dominates economic literature is consumers' inability to fill the gap between optimal and actual investment decisions concerning energy usage (DellaValle, 2019). The paradox of gradual diffusion of apparently cost-effective and energy-efficiency technologies concerns policymakers who are attempting to bring energy conservation into the spotlight. The traditional economic literature, based on Expected Utility Theory (EUT), presumes consumers' failure in making optimal decisions to be a result of information deficiencies and market failure. However, it has been systematically observed that people exhibit predictable patterns of decision-making that deviate from EUT's assumptions (Abrardi, 2018).

The results of three decades of research have established that the energy paradox is related to market failures (e.g. imperfect information, split incentives, distortion in fuel prices and lack of capital), time and risk preferences, behavioural aspects (e.g. rational inattention, bounded rationality, biased beliefs and heuristic decision-making) and socio-demographic characteristics (e.g. Abrardi, 2019; Allcott, 2011, 2016; Allcott & Greenstone, 2013; Brent & Ward, 2018; DellaValle et al., 2018; Gerarden et al., 2017; Gillingham & Palmery, 2014; Newell & Siikamäki, 2014; Newell & Siikamki, 2015; Shen, 2012; Poortinga et al., 2003). The behavioural barriers are known as cognitive biases and as mentioned before tending to lead to bounded rationality (Kahneman 2011, Huijsmans et al., 2019, Mani et al., 2020).

As far as individual decision-making is concerned, in the literature of Behavioural Science, the approach that prevails is the one of the dual system: System 1 and System 2 (Kahneman, 2011). The automatic and intuitive operations of System 1 and the controlled, more reflective operations of System 2 respectively produce fast and slow thinking. However, limited cognitive capacity often leads to the prevalence of System 1 over System 2, which in turn tends to lead to decisions likely to display errors (i.e. cognitive biases) in the framework of rational choice theory, a fallacy deriving from cognitive shortcuts (Kahneman 2011).

A factor that fundamentally affects individuals' cognitive capacity is scarcity conditions. Studies (DellaValle, 2019) have shown that individuals fail to make optimal decisions when they feel that it is unfeasible to bridge the gap between their needs and the resources available to fulfil them. They highlight that both individuals living in normal conditions and individuals living in scarcity conditions or poverty are equally capable of making optimal decisions. What evokes a weakened cognitive capacity is the context of scarcity changes which how they allocate attention. Given the limited financial resources combined with the lack of other basic services and the chronic stress that follows, individuals resort to financial trade-offs more often (e.g. DellaValle, 2019; Shafir 2015; Huijsmans et al., 2019; Mani et al., 2020). Therefore, the above-mentioned issues acquire even greater importance in the case of vulnerable consumers.

Aiming to explore particular informative, market and behavioural barriers to energy efficiency investigate whether these issues are related to energy vulnerability, the questionnaire of the ex-post social survey included a series of statements, as follows:

- *I keep a systematic file and carefully check the electricity and heating fuel bills;*
- *I systematically monitor the temperature of my house with a thermometer;*
- *Lack of financial incentives (tax exemption, interest-free instalments, subsidies, etc.) prevents me from taking energy-saving measures;*
- *I am aware of my home appliances' electricity consumption;*
- *I am informed about the prices of electricity and heating fuel;*
- *Among different providers' offers, it is really difficult for me to distinguish the most advantageous one;*
- *Every year - or more often if needed- I take care of the heating system's maintenance;*
- *I am more likely to take energy-saving actions if my friends, neighbours or colleagues do the same;*
- *Saving energy reduces the environmental impact caused by my household;*

- *I do not have the financial means to take energy-saving actions.*

The overall responses are presented in Figure 108.

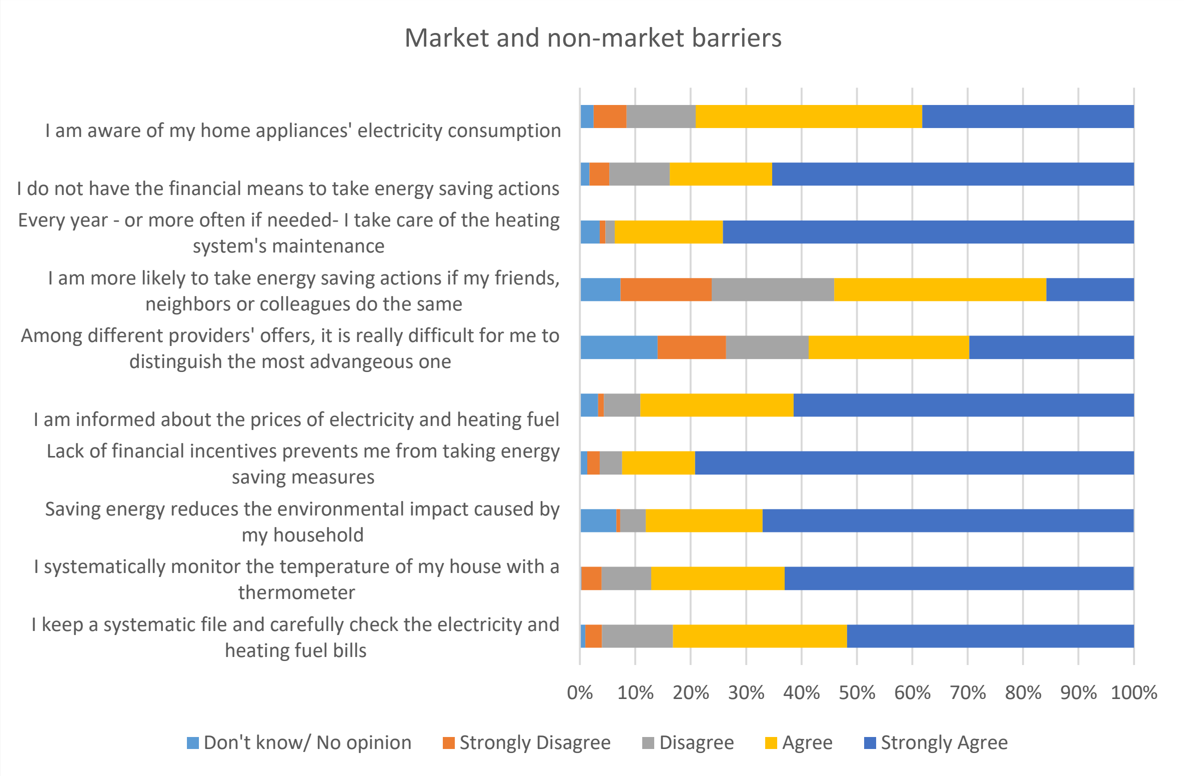

Figure 108: Lack of financial incentives inhibiting energy-efficient decisions.

As regards financial barriers, the answers of the participants come in line with the previous findings of the survey regarding energy efficiency (Section 5.2.1). More than 80% of the households' state that do not have the means to proceed to energy efficiency interventions and the vast majority (more than 90%) claim that the State should do more to help financially vulnerable households take energy-saving actions, reporting the lack of financial incentives.

It is argued that consumers tend towards procrastination if an action requires time, effort, or both. The more steps involved in the decision or action, the more likely someone is to procrastinate (Abrardi, 2018). This tendency can be often observed in the way households keep track of their energy bills and in their lack of commitment to taking energy-saving actions. However, when asked, in total, 82% of the households claim to keep a systematic file and carefully check the energy bills. In addition, about 87% claim to systematically monitor the temperature of their house by using a thermometer, and a rather high number, that of 93%, claim to take care of the heating systems' maintenance once a year, or –if needed- more often. Chi-square tests were performed to determine whether there is a statistically significant relationship between commitment in actions that would help save energy and age, gender, educational level and composite energy poverty index. Regarding the systematic check of an energy bills file, the null hypothesis is rejected for the parameter of age (χ^2=349.6 df=276, p=0.002), while regarding the systematic monitoring of temperature, the null hypothesis is rejected for the parameters of age (χ^2=259.3 df=207, p=0.008), educational level (χ^2=45.97 df=21, p=0.001) and composite energy poverty index (χ^2=22.12 df=12, p=0.036) showing that there is a statistically significant difference between them.

Another aspect that affects the energy-efficient decision is pro-environmental beliefs (Abrardi, 2018). The more environmentally conscious the consumer is, the more likely she/he is willing to take energy-saving actions. In the LL area, about 90% of the respondents agree that by saving energy they contribute to the reduction of the environmental impact. Chi-square tests were performed to determine whether there is a statistically significant relationship between pro-environmental beliefs and age, gender, educational level, and composite energy poverty index. According to the test's results, the null hypothesis is rejected for the parameters of age (χ^2=345.9, df=276, p=0.003), gender (χ^2=12.07, df=4, p=0.017), educational level (χ^2=72.9, df=28, p=0.000) and composite energy poverty index (χ^2=27.13, df=16, p=0.04) showing that there is a statistically significant difference between them.

Also, social norms form a very powerful cognitive shortcut. Extensive evidence shows that given the limited cognitive capacity, decisions are affected by what others do. Obtaining this kind of information provides a reference point against which people can compare options when they are unsure about what to do (Kahneman, 2011, DellaValle, 2019). In total, above half (about 55%) of the interviewees state that are more likely to proceed to an energy-saving investment if their friends, neighbours, or colleagues do the same, while around 30% claim not to be affected by what others do. Again, chi-square tests were performed to determine whether there is a statistically significant relationship between social norms effect and age, gender, educational level and composite energy poverty index. According to the chi-square test's results, the null hypothesis is rejected for the parameters of age (χ^2=349.17, df=276, p=0.002), gender (χ^2=15.18, df=4, p=0.004) and educational level (χ^2=54.93, df=28, p=0.001) showing that there is a statistically significant difference between them.

A factor that should also be taken into consideration when studying bounded rationality, is rational inattention, i.e. a systematic bias that leads to some information effectively being ignored. In the context of energy efficiency, the limited attention of consumers may lead them to systematically underestimate the future savings from a more energy-efficient product (Kahneman, 2011, Gillingham & Palmery, 2014). In the case of financially vulnerable households, chronic stress in combination with limited free time may allocate attention to other matters of a seemingly higher priority and may inhibit from obtaining information and gaining knowledge for energy-related matters. Nevertheless, among the households that participated in the survey, about 80% declare aware of their home appliances' electricity consumption, and in total, about 90% declare informed about the price of electricity and heating fuel. According to the chi-square test's results, the null hypothesis that there is no statistically significant relationship is rejected for the parameters of gender (χ^2=14.79, df=4, p=0.005) and educational level (χ^2=69.14, df=28, p=0.000).

Finally, about 60% state that it is really difficult for them to distinguish among different providers' offers, the most advantageous one. The null hypothesis is rejected for the parameters of age (χ^2=318.4, df=276, p=0.04), gender (χ^2=28.86, df=4, p=0.008) and educational level (χ^2=50.83, df=28, p=0.005) showing that there is a statistically significant difference between them.

Further, one of most the common behavioural barrier is the present bias. People who are present biased are systematically biased in favour of immediate benefits that they value much more than other available options, even if those options provide higher benefits in the future. Equivalently, they tend to dislike immediate costs much more than they dislike future costs (Shafir and Mullainathan, 2012). Last but not least, energy literacy plays a major role in making energy-efficient decisions. Energy literacy refers to the awareness of the individual energy consumption, the understanding of the process that involves the formation of the final energy price, the willingness to adopt energy-saving behaviours, and the need for information and willingness to access information related to energy (Martins et al., 2020). The survey included two questions aiming to measure the participants' present bias and energy-related financial literacy. In particular, the first question was formulated, as follows:

> *"Suppose an electricity provider offers two options for a 24-month (2 years) contract. Option A offers the first two months free while option B offers a 10% discount for the next 2 years. Which of the two offers would you choose?"*

The first option offers an 8.3% discount in advance and the second one 10% for the next 2 years. Therefore, it will be selected by respondents who tend to opt for immediate rewards than higher ones in the future.

The second question was based on (Brounen et al., 2013). More specifically, respondents are presented with two choices (in this case refrigerators) that differ in the purchase cost and the annual electricity consumption. The question examines whether the respondents can identify the appliance that has the lowest total purchase and operating cost during its lifetime and is framed, as follows:

"Suppose you need to replace your refrigerator. As a replacement, you can choose between two alternatives that are identical in terms of design, capacity, and cooling system efficiency. Refrigerator A sells for € 400 and consumes 300 kWh per year, while Refrigerator B sells for € 500 and consumes 260 kWh per year. Assuming that the electricity cost is 0.2 €/kWh and that both refrigerators have a lifespan of 10 years, which of the two refrigerators has the lowest total purchase and operating cost during its lifetime, in your opinion?

- *Refrigerator A*
- *Refrigerator B*
- *The two refrigerators have the same total upfront and operating cost*
- *I don't know/ I cannot estimate the total cost"*

In this case, the correct answer is Refrigerator A.

As illustrated in Figure 109, a rather small number of the respondents (18%) tend to systematically overvalue the present compared to the future, by choosing option A that offers immediate financial benefit, instead of option B that provides higher benefits in the future. Chi-square tests were performed to determine whether there is a statistically significant relationship between present bias and age, gender, educational level and composite energy poverty index. According to the chi-square test's results, the null hypothesis is rejected for the parameter of the composite energy poverty index (χ^2=21.74, df=4, p=0.000) showing that there is a statistically significant difference between them.

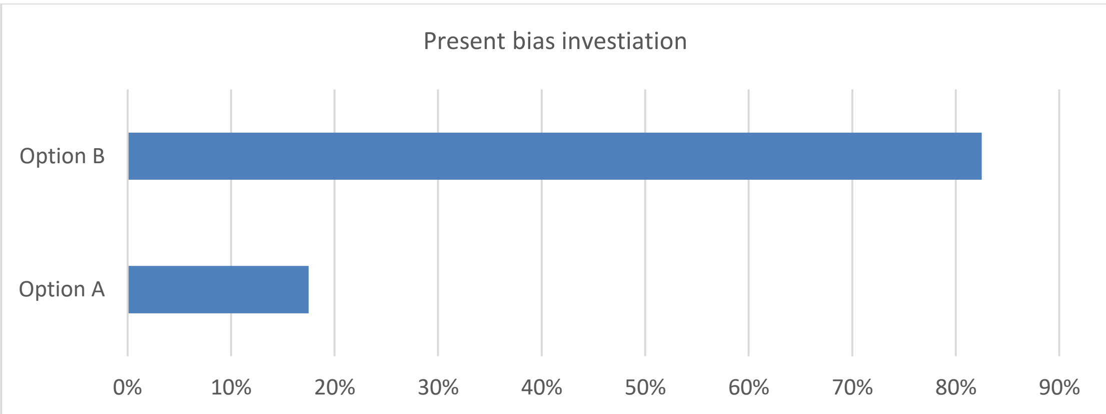

Figure 109: Investigating present bias among respondents.

Finally, a rather high number chose refrigerator B, probably because of the lower operational cost (Figure 110). However, the total purchase and operating cost for refrigerator A is lower than that of refrigerator B, providing evidence of energy illiteracy. Chi-square tests were performed to determine whether there is a statistically significant relationship between energy literacy and age, gender, educational level and composite energy poverty index. Regarding the choice of the energy-efficient refrigerator, the null hypothesis is rejected for the parameters of age (χ^2=243.4, df=297, p=0.042), gender (χ^2=13.32, df=3, p=0.004), educational level (χ^2=38.04, df=21, p=0.013) and composite energy poverty index (χ^2=24.58, df=12, p=0.017) showing that there is a statistically significant difference between them.

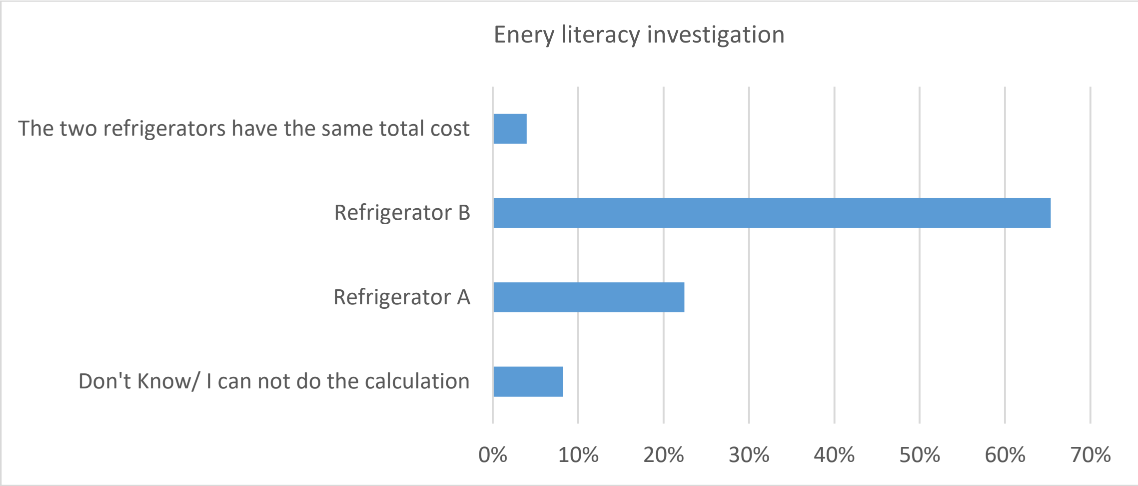

Figure 110: Investigating energy literacy among respondents.

Based on the above-mentioned results, it seems that there is a connection between energy vulnerability and certain market and behavioural biases. Focusing only on statistically significant findings, it was found that households facing higher energy vulnerability risk:

- keep a less systematic record of their energy bills;
- do not monitor regularly the temperature of their houses;
- face higher financial barriers;
- are not that convinced that energy-saving reduces the environmental impact caused by the residential sector;
- are less aware of their household appliances' energy consumption;
- are more prone to present bias.

These findings are worrisome because, without tailor-made support, the energy vulnerable households may face greater difficulties in making the right decisions towards improving their quality of life.

Finally, those who face the highest energy vulnerability risk seem to be more capable of calculating the total (i.e. purchase and operating) cost of household appliances. Yet, the number of observations is low (about 2.7% of total observations) and, thus, this conclusion should be seen with caution.

5.4 Analysis of energy efficiency preferences under the light of energy vulnerability

5.4.1 Methodological background

The ex-post assessment survey investigated also the interrelationships between energy vulnerability and energy efficiency investment decisions using a labelled choice-based experiment, which involves a hypothetical selection between three different alternative energy interventions. In particular, the respondents were presented with a number of choices sets and asked to choose which alternative they prefer. Each choice set included three alternatives, i.e. house retrofit, upgrading of heating system and upgrading of household electrical appliances, and an "opt-out" option (i.e. status quo). The respondents were asked to consider a hypothetical situation according to which their energy consumption would be improved by adopting one of the three alternative interventions. Each alternative, besides its label, was described using two parameters, i.e. the cost of the alternative and the annual energy savings in monetary terms. To provide the respondents with realistic attribute levels, each of the two attributes included three different levels that differed in each of the three alternatives.

The attributes and the related levels for each of the three alternatives are listed in Table 6. It is assumed that the respondents assess the trade-off between the annual savings and the cost of each intervention. Further, they also consider additional co-benefits (or costs) associated with each alternative, such as improved thermal comfort, reduced condensation, mould or damp problems and increased environmental benefits due to reduction in primary energy.

Table 6: Levels of the attributes for each of the three labelled alternatives

	House retrofit	Upgrading of heating system	Upgrading of electrical appliances
Cost of measure (€)	3000	600	300
	6000	1200	600
	9000	1800	900
Annual savings (€)	500	100	50
	1000	200	100
	1500	300	150

The full enumeration of possible choice sets is equal to L^{MA}, where L is the number of levels, M is the number of alternatives and A the number of attributes (Hesner et al., 2005). Hence, in our case, the total possible choice sets are 3^{3*2}=729. The experimental design followed Street and Burgess's cyclical design (Street et al., 2008) using an orthogonal main-effects plan (OMEP) 3^6 6^1. After dropping the unnecessary attributes, the design resulted in 18 treatment combinations. These 18 choice sets, which included an "opt-out" option, were split into three blocks of six choice cards to avoid respondent fatigue. Respondents were allocated randomly to a treatment block; making sure, however, that each of the three blocks was presented to an equal number of respondents.

The utility of the good is considered to depend on observed components (the attributes of the good and the characteristics of the respondent) and unobserved or undefined component, as follows (Hesner et al., 2005):

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \beta X_{ij} + \gamma Z_i + \varepsilon_{ij} \quad (1)$$

where U_{ij} is the utility function representing the satisfaction that consumer i receives from alternative j; V_{ij} is the non-stochastic component including the alternative-specific attributes X_{ij} and the respondent's characteristics Z_{ij}; β and γ are the vectors of models' parameters associated with X_{ij} and Z_{ij}; and ε_{ij} is the unobserved (stochastic) component of consumer i which follows a predetermined distribution.

The analysis was conducted using CL models assuming a linear relationship between utility and attributes, identically and independently distributed (*IID*) error terms with standard Type I extreme value distribution and choice sets that comply with the 'Independence from Irrelevant Alternatives' (*IIA*) property (Hesner et al., 2005). The basic model included three attributes (i.e. alternative specific constant, annual savings and cost of measure), which were specific to each alternative (that is nine variables in total). It is noted that the cost and annual savings were modelled as continuous variables. More specifically, the utility functions of the basic model were, as follows:

$$U_{insulation} = \beta_{01}.ASC + \beta_{11}.Cost\ of\ measure + \beta_{21}.Annual\ savings + \varepsilon_{ij}$$

$$U_{heating} = \beta_{02}.ASC + \beta_{12}.Cost\ of\ measure + \beta_{22}.Annual\ savings + \varepsilon_{ij}$$

$$U_{appliances} = \beta_{03}.ASC + \beta_{13}.Cost\ of\ measure + \beta_{23}.Annual\ savings + \varepsilon_{ij}$$

Also, a fourth utility function that represented the status quo situation was used as the base case scenario. The parameters of the base case utility function were normalized to zero (i.e. $U_0=0$).

Further, to investigate the role of respondents' sociodemographic characteristics (SDCs) in investing in energy efficiency, several SDC variables were included in the basic model ('SDC' model). In these models the SDC parameters were generic (i.e. the coefficients were not alternative-specific). Also, two different models were considered to dissect the role of energy poverty. The first model involved the introduction of the composite energy poverty index in the basic model as a non-alternative-specific covariate ('CIEP' model). In the second model, the composite energy poverty index was replaced by the three subjective energy poverty indicators, again as generic covariates ('SIEP' model).

The CL model offers the ability to estimate the marginal willingness-to-pay (MWTP) for 1 Euro of additional annual savings. The MWTP is simply the energy savings coefficient divided by the cost coefficient:

$$MWTP_{sav} = -\frac{\beta_{sav}}{\beta_{cost}} \quad (4)$$

In the case of an interaction term with the annual savings attribute, the MWTP is calculated, as follows (Holmes et al., 2017):

$$MWTP_{\mathrm{sav\_interact}} = -\frac{\beta_{\mathrm{sav}}+\beta_{\mathrm{savxinteract}}\cdot \mathrm{Savings}\times\mathrm{Interacted\ term}}{\beta_{\mathrm{cost}}} \quad (5)$$

The confidence intervals were estimated using the Krinsky-Robb approach with 1,000 draws (Krinsky & Robb, 1986).

Finally, a respondent's WTP for a change from the base case (status quo, U_0) to a new state (energy intervention, U_1) is estimated through the compensating variation (CV) associated with this change (Holmes et al., 2017):

$$CV = -\frac{1}{\beta_{cost}} * \{V_1 - V_0\} \quad (6)$$

5.4.2 Results

The results of the models are presented in Table 7. The coefficients are statistically significant, and the signs are as expected. The ASC of 'heating' alternatives is statistically significant at p=10% in the 'basic' model and insignificant in the 'SDC' model. Also, the ASC of 'appliances' alternatives is statistically insignificant in all model specifications. The 'SDC' model presents the best fit and, further, all variables but the ASC of 'heating' and 'appliances' alternatives are statistically significant at p=1% and have the expected sign. Focusing on the SDC parameters, the signs of the coefficients indicate that households with more members, younger householders and higher income are more likely to invest in energy efficiency. The composite energy poverty indicator ('CIEP' model) is statistically significant at p=5%. The negative sign implies that willingness to invest in energy efficiency decreases with energy vulnerability. According to the results of the 'SIEP' model, this is attributed to the inability of households to keep their houses adequately warm. The weight of thermal discomfort is twice as high as that of arrears in utility bills and problems with condensation, mould or damp. Further, the thermal discomfort coefficient is statistically significant at p=1%, whereas the coefficients of the other two subjective indicators are significant at p=10%.

Table 7: Results of the basic, SDC and energy poverty models

Variable	Basic model	SDC model	CIEP model	SIEP model
	Coeff.	*Coeff.*	*Coeff.*	*Coeff.*
$ASC_{Insulation}$	1.4599***	0.9639***	1.6096***	1.5727***
	(0.1801)	(0.3741)	(0.1901)	(0.1906)
$Cost_{Insulation}$	-0.0003***	-0.0003***	-0.0003***	-0.0003***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$Savings_{Insulation}$	0.0011***	0.0011***	0.0011***	0.0011***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$ASC_{Heating}$	0.4118*	-0.0910	0.4975**	0.4568*
	(0.2327)	(0.4042)	(0.2416)	(0.2421)
$Cost_{Heating}$	-0.0013***	-0.0013***	-0.0013***	-0.0013***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$Savings_{Heating}$	0.0045***	0.0046***	0.0044***	0.0044***
	(0.0008)	(0.0008)	(0.0008)	(0.0008)
$ASC_{Appliances}$	-0.0372	-0.5483	0.0306	-0.0103
	(0.2341)	(0.4036)	(0.2447)	(0.2452)
$Cost_{Appliances}$	-0.0027***	-0.0027***	-0.0027***	-0.0027***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
$Savings_{Appliances}$	0.0115***	0.0115***	0.0115***	0.0115***
	(0.0017)	(0.0018)	(0.00178)	(0.0018)
HH members	--	0.1491***	--	--
		(0.0487)		
Age class	--	-0.4174***	--	--
		(0.0632)		
Coping on income	--	0.7532***	--	--
		(0.0997)		
EP index	--	--	-0.1059**	--
			(0.048)	
Damp/mould	--	--	--	0.2258*
				(0.1319)
Thermal disc.	--	--	--	-0.5734***
				(0.1298)
Arrears	--	--	--	0.3630*
				(0.2136)
-LL	*-2099.06*	*-1977.50*	*-2043.45*	*-2034.87*
Pseudo R^2	*11.3%*	*16.4%*	*13.7%*	*14.0%*
n	*1818*	*1788*	*1776*	*1776*

*Note: St. error in parentheses; *,**,***: significance at 10%, 5% and 1% level*

The average MWTP values are presented in Table 8. Households are on average willing to pay around 3.4, 3.5 and 4.3 Euros for saving 1 Euro by investing in insulation, upgrading of heating systems and upgrading of household appliances, respectively. Yet, the differences in the mean WTP values are not statistically significant.

As far as the role of SDC is concerned, WTP for energy retrofit, upgrading of heating system and upgrading of household appliances increases by about 459, 11 and 55 Euros per household member, respectively. An increase in the age class results in a decrease of 1285 Euros in WTP for energy retrofit, 311 Euros for upgraded heating systems and 155 Euros for more energy-efficient appliances. Finally, WTP for energy retrofit, upgraded heating systems and more energy-efficient appliances increases by 2320, 562 and 280 Euros, respectively, with an increase in income class. The differences in the WTP values for the three energy interventions are statistically significant in all SDC parameters (the null hypothesis of equal means is rejected at $p<1\%$ in all cases). Based on the 'SIEP' model, it is found that households who face condensation, mould and damp problems are willing to pay 708.3 Euros more for energy retrofit and 178.4 Euros for upgraded heating systems compared to those who do not face similar issues. Also, those who are struggling to pay their energy bills are willing to pay around 1140 Euros more for energy retrofit and 140 Euros more for energy-efficient appliances. The differences in WTP values are statistically significant in all these cases (the null hypothesis of equal means is rejected at $p<1\%$). Finally, households who are not able to keep their homes warm are not willing to pay for energy interventions and the same finding is observed in the 'CIEP' model regarding the composite energy poverty indicator. This seemingly inconsistent behaviour is explained by the association of thermal discomfort with household income. The percentage of low-income households among those who are faced with thermal discomfort is around 40%. The respective percentage for those faced with mould and damp and arrears in energy bills is less than 25% (it is also noted that energy-bill arrears concern only 10% of the households). Household income seems to have a more significant effect on energy efficiency investments than the energy poverty indicators. To explore this hypothesis, an additional model was tested (the results are omitted for conciseness reasons), adding energy poverty indicators in the 'SDC' model. Indeed, the energy poverty coefficients were statistically insignificant while household income was statistically significant at $p=1\%$.

Table 8: MWTP estimates for the Basic, SDC, CIEP and SIEP models

	Basic	SDC	CIEP	SIEP
Annual savings - Insulation	3.43	3.43	3.38	3.38
Annual savings - Heating	3.43	3.42	3.47	3.48
Annual savings - Appliances	4.27	4.26	4.34	4.34
HH members - Insulation	--	458.94	--	--
HH members - Heating	--	111.20	--	--
HH members - Appliances	--	55.33	--	--
Age class - Insulation	--	-1285.11	--	--
Age class - Heating	--	-311.37	--	--
Age class - Appliances	--	-154.94	--	--
Income class - Insulation	--	2319.28	--	--
Income class - Heating	--	561.94	--	--
Income class - Appliances	--	279.63	--	--
EP indicator - Insulation	--	--	-333.12	--
EP indicator - Heating	--	--	-83.75	--
EP indicator - Appliances	--	--	-39.94	--
Damp/mould - Insulation	--	--	--	708.25
Damp/mould - Heating	--	--	--	178.42
Damp/mould - Appliances	--	--	--	$^{+++}$
Thermal comfort - Insulation	--	--	--	-1798.53
Thermal comfort - Heating	--	--	--	-453.07
Thermal comfort - Appliances	--	--	--	-216.02
Arrears in bills - Insulation	--	--	--	1138.43
Arrears in bills - Heating	--	--	--	$^{+++}$
Arrears in bills - Appliances	--	--	--	136.74

Note: $^{+++}$: not statistically significant at p=5%

To further investigate the impact of income and subjective energy poverty indicators on households' willingness to invest in energy efficiency, four additional models with split samples were run. In each model, ASCs, cost and annual savings attributes were estimated separately for each income and energy poverty class. For conciseness reasons, the detailed model results are omitted and instead only the estimated choice probabilities for each alternative, per model and group, are presented in Table 9.

Table 9: Choice probabilities for each alternative per model and group

Alternative	Income model	Mould/damp model	Thermal discomfort model	Arrears in bills model
Group I				
House insulation	36.1%	40.5%	43.9%	45.0%
Heating system	19.3%	21.8%	20.8%	19.0%
Household appliances	10.9%	15.6%	16.6%	14.0%
No option	33.7%	22.1%	18.7%	22.0%
Group II				
House insulation	44.0%	48.9%	41.1%	30.0%
Heating system	19.6%	14.9%	16.7%	24.0%
Household appliances	17.6%	15.5%	13.8%	28.3%
No option	18.8%	20.7%	28.4%	17.7%
Group III				
House insulation	52.8%			
Heating system	20.2%			
Household appliances	18.5%			
No option	8.5%			

Note: *Income* – Group I: Difficult to live on current income, Group II: Coping on current income, Group III: Living comfortably on current income; *Damp/mould problems* – Group I: No condensation, mould and damp issues, Group II: Condensation, mould and damp issues; *Inability to keep house warm* – Group I: Ability to keep house adequately warm, Group II: Inability to keep house adequately warm; *Arrears in energy bills* – Group I: No arrears in energy bills, Group II: Arrears in energy bills.

As far as the 'income' model is concerned, the influence of income is reflected on households' choices. The 'opt-out' alternative is selected by the 34% of Group I ('Difficult to live on current income') participants, 19% of Group II ('Coping on current income') participants and only 8.5% of Group III ('Living comfortably on current income') participants. Moreover, households with higher income tend to select more expensive choices (i.e. energy retrofits). Households facing condensation, mould and damp problems are willing to invest in energy retrofit. Another interesting point is that the 'opt-out' alternative is preferable than the 'appliances' alternative for those facing these problems and coincides with the negative sign in the ASC of the 'appliances' alternative (it is reminded however that the coefficient was not statistically significant at p=10%). Households who report that they are unable to stay comfortably warm also prefer to invest in energy retrofit or not to invest at all (the 'opt-out' option is preferable to the 'appliances' option). It is also worth noting that the probability of choosing the 'opt-out' alternative increases by 10% in the 'discomfort' group (i.e. Group II), while the probability of choosing any of the energy-efficiency investment alternatives decreases. As explained earlier, this finding is related to the lower-income class of those who are faced with thermal discomfort and is supported also by the findings of the 'income' model.

The preference probabilities for those who report arrears in energy payments show a similar pattern with that of the other two subjective indicators models, i.e. the 'insulation' alternative is the most preferred choice and the 'opt-out' alternative is more preferable than the 'appliances' choice. It is interesting, however, that those who report arrears in bills tend to have higher preferences for the 'heating' and 'appliances' alternatives compared to those who are unable to stay comfortably warm or face damp problems.

From a policy perspective, several interesting remarks can be made. First, it seems that energy retrofit is the most preferred option, regardless of other factors. This may be related to unobserved benefits of retrofits, e.g. insulation may enhance occupant's comfort and increase future resale value (Hyland et al., 2013). Second, it is important to underline that the preferences of vulnerable households depend on the different aspects of energy poverty. For instance, those who are unable to keep a level of thermal comfort at home are less willing to invest in energy efficiency while the opposite stands for those who are faced with damp problems or arrears in bills. This is attributed to the fact that a significant percentage of the households who report thermal discomfort (at least in the study area) belong to the lower-income group. Third, vulnerable households hold different WTP values for each of the proposed interventions. These differences are not observed only across groups but also between groups. For example, those who claim inability to keep their houses adequately warm are willing to pay around 2.8 Euros for every Euro saved on an annual basis from the upgrading of the heating system, whereas those who face damp problems are willing to pay around 5 Euros, respectively. Finally, the SDC of the respondents, which are known to be related to energy poverty, such as income and age, also possess a crucial role in the energy efficiency decision-making process. In general, elderly people, who are more prone to energy poverty, are at the same time more reluctant to invest in energy saving. The same conclusion is drawn for low-income households. Further, the estimated values show that households who are struggling to live on their income can afford to pay for energy retrofits only one-third of the amount estimated for households who are living comfortably.

All in all, these findings are worrisome because without support to implement structural measures like energy efficiency, elderly and low-income households could be trapped in the vicious circle of energy poverty, as previous studies suggest (e.g. González-Eguino, 2015; Terés-Zubiaga et al., 2013).

5.5 The impact of STEP-IN on the local community

The ex-post assessment survey aimed also to evaluate the impact of the LL activities on the households of Metsovo. Among the households that participated in the survey, about one-fourth were directly involved in the LL activities of the project. Provided that the impact of the LL activities on those who participated in the project is described in detail in Section 4, the present section focuses mainly on non-participating households. However, a comparative analysis is conducted between these two groups to conclude the methodology developed by the STEP-IN project.

In total, about 11% of the non-participating households received information (e.g. the energy advice booklet) by the project. It should be noted that the booklet should have been distributed to all local households by the Municipality of Metsovo. Nevertheless, this task could not be completed due to the national and local restrictions imposed to curb coronavirus spread. Of those households who received information, 83% found this material useful. In particular, about 70% said that they gained a better understanding of the energy bills and changed some bad everyday habits, 35% were motivated to service their heating system and learned how to use their heating system more efficiently and less than 10% started examining the adoption of insulation measures. More importantly, about half of them (i.e. 48%) stated that their living conditions improved thanks to the advice received by the project, mainly by improving the level of thermal comfort at home (36%), by reducing energy costs (20%) and by facing less moisture/mould problems and paying energy bills on time (8%).

The above findings coincide with the results of the LL participants. Considering all three rounds of the LL, 76% of those who participated in the LL's activities said that the project was useful to them (approximately 29% changed everyday habits, 22% gained a better understanding of electricity bills, 17% maintained their heating system, 16% learned how to use their heating system more efficiently and 8% implemented insulation measures). Further, around 40% of them said that they saw an improvement in the quality of their lives, mainly by improving the level of thermal comfort at home (42%), by facing less moisture/mould problems (26%), by reducing energy costs (23%) and paying energy bills on time (6%).

Considering the total number of households in the Municipality of Metsovo (after excluding those who participated in the LL to avoid double-counting), it is estimated that the STEP-IN information and advice material reached more than 240 households or 670 people. Based on the ex-post assessment survey findings, the following benefits are estimated:

- STEP-IN helped 525 people
  - Better understanding of energy bills: 365 people
  - Change in everyday habits: 365 people
  - Change/maintenance of the heating system: 185 people (about 70 houses)
  - More efficient use of the heating system: 185 people
  - Motivated to implement insulation measures: 40 people (15 houses)
- STEP-IN improved the quality of life of 305 people
  - Improved thermal comfort: 110 people
  - Energy cost reduction: 60 people
  - Moisture/mould reduction: 25 people
  - Payment of utility bills on time: 25 people
- Potential heating energy savings: 85 houses
  - Heating energy savings due to heating system maintenance: 86,520 kWh_{th} per year (based on savings of 4% and average heating energy of 30,900 kWh_{th} per household for 70 households)
  - Heating energy savings due to insulation: 139,050 kWh_{th} per year (based on savings of 30% and average heating energy of 30,900 kWh_{th} per household for 15 households)
- Potential reduction in CO_2 emissions: 51 tn per year

6. The impact of COVID-19 pandemic on energy vulnerability

To investigate the new living conditions established due to the coronavirus pandemic-related restrictions, two different approaches were adopted. First, as discussed in Section 3, the monitoring equipment stayed at the same V2 round households to collect 'hard' data regarding the impact of the lockdown on households' energy usage. Second, several related questions were added to the LL evaluation questionnaire as well as to the questionnaire of the ex-post assessment survey to examine changes in the socio-economic status (e.g. employment status and income) and in energy-related behaviour (e.g. usage of heating system and electrical appliances).

6.1 Impact on the socio-economic status

6.1.1 Findings from the ex-post assessment survey

About 41.5% of the interviewees reported changes in their working conditions due to the COVID-19 coronavirus, i.e. work suspension (37%), part-time work (22%), operation closure (20%), job loss (13.7%), working from home (4%) and rotational shift work (3.2%) as shown in Figure 111.

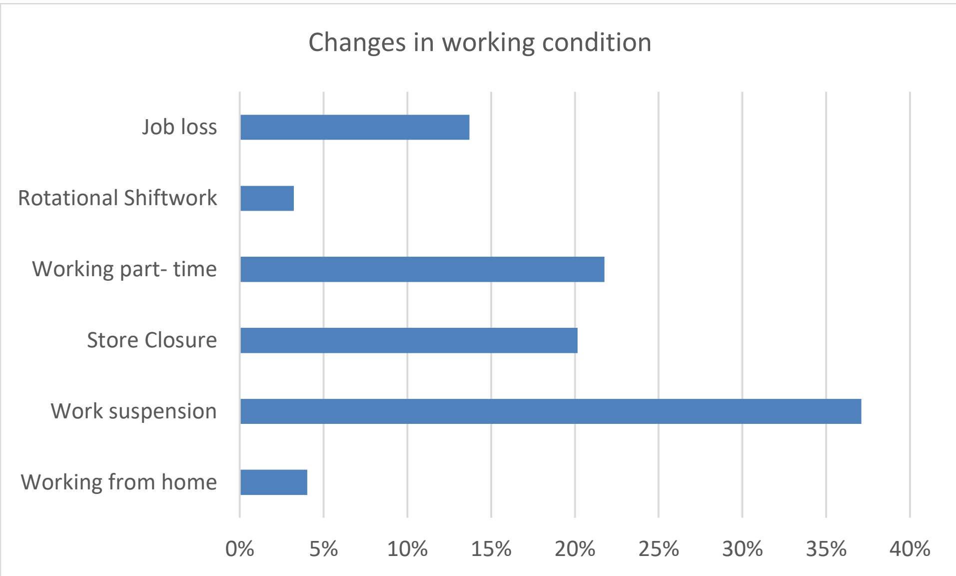

Figure 111: Changes in working condition due to Covid-19 restrictive measures.

About half (49%) of the households that participated in the survey stated their income was not affected during this period. However, the number of households that reported a decrease in their income is rather high and should be taken into consideration for further analysis (Figure 112). Among those who stated that the household's income was affected by the restrictive measures, 20% claimed the decrease to be in the range of 5-25%, 40% in the range of 25%-45%, and the rest over reported a reduction in income 50%. It should be noted that there were households (10%) that reported a decrease in their income in the range of 80-100% (Figure 113).

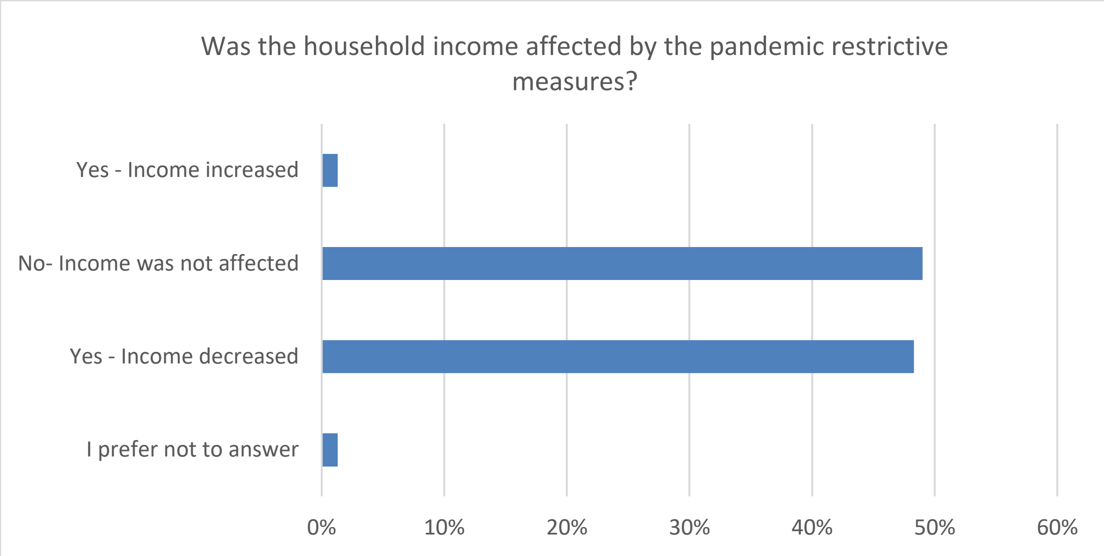

Figure 112: Qualitative changes in household income due to COVID-19.

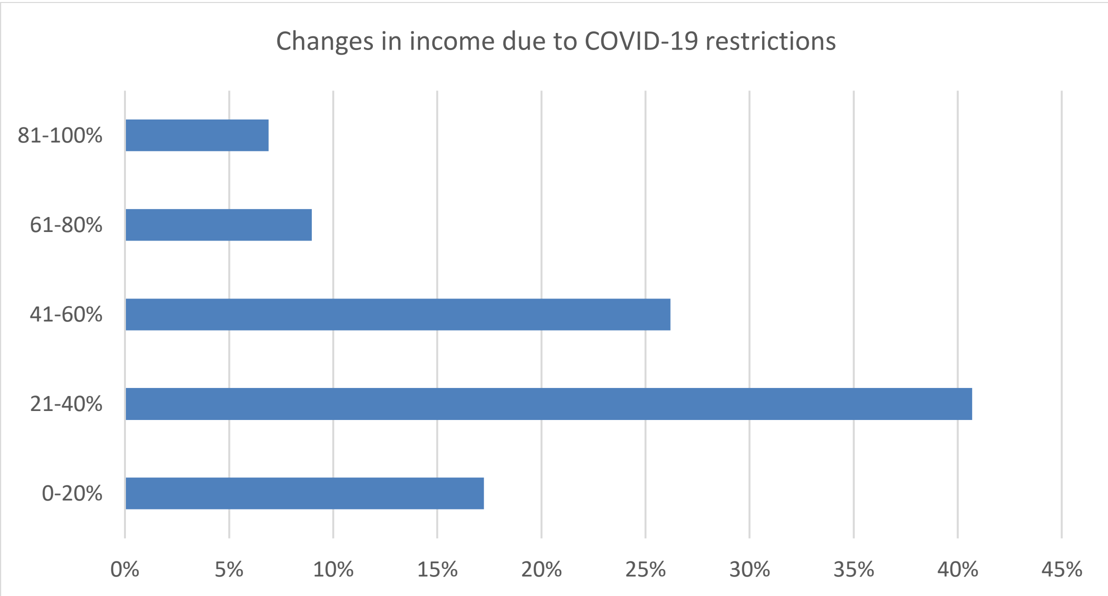

Figure 113: Percentage change in household income due to COVID-19 restrictions.

6.1.2 Findings from the LL evaluation questionnaires

In total 40% of the LL participants reported changes in their working conditions due to the COVID-19 coronavirus, namely, work suspension (47.5%), part-time work/ rotational shift work (12.5%), operation closure/job loss (30%) and working from home (10%) as shown in Figure 114.

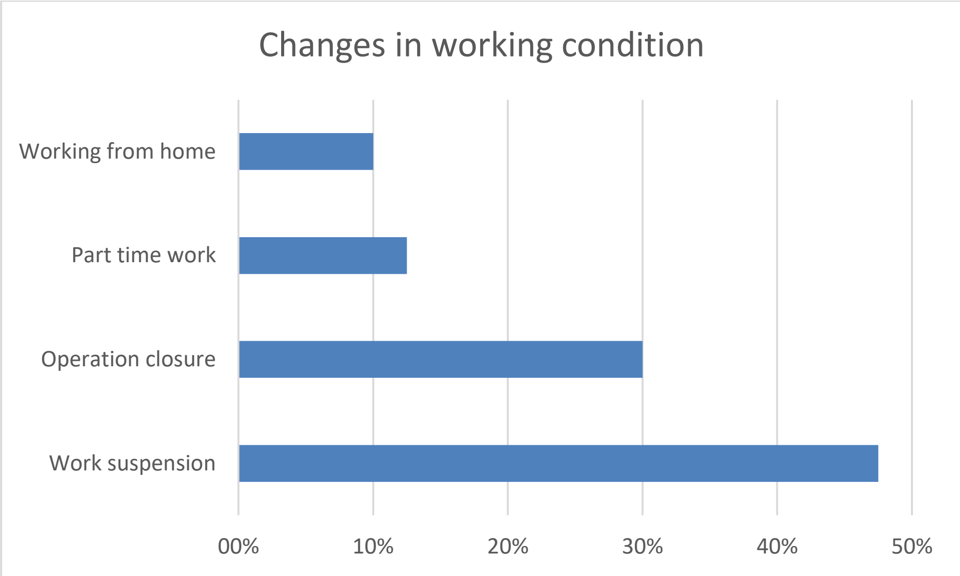

Figure 114: Changes in working condition due to COVID-19 restrictive measures – LL participants in V2 and V3 rounds.

About 45% of the households that participated in the V2 and V3 rounds of the LL stated their income decreased during the lockdown. More specifically, among those who stated that the household's income was decreased, 7.5% claimed that the decrease was less than 10%, 12.5% said that the decrease was around 20%, 32.5% that the decrease was about 30%, 15% declared a decrease between 40% and 50% and 32.5% that the decrease in income was higher than 50% (Figure 113).

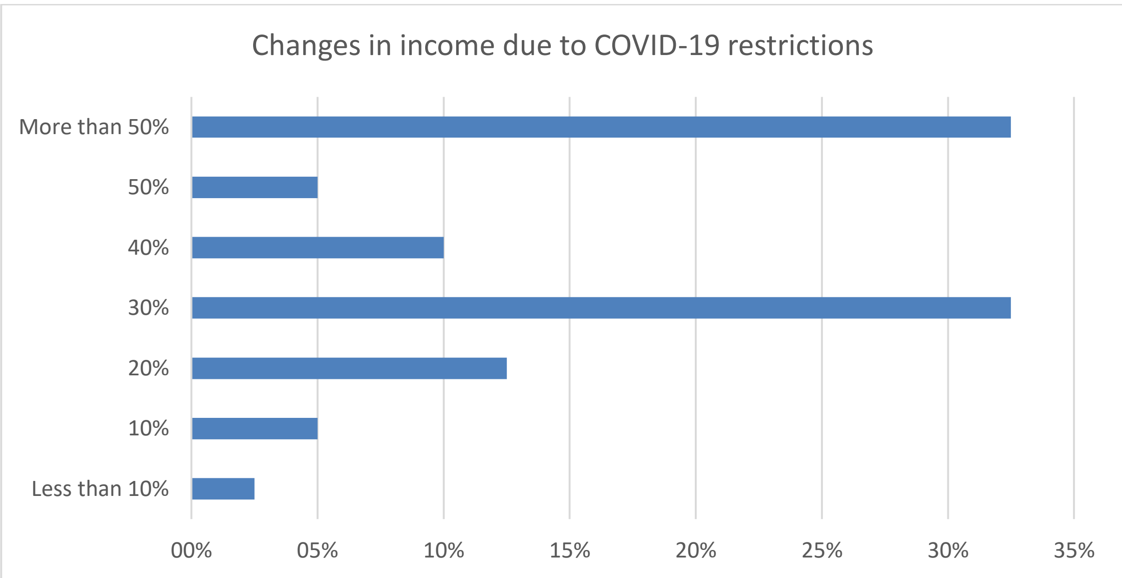

Figure 115: Percentage change in household income due to COVID-19 restrictions – LL participants in V2 and V3 rounds.

6.2 Impact on energy usage

6.2.1 Findings from the ex-post assessment survey

Regarding the use of the heating system, 28.5% of the interviewees stated that during the restrictive measures due to Covid-19 their heating system worked more hours than usual. About 10% of them reported working for an extra 1 to 2 hours. The vast majority (82.6%) reported working for between 3 to 6 hours and the rest, for 7 to 8 hours more than usual (Figure 116). Further, 55.6% of the participants reported an increase in the operation of some electrical appliances during the restrictive measures. As Figure 117 illustrates, about 28% reported using the television more than usual, 24% mentioned an increase in the operation of the computer, about 22% stated using more than usual small household appliances and 20% reported using more the electric cooker. Among the households that participated in the survey, 33.4% stated that there were e-learning students in their home during the COVID-19 restrictions period, which also partially explains the increased use of computers.

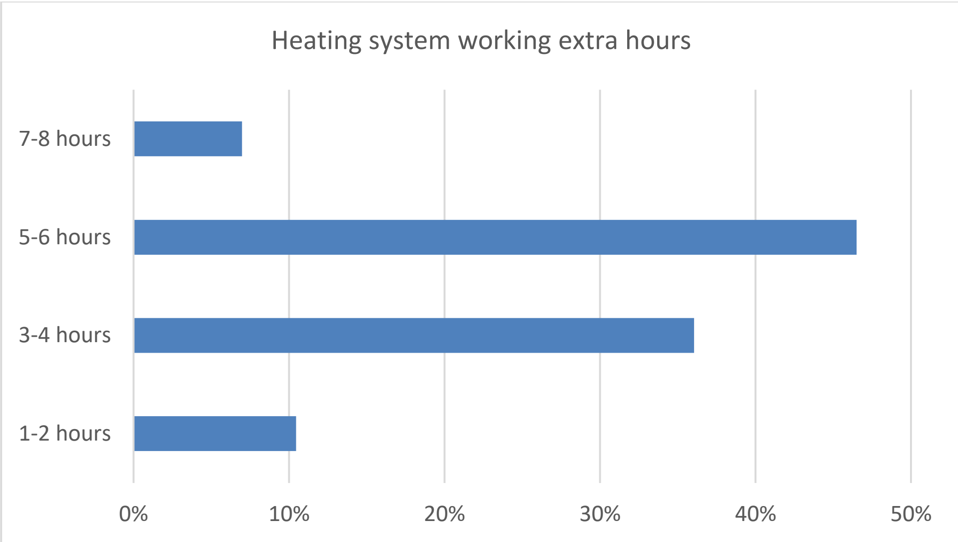

Figure 116: Increase in use of heating system due to COVID-19 restrictive measures.

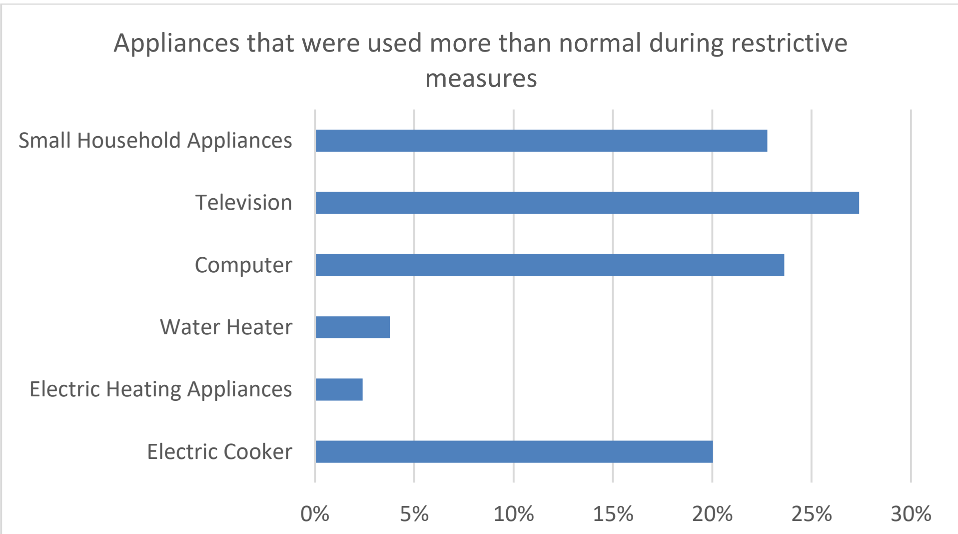

Figure 117: Increase in the operation of electrical appliances due to COVID-19 restrictive measures.

6.2.2 Findings from the LL evaluation questionnaires

As far as the LL participants in rounds V2 and V3 are concerned, 30% said that they used more their heating systems during the lockdown. In particular, 20% reported extra 1 to 2 hours, 24% between 3 and 4 extra hours, 20% between 5 and 6 extra hours and the rest (i.e. 27% more than 6 hours (Figure 118). Also, 64% of them reported an increase in the operation of some electrical appliances during the restrictive measures. About 32% reported using the television more than usual, 22% mentioned an increase in the operation of the computer, about 16% stated using more than usual small household appliances and 20% reported using more the electric cooker. Among the households that participated in the survey, 27% stated that there were e-learning students in their home during the lockdown period, which explains, at least partially, the increased use of computers.

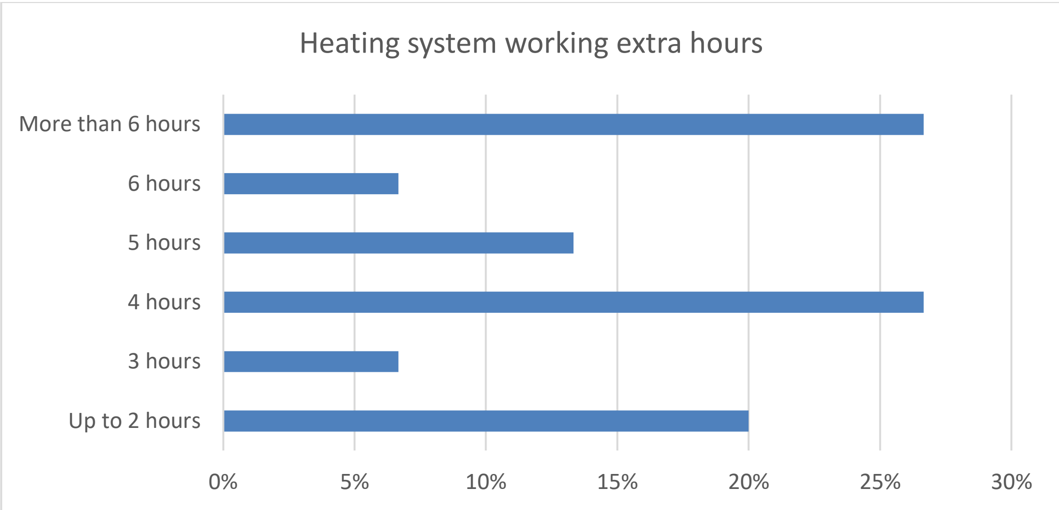

Figure 118: Increase in use of heating system due to COVID-19 restrictive measures – LL participants in V2 and V3 rounds.

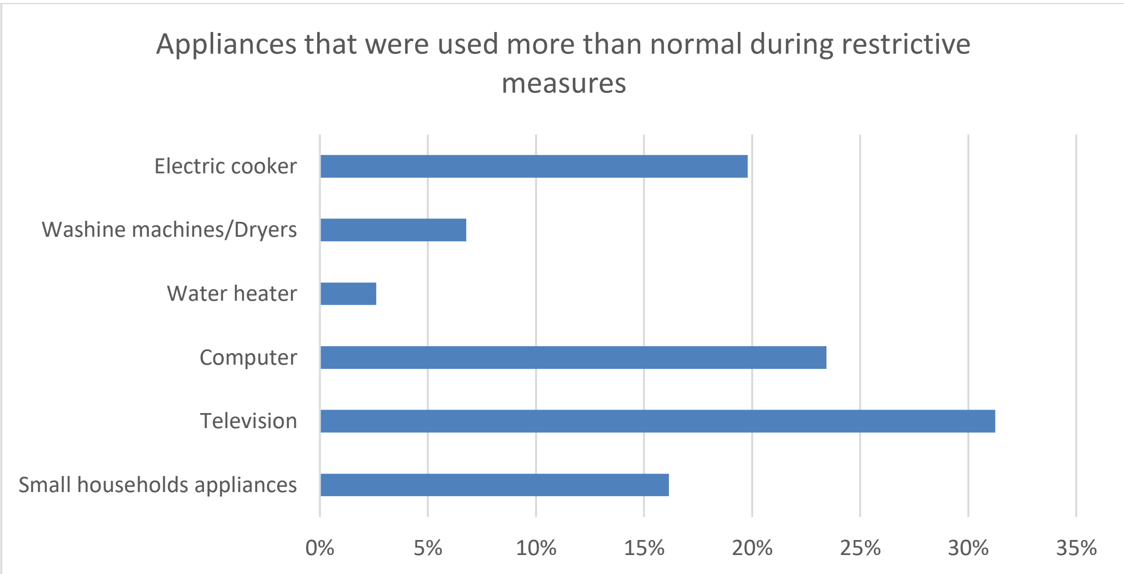

Figure 119: Increase in the operation of electrical appliances due to COVID-19 restrictive measures.

6.2.3 Findings from the LL monitoring equipment

Impacts of the first lockdown on electricity and heating usage

As described in Section 3.2.10, Greece put in place a number of measures and restrictions on movement and business activities to control the COVID-19 spread. The restrictions started on March 10, 2020, suspending the operation of educational institutions of all levels. On March 13, 2020, all cafes, sports leagues bars, museums, shopping centres, sports facilities and restaurants were closed and from March 23 until May 4, 2020, all non-essential movements throughout the country were restricted.

To measure the impact of this first lockdown on electricity and heating usage, the electricity consumption and the temperature data of the V2 households (with installed equipment) were analysed for three distinct periods, as follows:

- March 1 to March 10 (the period immediately before any kind of restrictions were put in place)
- March 23 to May 3 (period of the strict lockdown)
- May 4 to May 10 (immediate period after the strict lockdown)

The measurement of the pandemic-related restrictions on electricity consumption was straightforward based on the records of the electricity meters. The impact on the heating consumption, however, was evaluated qualitatively by examining the differences in the indoor temperature. For a limited number of houses, however, it was also possible to record the operating hours of the heating system (oil-fired burners in all cases).

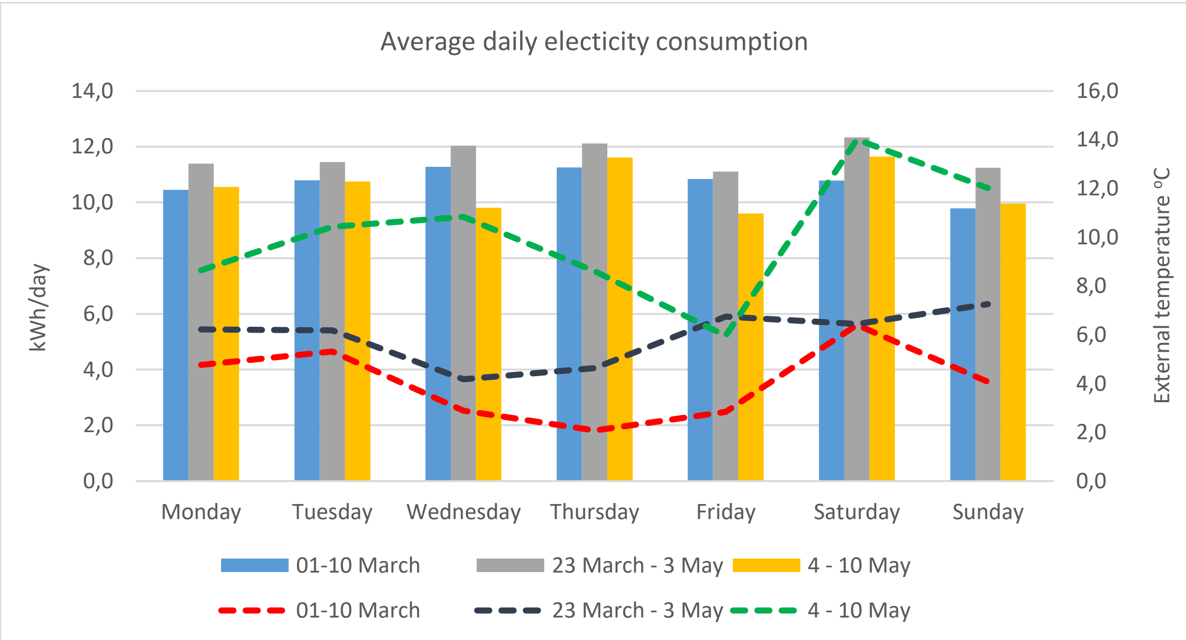

Figure 120: Average daily electricity consumption.

As shown in Figure 120, the average increase in electricity consumption during the lockdown was 9.2% (or approximately 1 kWh per day). In more detail, the average increase in electricity consumption during weekdays was 8.6% and during weekends almost doubled, i.e. it reached 16%. The impact of the strict lockdown on electricity consumption becomes evident when comparing post-lockdown electricity consumption. The average decrease in electricity consumption after the lockdown is 9.5% and practically corresponds to pre-lockdown consumption.

The change in electricity consumption differs in the daily energy profile. According to Figure 121 and Table 10, electricity consumption increases mainly in the morning and till noon (i.e. 9:00-13:00) and in the afternoon (i.e. 18:00-21:00).

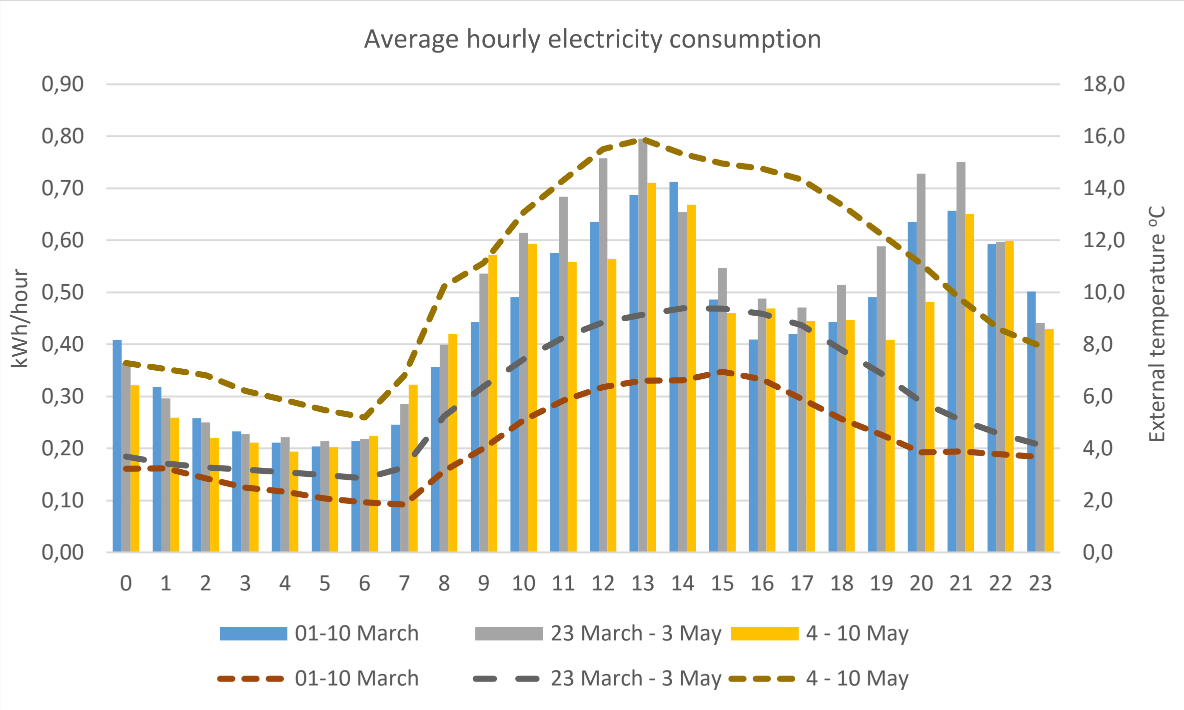

Figure 121: Average daily electricity consumption.

Table 10: Percentage change per hour of the day before and during the lockdown

Hour	% change before and during lockdown	Hour	% change before and during lockdown
0	-10.9%	12	19.3%
1	-6.9%	13	15.7%
2	-3.3%	14	-8.2%
3	-2.0%	15	12.4%
4	4.9%	16	19.1%
5	5.2%	17	12.1%
6	2.1%	18	15.9%
7	16.3%	19	19.9%
8	12.1%	20	14.7%
9	20.9%	21	14.2%
10	25.2%	22	0.7%
11	18.8%	23	-12.1%

The pattern of electricity consumption varies between weekdays and weekends (Figure 122 Figure 123). On weekdays, electricity consumption increases by 10.5% between working hours (i.e. 9:00-17:00), by 15.9% during the morning and till noon (i.e. 9:00-13:00) and by 14.5% in the afternoon (i.e. 18:00-20:00). During weekends, electricity consumption increases by almost 34% between 14:00-17:00 and by more than 20% between 18:00-23:00 (especially in the night hours).

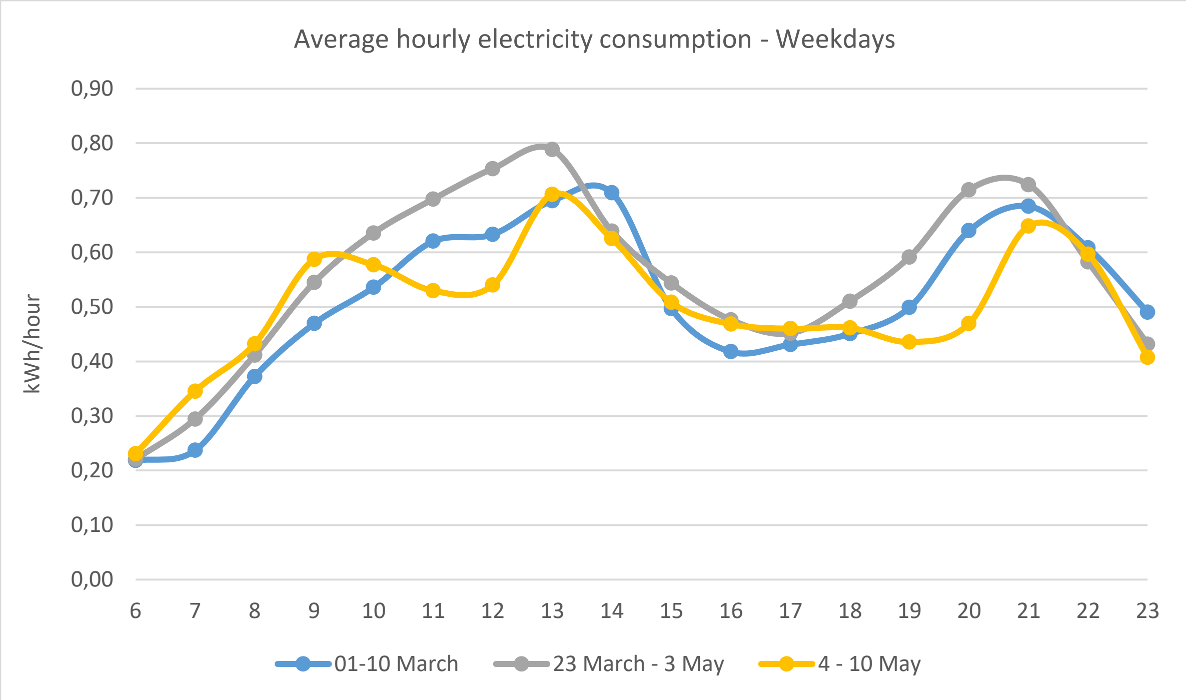

Figure 122: Average hourly electricity consumption on weekdays.

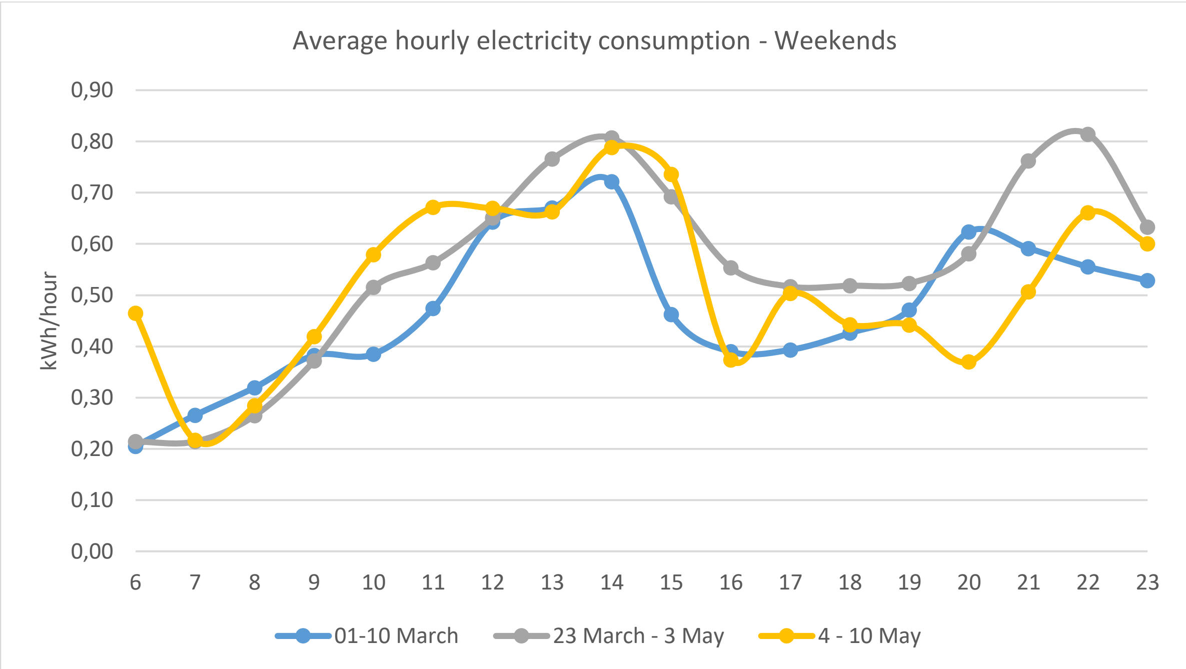

Figure 123: Average hourly electricity consumption at weekends.

The indoor temperature, on average, increases by 1.3% (Figure 124) during the lockdown period. It is mentioned, however, that in the same period the average external temperature increased by 2°C, resulting in a slight reduction in heating degree-days. Further, it is mentioned also that 11 out of the 30 monitored households stated that they operated their heating systems more hours per day during the first lockdown.

A clearer picture is gained by those households where an electricity sensor was installed on the power line of the burner (Figure 125 and Table 11). The average increase in the operating hours of the heating systems was 1.3 (ranging from 0.1 to 3 hours per day). Nevertheless, significant differences exist among households.

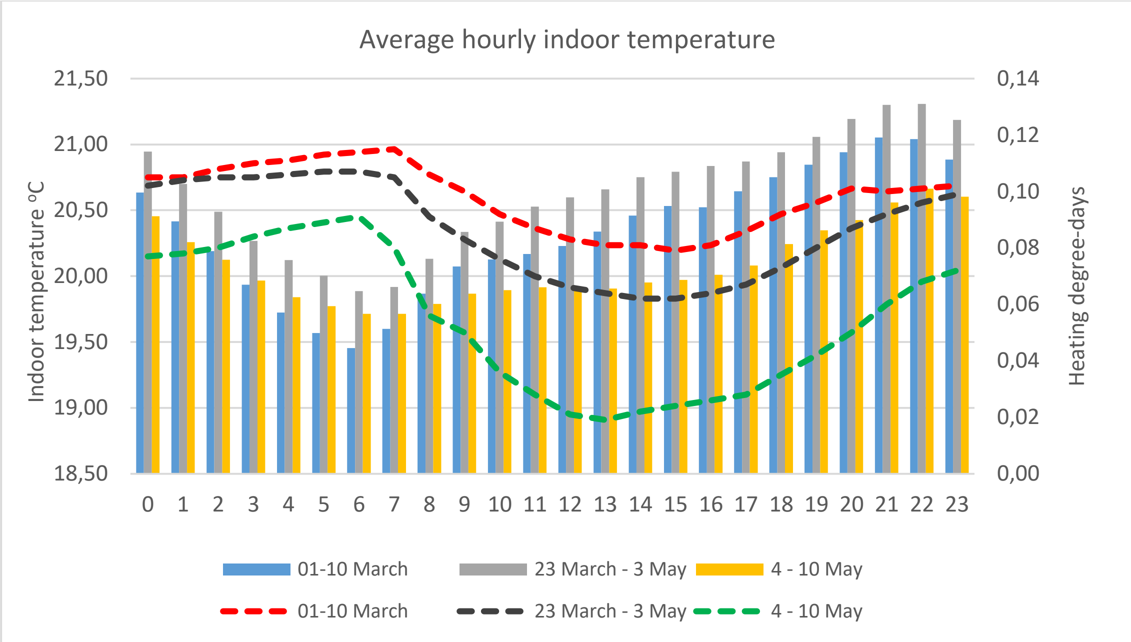

Figure 124: Average hourly indoor temperature and heating degree-days.

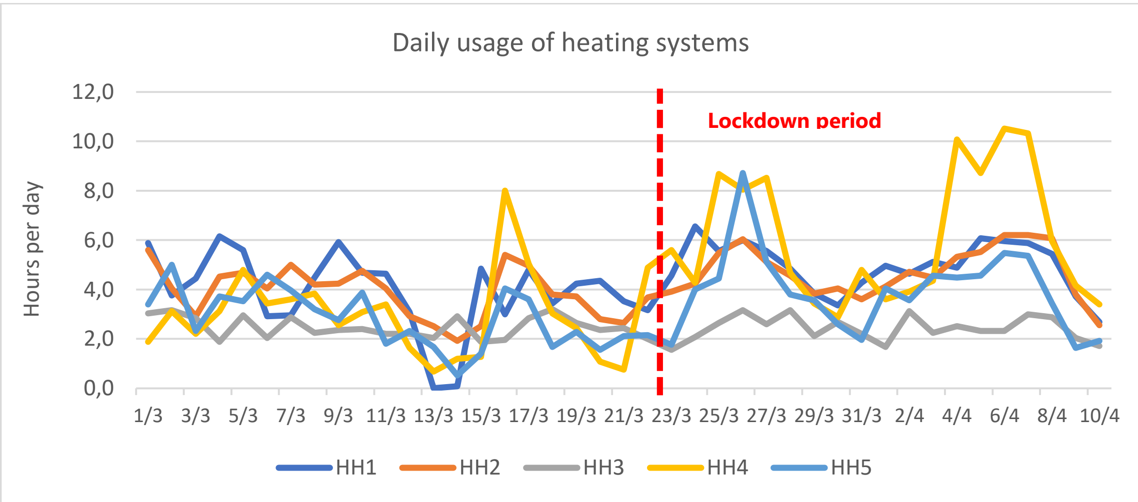

Figure 125: Daily usage of selected heating systems.

Table 11: Average increase in operating hours of selected heating systems

	Operating hours Before/During	Increase in heating hours	HH members	Insulation	House area (m²)	Net monthly income (€)	Income affected by COVID-19
HH1	3.9/5.0	26.1%	4	Yes	130	1500-2000	Yes
HH2	3.9/4.8	23.6%	4	Yes	120	600-900	Yes
HH3	2.4/2.5	1.4%	3	Yes	150	900-1200	Yes
HH4	3.1/6.1	99.5%	3	No	95	900-1200	Yes
HH5	2.8/4.1	47.9%	4	Yes	75	1500-2000	No

To illustrate this case, two households of different income class with 4 members (two adults and two children) are compared in the following Figure 126 Figure 131. The high-income class household presented an average increase in electricity consumption of around 7 kWh per day (or 118%) and indoor temperature of 2°C (or 10%) during the lockdown. On the contrary, the low-income household had a decrease in electricity consumption around 0.8 kWh per day (or 8%) on average and a negligible increase in indoor temperature 0.1°C (0.6%).

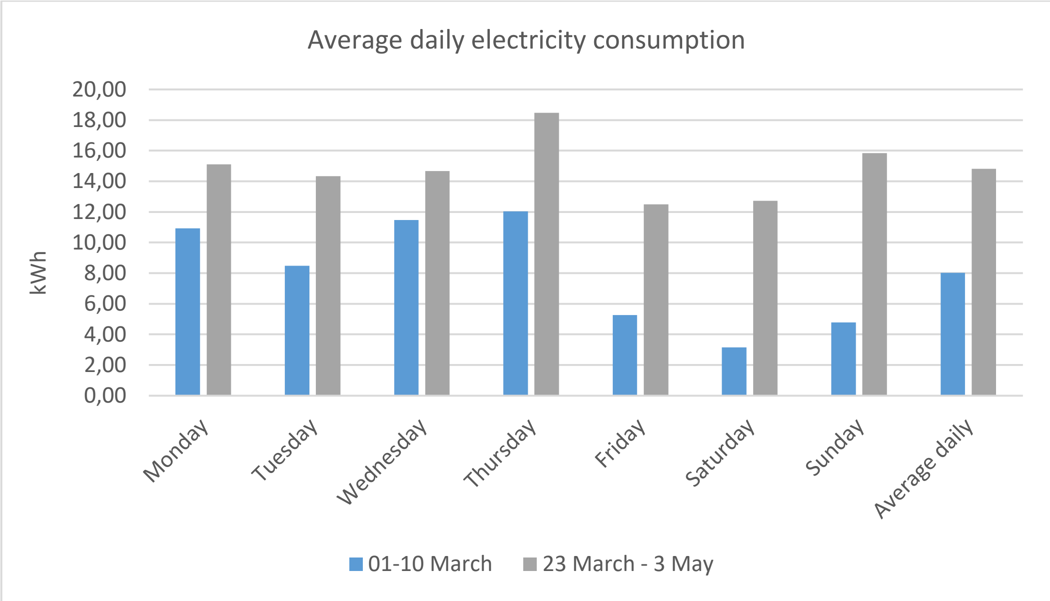

Figure 126: Average daily electricity consumption of a high-income household with 4 members.

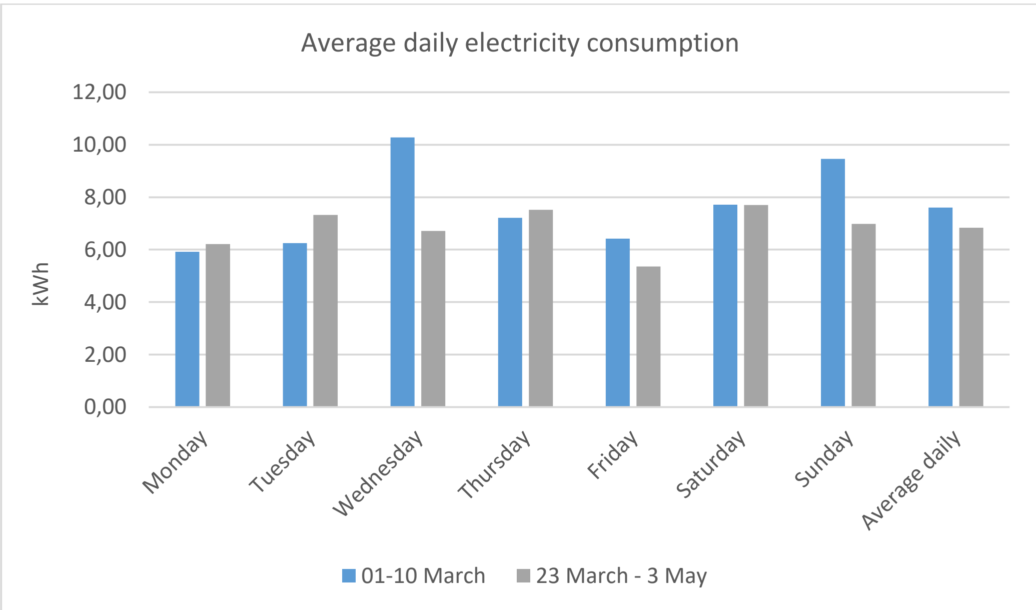

Figure 127: Average daily electricity consumption of a low-income household with 4 members.

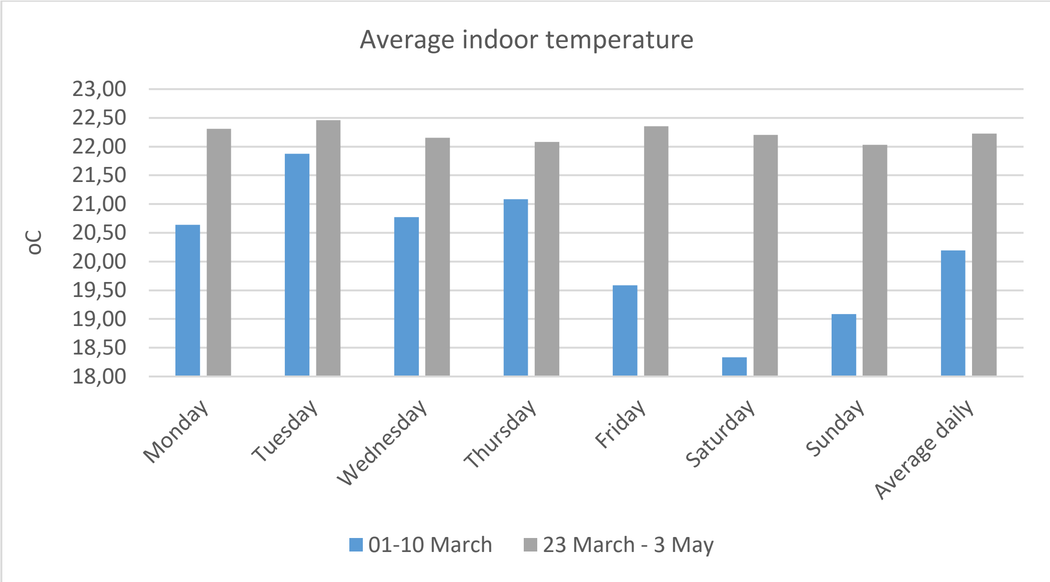

Figure 128: Average daily indoor temperature of a high-income household with 4 members.

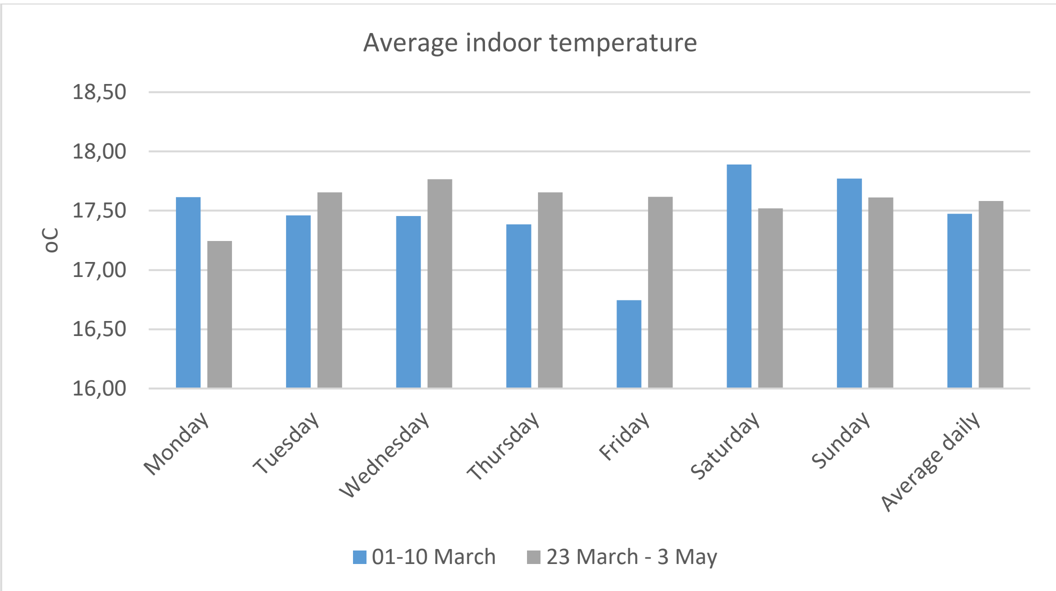

Figure 129: Average daily indoor temperature of a low-income household with 4 members.

Impacts of the second lockdown measures on the electricity and heating usage

From 7 November, the Greek government instituted new measures and restrictions on movement and business activity and a traffic ban during night hours. These measures were taken almost a week or so earlier in the area of Ioannina, including Metsovo. During this second national lockdown, shops (using the "click away" method), hairdressers and other facilities were allowed to open (from December 14, 2020) and kindergartens and primary schools initially remained open (till November 18, 2020), unlike the first lockdown. On January 3, 2021, all the measures relaxed on 14 December were reinstated until 18 January, and on January 11, 2021, primary schools reopened but then closed again.

The second lockdown included once more movement and business operation restrictions, but it is common ground that the enforcement of these measures was not as strict as in the first lockdown. In any case, however, the coronavirus restriction measures change people's routines and cause "anomalies" in the typical electricity consumption profile. In this direction, this section analyses the electricity consumption of the 30 households in which the measurement equipment was installed at the beginning of the V2 round, between October and November 2020 (heating is not examined in this period because October was relatively warm, and the operation of heating systems was limited). Moreover, this section attempts to evaluate the potential long-term impacts of the COVID-19 pandemic, by comparing the electricity consumption and indoor temperature values for the above-mentioned households between two different periods, namely November 2019, December 2019 and January 2020 and November 2020, December 2020, and January 2021.

As shown in Figure 130, the hourly average electrical consumption between October 2020 and November 2020 increased by about 24%.

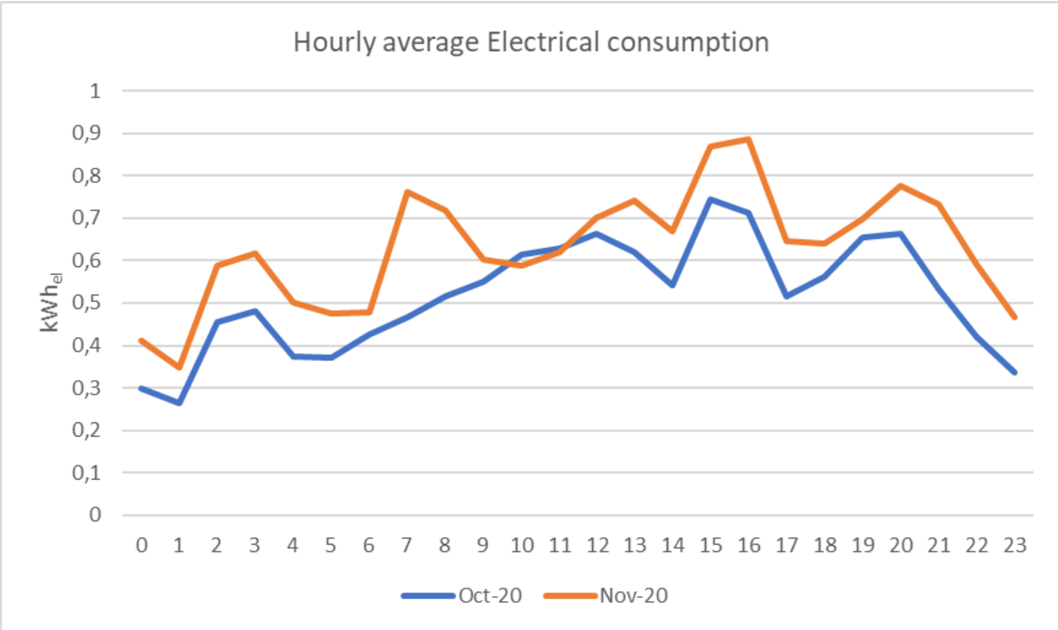

Figure 130: Hourly average electricity consumption before and after the implementation of the second lockdown.

With most shops, schools and offices closed or under certain operating restrictions, it is expected that the electricity demand of a normal working day will match that of a weekend or bank holiday. Further, it is expected to record a different profile at weekends, provided that taverns, café and bars are closed, and movement restrictions are in place. Hence, a distinction was made between weekdays and weekends. According to the analysis, during the second lockdown, there was an increase in the hourly average electrical energy consumption of about 29.3% at the weekends (compared to October 2020) and of about 22.3% during the weekdays, as shown in Figure 131 and Figure 132.

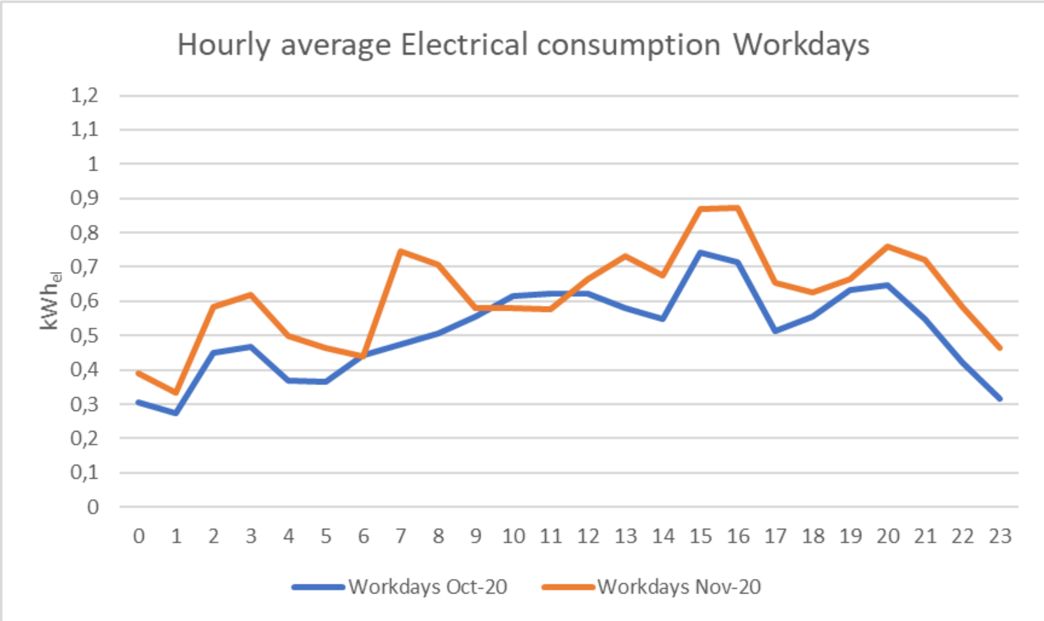

Figure 131: Hourly average electricity consumption before and after the implementation of the second lockdown – Weekdays.

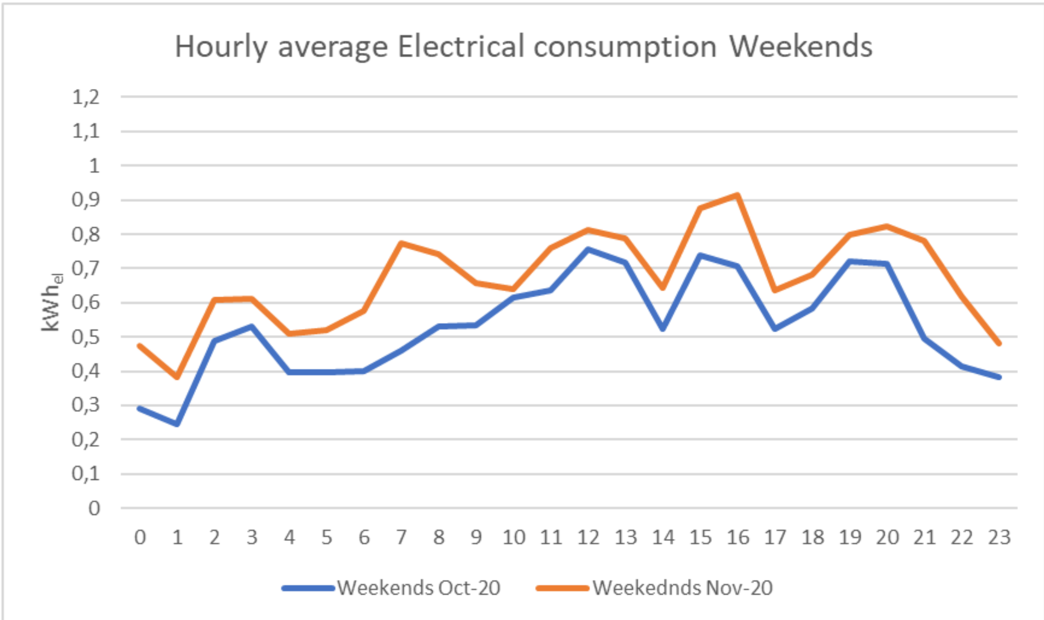

Figure 132: Hourly average electricity consumption before and after the implementation of the second lockdown – Weekends.

Towards studying the impact of the pandemic-related measures on households' electricity consumption, a comparison was made, as mentioned between November and December 2019 and January 2020 and November and December 2020 and January 2021. As shown in Figure 133, Figure 134 and Figure 135, there is an important increase in all three months. More specifically, the increase in the average hourly electricity consumption between November 2019 and November 2020 is 41%, between December 2019 and 2020 is 14% and between January 2020 and January 2021 is 29%, respectively.

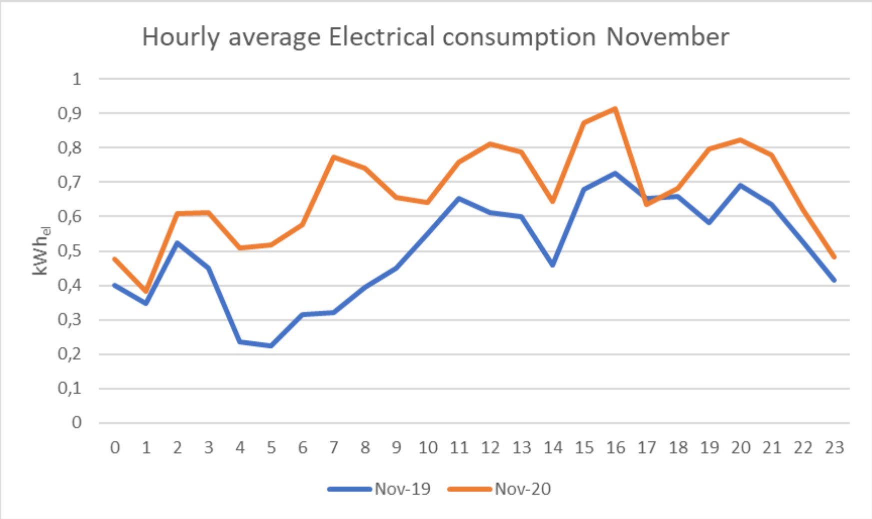

Figure 133: Hourly average Electrical consumption November 2019 and 2020.

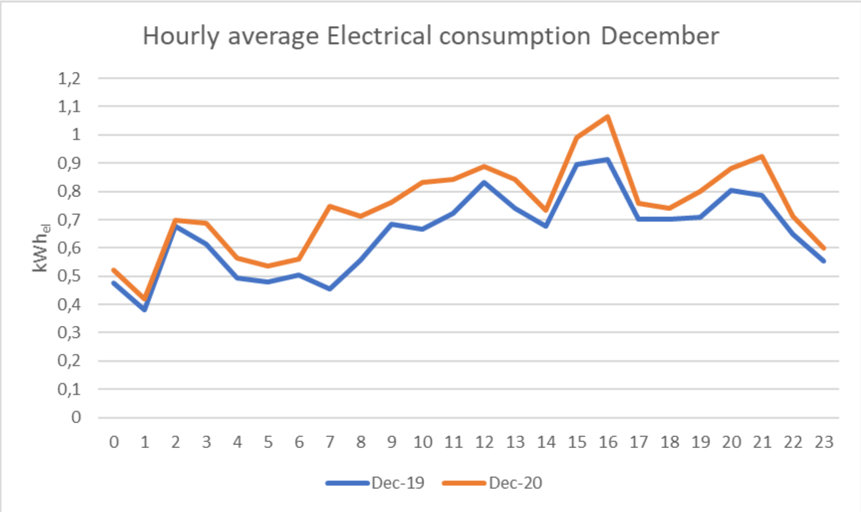

Figure 134: Hourly average Electrical consumption in December 2019 and 2020.

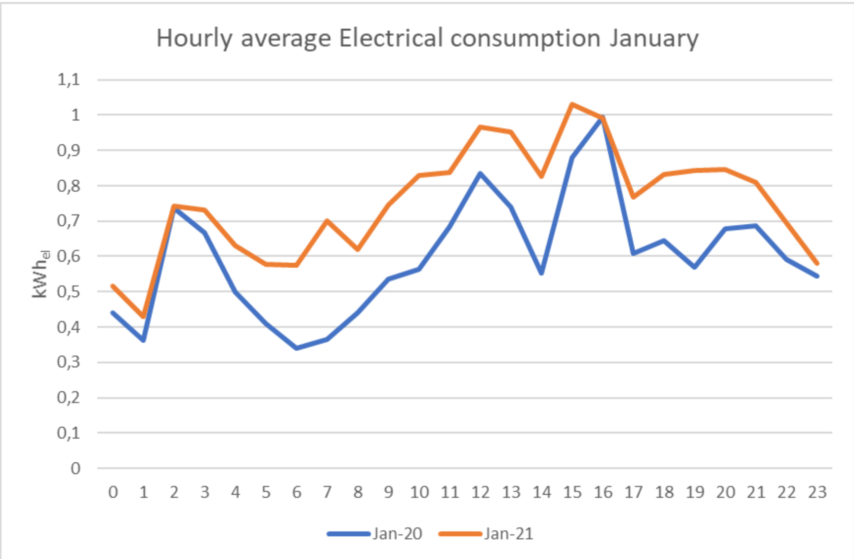

Figure 135: Hourly average Electrical consumption in January 2020 and 2021.

Further, the indoor temperature of the monitored houses was examined for the same periods taking into consideration the heating degree-days for each month. The results are presented in Figure 136, Figure 137 and Figure 138 and Table 12, Table 13 and Table 14. On average, the indoor temperature differences between the pre-COVID and the COVID period are low (around 1% to 2%) and follow the pattern of the heating degree-days. For example, in November 2019 and January 2020, the external temperature was higher than that in November 2020 and January 2021 and the indoor temperature values in the monitored houses are lower during the COVID period. On the contrary, the external temperature was lower in December 2019 compared to December 2020, and the indoor temperature values are higher (always on average) in the COVID period. This is an indication that the heating systems worked, on average, the same hours and the slight differences are attributed to the external temperature (and consequently the heating degree-days).

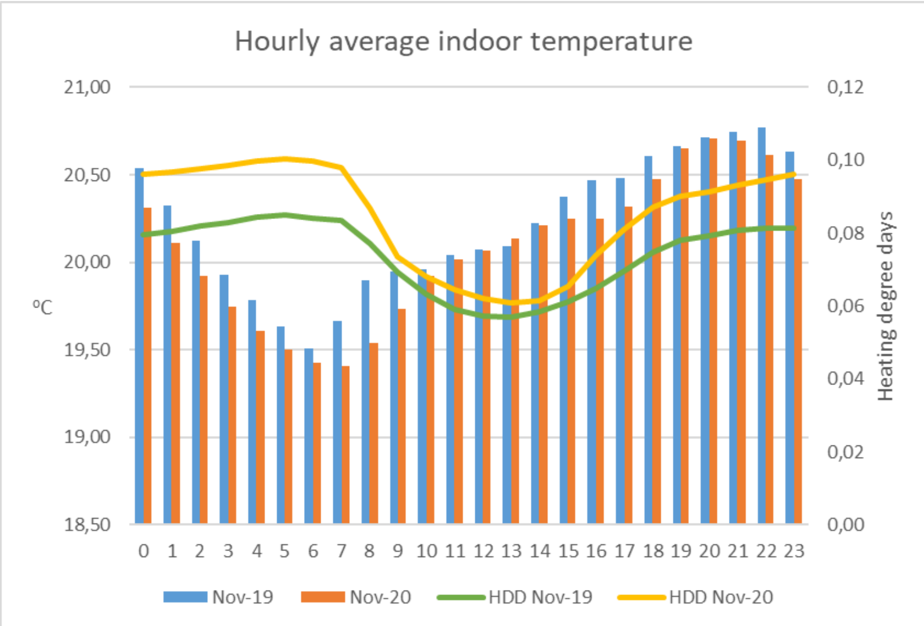

Figure 136: Hourly average indoor temperature for November 2019 and 2020.

Table 12: Percentage change of the average hourly electricity consumption and of the heating degree days per hour of the day for November 2019 and 2020

Hour	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00
% change T	-1,1%	-1,1%	-1,0%	-0,9%	-0,9%	-0,7%	-0,4%	-1,3%
% change HDD	20,8%	20,4%	19,3%	18,8%	17,9%	18,2%	18,8%	17,6%
Hour	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00
% change T	-1,8%	-1,1%	-0,2%	-0,1%	0,0%	0,2%	0,0%	-0,6%
% change HDD	12,3%	6,1%	7,6%	9,1%	8,4%	7,0%	5,3%	6,9%
Hour	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
% change T	-1,0%	-0,8%	-0,6%	-0,1%	0,0%	-0,3%	-0,8%	-0,8%
% change HDD	13,8%	16,7%	16,3%	15,5%	15,3%	15,3%	16,4%	18,0%

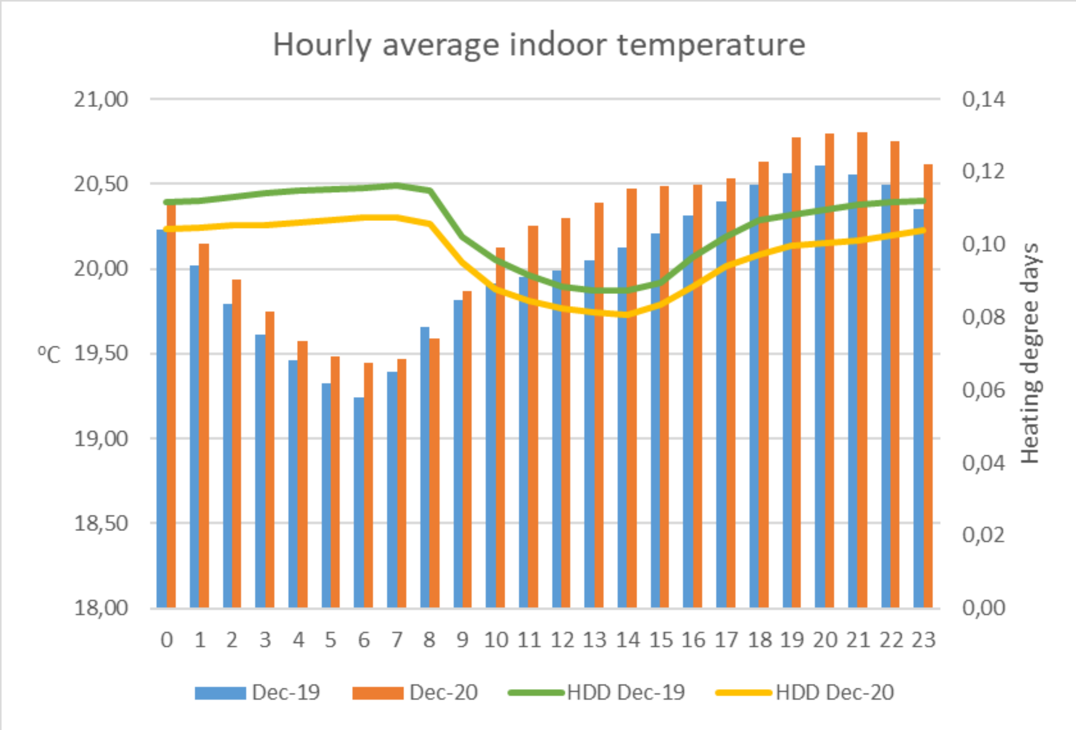

Figure 137: Hourly average indoor temperature for December 2019 and 2020.

Table 13: Percentage change of the average hourly electricity consumption and the heating degree days per hour of the day for December 2019 and 2020

Hour	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00
% change T	0,9%	0,7%	0,7%	0,7%	0,6%	0,8%	1,1%	0,4%
% change HDD	-6,7%	-6,7%	-6,9%	-7,5%	-7,9%	-7,3%	-7,1%	-7,5%
Hour	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00
% change T	-0,3%	0,3%	1,0%	1,5%	1,5%	1,7%	1,7%	1,4%
% change HDD	-7,8%	-7,0%	-8,2%	-7,7%	-6,7%	-6,6%	-7,4%	-6,6%
Hour	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
% change T	0,9%	0,7%	0,7%	1,0%	0,9%	1,2%	1,3%	1,3%
% change HDD	-8,5%	-7,8%	-8,8%	-7,9%	-8,5%	-8,9%	-8,2%	-7,3%

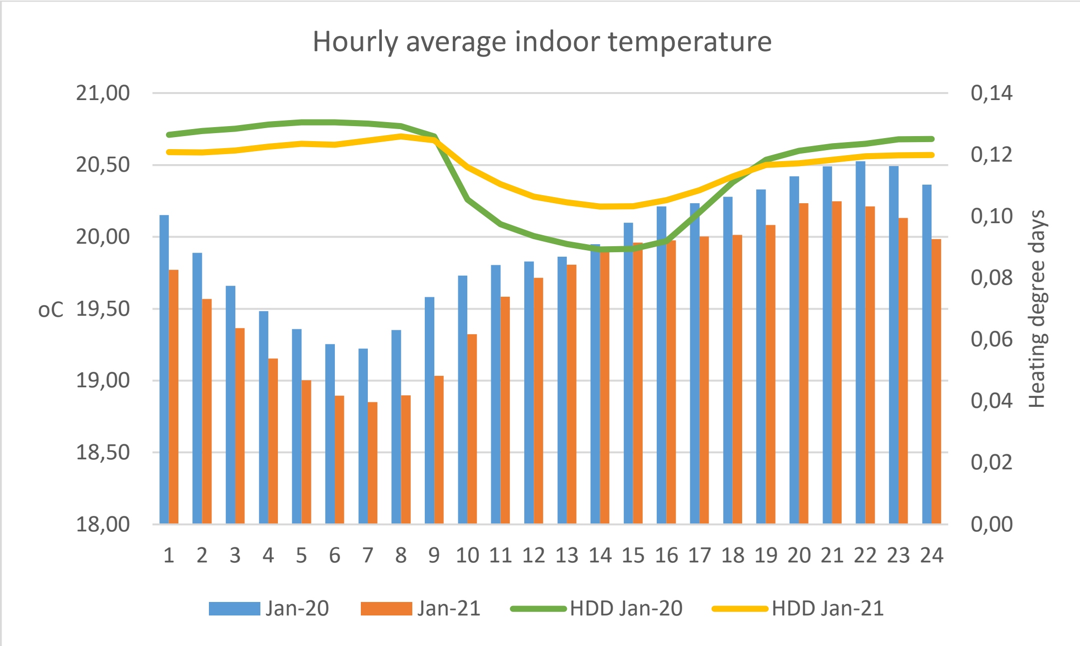

Figure 138: Hourly average indoor temperature for January 2020 and 2021.

Table 14: Percentage change of the average hourly electricity consumption and the heating degree days per hour of the day for December 2019 and 2020

Hour	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00
% change T	-1,9%	-1,6%	-1,5%	-1,7%	-1,8%	-1,9%	-1,9%	-2,3%
% change HDD	-4,5%	-5,4%	-5,5%	-5,5%	-5,3%	-5,5%	-4,2%	-2,5%
Hour	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00
% change T	-2,8%	-2,1%	-1,1%	-0,6%	-0,3%	-0,2%	-0,7%	-1,2%
% change HDD	-1,0%	10,0%	13,4%	13,7%	14,8%	15,6%	15,5%	14,4%
Hour	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
% change T	-1,1%	-1,3%	-1,2%	-0,9%	-1,2%	-1,5%	-1,8%	-1,9%
% change HDD	7,2%	1,7%	-1,4%	-3,3%	-3,6%	-3,3%	-4,2%	-4,1%

The above-mentioned remark coincides with the fact that only one-third of the households said that they operated their heating system more hours per day. Even if the heating cost does not increase between the two periods, this finding is worrisome because almost half of the households stated that their income reduced during the pandemic. Hence, in the' best-case' scenario, the subjective indicators of energy vulnerability will remain stable, but the already high "energy-cost-to-income" ratio will worsen, especially in the area of the mountain LL where heating is an "inelastic" good.

Further, it should be underlined that there exist certain differences between the households, as was also illustrated in the case of the first lockdown. For example, Table 15 compares the average increase in the operating hours of the heating system between December 2019-2020 and January 2020-2021 for two different households. The first household (HH1) consists of 3 persons, lives in a house of 95 m^2 without insulation, has a net monthly income between 900 and 1200 Euros, which has been affected by the pandemic. The second household (HH2) consists of 4 persons, lives in a smaller and insulated house of 75 m^2, has a higher net monthly income between 1500 and 2000 Euros, which has not been affected by the pandemic. In December 2020, during the pandemic, HH1 increased the usage of the heating system by 1 hour per day on average (around 15%), while HH2 had practically the same usage as in December 2019. In January 2021, HH1 and HH2 increased the usage of their heating systems by

4 hours and 1 hour per day, on average (around 60% and 25%, respectively) compared to January 2020, and by 2 hours and 1 hour per day, on average, compared to December 2020. The indoor average temperature was practically stable for both households, in all four months, verifying the argument that thermal energy is practically an "inelastic" good for the area of interest. To achieve the desired indoor temperature, however, households need to spend an important portion of their income on heating bills. More importantly, HH1, which has a lower income that was affected by the COVID-19 pandemic, needs to spend even more money because it lives in an uninsulated house. As mentioned before, the thermal comfort is not altered but the heating cost as a proportion of total household expenditure increases significantly.

Table 15: Average increase in operating hours of selected heating systems between December 2019-2020 and January 2020-2021

	Operating hours Before/During	Increase in heating hours	Average indoor temperature Dec-19/Dec-20 Jan-20/Jan-21	Average external temperature Dec-19/Dec-20 Jan-20/Jan-21	HH members	Insula-tion	House area (m²)	Net monthly income (€)	Income affected by COVID-19
HH1 Dec	7.3/8.3	14.7%	20.2 ºC /20.3 ºC	3.2ºC/4.3 ºC	3	No	95	900-1200	Yes
HH1 Jan	6.6/10.5	58.7%	19.9 ºC /20.2 ºC	1.7 ºC /1.6 ºC					
HH2 Dec	3.8/3.9	1.8%	21.3 ºC /21.3 ºC	3.2ºC/4.3 ºC	4	Yes	75	1500-2000	No
HH2 Jan	4.1/5.2	25.2%	21.1 ºC /21.6 ºC	1.7 ºC /1.6 ºC					

7. Conclusions

The operation of the mountainous LL activities in Metsovo, Greece, included the following steps:

- Information campaigns;
- Benchmarking;
- Training of the Home Energy Advisors;
- Organisation of the first energy café;
- Recruitment of Living Lab Participants (for the V1 LL activities);
- Market segmentation;
- Home visits from the Energy Advisors;
- Installation of monitoring equipment ('smart meters' and temperature and humidity monitors);
- Operation of an Information Centre;
- ICT tools;
- Evaluation of impacts.

Different kind of data was gathered (e.g. measurements of electricity consumption and indoor temperature and humidity from real-time sensors, ambient meteorological conditions from a meteorological station operated by the NTUA, qualitative and quantitative information from questionnaires during the Energy Advisors' visits and the energy café, etc.). Further, a second social survey (i.e. ex-post assessment survey) was conducted to study the impact of the project, the impact of the COVID-19 pandemic on the local community as well as to conduct a Choice Experiment to study households' preferences regarding the role of energy vulnerability in energy-saving interventions.

Based on the activities of the project in the area of Metsovo (i.e. social surveys and LL activities), the main conclusions drawn are as follows:

- The main problem faced by the local people in the mountainous LL is the excess cost of heating. As a result, they usually tend to underestimate the burden of electricity costs. The LL measurements, however, showed that important reductions in energy bills may be gained from reducing electricity consumption (e.g. when replacing old, energy-consuming, appliances). Thus, further attention needs to be paid to electricity conservation measures. In the same direction, a solution needs to be found regarding the use of solar water heaters in the settlement. As has been mentioned before, the use of solar panels is not allowed today. Yet, the estimates showed that households using electric water heaters spend on electricity around 350-400 Euros per year more than those without electric boilers.
- Thermal insulation is important in Metsovo because the area experiences a high number of heating degree-days. Based on the stated heating expenses and the engineering model calculations, the presence of thermal insulation leads to 30% lower heating expenses, on average.
- The LL activities revealed that many diesel-fired heating systems had a low-efficiency ratio (even lower than 84% compared to 90% which is the proper rate). The maintenance of the oil burner led to an average increase in the efficiency ratio of 4% (even up to 7%). Regular maintenance of the heating system is a low-cost and effective measure for reducing heating expenses.
- In some cases, zero-cost behavioural changes, like setting the thermostat to the right temperature, may result in a significant reduction in the heating cost. For example, it was shown that if the indoor temperature exceeds 20°C, heating expenses can increase even by 1,000 €/year. This is another reason why replacing old analogue thermostats with digital ones is a useful and cost-efficient measure.

Overall, considering the total number of households that took place in the three LL rounds, i.e. 150 or 442 people, the following benefits are estimated:

- STEP-IN helped 335 people
    - Better understanding of energy bills: 75 people
    - Change in everyday habits: 96 people

- Change/maintenance of the heating system: 56 people (19 houses)
- More efficient use of the heating system: 53 people
- Motivated to implement insulation measures: 28 people (10 houses)
- Change of electricity provider: 9 people (3 households)
- Use of night tariff: 11 people (4 households)

- STEP-IN improved the quality of life of 170 people
  - Improved thermal comfort: 74 people
  - Energy cost reduction: 41 people
  - Moisture/mould reduction: 46 people
  - Payment of utility bills on time: 10 people
  - Replaced defective appliance/insulate the house: 5 people (2 houses)
- Actual and potential heating energy savings achieved during the project (on an annual basis):
  - Heating energy savings due to heating system maintenance: 19,640 kWh_{th}
  - Heating energy savings due to replacement of thermostats: 52,840 kWh_{th}
  - Heating energy savings due to insulation: 220,260 kWh_{th}
  - Electricity energy savings due to the replacement of old appliances: 3,200 kWh_{el}
- Potential reduction in CO_2 emissions: 66.4 tn per year

Further, taking into account the results of the ex-post assessment survey and the total number of households in the Municipality of Metsovo (after excluding those who participated in the LL to avoid double-counting), it is estimated that the STEP-IN information and advice material reached more than 240 households or 670 people. In particular, the following benefits are estimated:

- STEP-IN helped 525 people
  - Better understanding of energy bills: 365 people
  - Change in everyday habits: 365 people
  - Change/maintenance of the heating system: 185 people (about 70 houses)
  - More efficient use of the heating system: 185 people
  - Motivated to implement insulation measures: 40 people (15 houses)
- STEP-IN improved the quality of life of 305 people
  - Improved thermal comfort: 110 people
  - Energy cost reduction: 60 people
  - Moisture/mould reduction: 25 people
  - Payment of utility bills on time: 25 people
- Potential heating energy savings: 85 houses
  - Heating energy savings due to heating system maintenance: 86,520 kWh_{th} per year (based on savings of 4% and average heating energy of 30,900 kWh_{th} per household for 70 households)
  - Heating energy savings due to insulation: 139,050 kWh_{th} per year (based on savings of 30% and average heating energy of 30,900 kWh_{th} per household for 15 households)
- Potential reduction in CO_2 emissions: 51 tn per year

As regards the general context of the LL, the following methodological remarks can be made:

- Even when there is a great interest in the local community on how to reduce energy consumption and spending, or how to improve the thermal comfort in their homes, it is not easy to engage households committed to the activities of the LL. Paying long and often visits for collecting the energy data or assigning tasks, such as keeping a complete energy diary for the use of heating and electrical appliances daily, is not possible without causing annoyance (or even withdrawal). Thus, a "compromise" between what is planned and what is acceptable from the local community needs to be found.
- Towards gaining the local community's trust and support, it is more than useful to involve local people in the LL activities. For instance, people who seemed reluctant to let the Energy Advisors install the monitoring equipment to the electric switchboard were appeased when local electricians were hired and paid visits together with the Energy Advisors.

- Discussing the benefits of the project is simply not enough. It is more than important to undertake promoting actions to motivate the local community. For example, in the case of the mountainous LL servicing for free oil-fired heating systems was strongly discussed among the members of the local community and promoted a sense of ownership of the LL actions.
- Relying on questionnaires for collecting information about the estimated heating and electricity consumption and spending is inevitable. Yet, in some cases, the estimated and measured figures do not fully coincide. This stands particularly for the electricity costs, as the electricity bills in Greece include charges for local taxes and public TV licence.
- People seem to be more convinced to get involved in energy conservation and to adopt the advices provided by the Energy Advisors when presented with actual measurements, as discussed later on. For example, less than 30% of those who didn't have monitoring equipment installed said that they noticed an improvement in their quality of life, whereas around 60% of those who had monitoring equipment installed said that they noticed an improvement in their quality of life. Further, 80% of the participants who had monitoring equipment installed said that the installation of electricity consumption meters motivated them to check regularly their electricity consumption and almost all of the participants with temperature and humidity monitoring equipment said that they were helped in taking energy efficiency decisions, i.e. replacement of thermostat, purchase of a dehumidifier, etc.
- Using monitoring equipment is not only helpful towards convincing people to implement energy-saving measures (either technological or behavioural) but also useful towards identifying problems in the operation of malfunctioned appliances. In one case, in the mountainous LL, a defective appliance, namely a refrigerator, was found and replaced, saving hundreds of Euros per year. Moreover, temperature and humidity sensors revealed significant differences within certain residences that use non-central heating systems or are unable to heat the total house area.
- The Information Centre did not seem to work well, at least at the mountainous LL. This suggests that it is not always easy to inform energy vulnerable households because they need to be proactive to change their status quo. This problem is not unprecedented. As referred to in DellaValle, (2019), in Malta, there was a scheme to support energy vulnerable households. Every year, €500,000 vouchers were not claimed. Hence, the government changed the scheme without changing the eligibility criteria. More specifically, households identified as vulnerable categories were automatically enrolled in the voucher program and receive a credit to their bill through their service provider. Also, the Italian Regulatory Authority for Energy, Networks and Environment has advanced a proposal to automatically enrol energy vulnerable households automatically in subsidy programs. In the same direction, during the first energy café which was held at the premises of NTUA, the participants said that moving closer to the Metsovo's centre could attract more people. Thus, it was decided to move the next energy cafés to a more familiar place, either to the Municipality Hall or a local café. Indeed, the second energy café was held at the Municipality Hall. Unfortunately, the third energy café was organised as an online event to respect the social distancing measures in force.
- It seems that the remote operation of the LL cannot fully replace face-to-face LL activities. For instance, remote advice and assistance on energy issues are feasible on a one-to-one basis. Yet, participatory actions, such as energy cafés, at least in the mountainous LL didn't work well. Further, remote assistance and advice may not reach the most vulnerable households, e.g. those who do not have internet access (or even telephone access in many cases). This is also reflected in the achieved energy savings in the three rounds. More specifically, the energy savings in the V1, V2 and V3 rounds were 9.2%, 5.4% and 3.9% of the total energy consumed by the households.

From a policy perspective, many interesting remarks can be made based on the Choice Experiment conducted in the ex-post assessment survey. First, it seems that the energy retrofit is the most preferred option (the other two options were upgrading/replacement of the heating system and replacement of old household appliances). This may be related to unobserved benefits of retrofits, e.g. insulation may enhance occupant's comfort and increase future resale value. Second, it is important to underline that the preferences of vulnerable households depend on the different aspects of energy poverty. For instance, those who are unable to keep a level of thermal comfort at home are less willing to invest in energy efficiency while the opposite stands for those who are faced with damp problems or arrears in bills. This is attributed to the fact that a significant percentage of the households who report thermal discomfort (at least in the study area) belong to the lower-income group. Third, vulnerable households hold different willingness to pay (WTP) values for each of the proposed interventions. These differences are not observed only across groups but also between groups. For example, those who claim inability to keep their houses adequately warm are willing to pay around 2.8 Euros for every Euro saved on an annual basis from the upgrading of the heating system, whereas those who face damp problems are willing to pay around 5 Euros, respectively. Finally, the socio-demographic characteristics of the respondents, which are known to be related to energy poverty, such as income and age, also possess a crucial role in the energy efficiency decision-making process. In general, elderly people, who are more prone to energy poverty, are at the same time more reluctant to invest in energy saving. The same conclusion is drawn for low-income households. Further, the estimated values show that households who are struggling to live on their income can afford to pay for energy retrofits only one-third of the amount estimated for households who are living comfortably. All in all, these findings are worrisome because, without support to implement structural measures like energy efficiency, elderly and low-income households could be trapped in the vicious circle of energy poverty, as previous studies suggest.

Finally, concerning the impact of the COVID-19 pandemic (and the restrictions adopted to prevent its spread) on households' socioeconomic status and energy consumption, the main findings from the survey and the LL activities are the following:

- About half of the households in the study area reported that their income decreased during the pandemic. Among those who stated that the household's income was affected by the restrictive measures, 20% claimed the decrease to be in the range of 5-25%, 40% in the range of 25%-45%, and the rest reported a reduction in income over 50%. It should be noted that there were households (10%) that reported a decrease in their income in the range of 80-100%.
- Almost 3 out of 10 households that participated in the ex-post social survey stated that during the restrictive measures due to Covid-19 their heating system worked more hours than usual. About 10% of them reported working for an extra 1 to 2 hours and 80% reported working for between 3 to 6 hours. Further, 55.6% of the participants reported an increase in the operation of some electrical appliances during the restrictive measures. As far as the LL participants in rounds V2 and V3 are concerned, also 3 out of 10 households said that they used more their heating systems during the lockdown. In particular, 20% reported extra 1 to 2 hours, 24% between 3 and 4 extra hours, 20% between 5 and 6 extra hours and the rest (i.e. 27% more than 6 hours. Also, 64% of them reported an increase in the operation of some electrical appliances during the restrictive measures.
- Based on the measurements taken by the monitoring equipment, it was found that the average increase in electricity consumption during the first lockdown was 8.6% (or approximately 1 kWh per day). In more detail, the average increase in electricity consumption during weekdays was 9.2% and during weekends almost doubled, i.e. it reached 16%. During the second lockdown that started in late October, early November the hourly average electrical consumption between October 2020 (before the lockdown) and November 2020 increased by about 24%. In particular, the increase in the hourly average electrical energy consumption was about 29% at the weekends (compared to October 2020) and 22% during the weekdays. Further, the increase in the average hourly electricity consumption between November 2019 and November 2020 was 41%, between December 2019 and 2020 was 14% and between January 2020 and January 2021 was 29%, respectively.
- Based on a limited number of households where an electricity sensor was installed on the power line of the burner, it was found that the average increase in the operating hours of the heating systems was 1.3 (ranging from 0.1 to 3 hours per day). On a percentage base, this corresponds to an average increase of 39% (from 1.5% to 99.5%).

- The average increase in the house temperature was around 1%. This remark coincides with the fact that only one-third of the households said that they operated their heating system more hours per day. Even if the heating cost does not increase between the two periods, this finding is worrisome because almost half of the households stated that their income reduced during the pandemic. Hence, in the' best-case' scenario, the subjective indicators of energy vulnerability will remain stable, but the already high "energy-cost-to-income" ratio will worsen, especially in the area of the mountain LL where heating is an "inelastic" good. It is important to mention, also, that significant differences exist between the households depending on the housing characteristics, socio-demographic, and heating system characteristics. The analysis of specific examples shows that low-income households are forced to spend an even higher proportion of their income on heating and electricity cost to achieve the desired indoor temperature.

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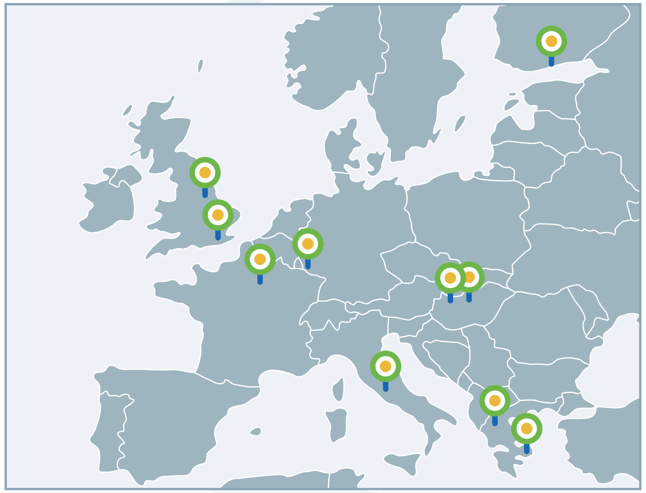
9. Annexes

Annex I: STEP-IN's main leaflet (in Greek)

Η κοινοπραξία STEP-IN

Οι ερευνητικοί εταίροι του STEP-IN διαθέτουν σημαντική εμπειρία στον τομέα της ενεργειακής απόδοσης και της στήριξης των καταναλωτών: φιλανθρωπικές οργανώσεις, ενώσεις καταναλωτών, δήμοι, πάροχοι ενέργειας, ρυθμιστικές αρχές, ερευνητικά ιδρύματα και πανεπιστήμια. Όλοι οι εταίροι αφιερώνονται στο να κάνουν τη διαφορά στη ζωή των καταναλωτών.



Οι εταίροι δεσμεύονται να φέρουν τις γνώσεις και την εμπειρία τους στο πρόγραμμα, ώστε πραγματικά να κάνουν τη διαφορά στις ζωές εκείνων που έχουν ανάγκη.

Rod McCall
STEP-IN Coordinator, Luxembourg Institute of Science and Technology

Θα θέλατε να συμμετάσχετε στο STEP-IN και να λάβετε ενεργειακές συμβουλές από εξειδικευμένους συμβούλους;

Το STEP-IN στοχεύει στη βελτίωση της ποιότητας ζωής σας από πλευράς θερμικής άνεσης, μείωσης των ενεργειακών δαπανών, γνώσης της χρήσης ενέργειας και καλύτερης κατανόησης των λογαριασμών ενέργειας.

Παρακαλώ επικοινωνήστε με την τοπική ομάδα του Βιωματικού Εργαστηρίου Μετσόβου για περισσότερες πληροφορίες και συμμετοχή σε αυτό.

ΒΙΩΜΑΤΙΚΟ ΕΡΓΑΣΤΗΡΙΟ ΜΕΤΣΟΒΟΥ

Καθηγητής Δημήτρης Χ. Καλιαμπάκος
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ΣΥΝΤΟΝΙΣΤΗΣ ΤΟΥ ΕΡΓΟΥ

Rod McCall
Luxembourg Institute of Science and Technology (LIST)
Belvaux, Luxembourg
roderick.mccall@list.lu

Επισκεφθείτε το STEP-IN στο Facebook!

STEP-IN

Βελτίωση της ποιότητας ζωής

Βελτίωση της ενεργειακής απόδοσης

Βελτίωση των επιπέδων άνεσης

Το STEP-IN χρηματοδοτείται από το πρόγραμμα έρευνας και καινοτομίας «Horizon 2020» της Ε.Ε., με την υπ' αριθ. 785125 συμφωνία επιχορήγησης

STEP-IN

Χρήση Βιωματικών Εργαστηρίων για βελτίωση της ενεργειακής απόδοσης και των επιπέδων άνεσης

Το Ευρωπαϊκό πρόγραμμα STEP-IN βοηθά τους καταναλωτές στη χρήση της ενέργειας

Το Έργο συνεργάζεται με καταναλωτές για να συμβάλει στη βελτίωση της ποιότητας ζωής, της ενεργειακής απόδοσης και των επιπέδων άνεσης του νοικοκυριού. Επίσης παρέχει συμβουλές βέλτιστων πρακτικών σε φορείς που συνεργάζονται με καταναλωτές και συμβάλλει στην ανάπτυξη νέων κατευθυντήριων γραμμών και πολιτικών. Το STEP-IN στηρίζεται σε προηγούμενες έρευνες και ο σχεδιασμός του επιτρέπει συγκρίσεις με πρότερα ευρήματα.

Το STEP-IN συνεργάζεται με πολίτες σε τρία Βιωματικά Εργαστήρια στην Ευρώπη, ένα εκ των οποίων είναι στο Μέτσοβο. Οι τοπικοί καταναλωτές έχουν την καλύτερη γνώση για ενεργειακά ζητήματα της περιοχής τους όπως η ενεργειακή κατανάλωση, η ενεργειακή απόδοση, τα ενεργειακά κόστη, τα καύσιμα κλπ.

Τα οφέλη σας από το STEP-IN

Τα Βιωματικά Εργαστήρια του STEP-IN είναι συμμετοχικά και επικεντρώνονται στον καταναλωτή, για να φέρουν πραγματικά μακροπρόθεσμα οφέλη στις κοινότητες, τα νοικοκυριά και τους καταναλωτές. Οι υπηρεσίες που προσφέρονται από τα Βιωματικά Εργαστήρια είναι δωρεάν.

Ενεργειακά Καφέ

Μπορείτε να συναντηθείτε με ειδικούς στην εξοικονόμηση ενέργειας και να λάβετε συμβουλές, σε ένα χαλαρό περιβάλλον με ποτό και φαγητό. Τα ενεργειακά καφέ δίνουν τη δυνατότητα σε τοπικά νοικοκυριά να κάνουν ερωτήσεις και να συζητήσουν με ενεργειακούς ειδικούς.

Οικιακοί ενεργειακοί σύμβουλοι

Οι ενεργειακοί σύμβουλοι επισκέπτονται το σπίτι σας και παρέχουν λεπτομερείς και εξειδικευμένες συμβουλές και εκπαίδευση σε θέματα μείωσης της ενεργειακής σπατάλης όπως

- Αποδοτική χρήση του συστήματος θέρμανσης
- Εξοικονόμηση ενέργειας μέσω μόνωσης, ανακαίνισης, αποδοτικών συσκευών, λαμπτήρων LED κλπ.
- Αλλαγή του προμηθευτή ενέργειας

Χρήση εργαλείων ΤΠΕ

Εργαλεία ΤΠΕ χρησιμοποιούνται για να απεικονίσουν ενεργειακές πληροφορίες του σπιτιού και να βοηθήσουν εσάς και τον ενεργειακό σύμβουλο να κατανοήσετε καλύτερα την ενεργειακή σας κατανάλωση, τους λογαριασμούς κλπ.

Ενημερωτικές καμπάνιες

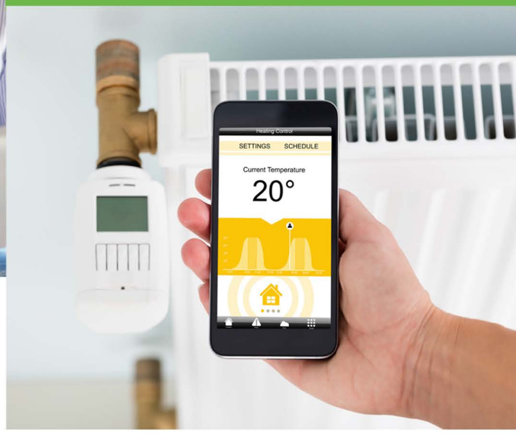
Φυλλάδια, αφίσες, ενημερωτικά δελτία και εκπαιδευτικές δραστηριότητες παρέχουν πρόσθετη υποστήριξη για βιώσιμη χρήση της ενέργειας και ενεργειακά αποδοτικές επιλογές στην καθημερινή ζωή.

Annex II: STEP-IN's second energy café poster used in Metsovo (in Greek)

Energy Café

Θα ήθελες να γίνεις μέρος του STEP-IN και να λάβεις ενεργειακές συμβουλές από ενεργειακούς συμβούλους και ειδικούς σε θέματα εξοικονόμησης ενέργειας;

Το STEP-IN στοχεύει να βελτιώσει το επίπεδο ζωής , βελτιώνοντας την άνεση στο σπίτι, εξοικονομώντας ενεργειακά κόστη, μαθαίνοντας περισσότερα για το ενεργειακό προφίλ του σπιτιού και κατανοώντας καλύτερα το λογαριασμό ενέργειας



STEP-IN

Επισκεφτείτε τη σελίδα του προγράμματος στο Facebook

Βελτιώνοντας το επίπεδο ζωής
Βελτιώνοντας την ενεργειακή αποτελεσματικότητα
Βελτιώνοντας τα επίπεδα άνεσης

STEP-IN has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 785125

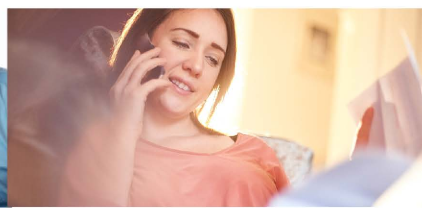
ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ
ΜΕΤΣΟΒΙΟ ΚΕΝΤΡΟ ΔΙΕΠΙΣΤΗΜΟΝΙΚΗΣ ΕΡΕΥΝΑΣ

Δήμος Μετσόβου

Σάββατο 25 Ιανουαρίου 2020 ώρα 18:00

στην αίθουσα του Δημοτικού Συμβουλίου στο Δημαρχείο Μετσόβου





Annex III: Questionnaires used by the Energy Advisors at the initial and the evaluation phase (in Greek)

ΕΡΩΤΗΜΑΤΟΛΟΓΙΟ ΕΝΕΡΓΕΙΑΚΩΝ ΣΥΜΒΟΥΛΩΝ ΓΙΑ ΤΙΣ ΚΑΤΟΙΚΙΕΣ

Α. ΚΥΡΙΑ ΧΑΡΑΚΤΗΡΙΣΤΙΚΑ

1. Ημερομηνία κατασκευής ……………………………………………………………………………………………
2. Τύπος κατοικίας

Μονοκατοικία/ένας όροφος ☐
Μεζονέτα ☐
Διαμέρισμα ☐

3. Επιφάνεια (m2) ……………………………………………………………………………………………………….
4. Θερμαινόμενη επιφάνεια (m2) ………………………………………………………………………………….
5. Αριθμός μελών νοικοκυριού ……………………………………………………………………………………..
6. Αριθμός υπνοδωματίων ……………………………………………………………………………………………

Β1. ΧΑΡΑΚΤΗΡΙΣΤΙΚΑ ΚΤΙΡΙΑΚΟΥ ΚΕΛΥΦΟΥΣ

1. Εξωτερικοί Τοίχοι

   Υλικά ……

   Μόνωση ΝΑΙ/ ΟΧΙ

2. Φέροντα στοιχεία

   Κρέμαση δοκαριού (cm) …………………………………………………………………….

   Μόνωση ΝΑΙ/ ΟΧΙ

3. Οροφή σε επαφή με εξωτερικό αέρα ΝΑΙ/ ΟΧΙ

   Μόνωση ΝΑΙ/ ΟΧΙ

   Επιφάνεια (m^2) ……………………………………………………………………………………………………

4. Δάπεδο σε επαφή με εξωτερικό αέρα ΝΑΙ/ ΟΧΙ

   Μόνωση ΝΑΙ/ ΟΧΙ

   Επιφάνεια (m^2) ……………………………………………………………………………………………………

5. Δάπεδο σε επαφή με φυσικό έδαφος ΝΑΙ/ ΟΧΙ

   Μόνωση ΝΑΙ/ ΟΧΙ

   Επιφάνεια (m^2) ……………………………………………………………………………………………………

6. Δάπεδο σε επαφή με μη θερμαινόμενο χώρο ΝΑΙ/ ΟΧΙ

   Μόνωση ΝΑΙ/ ΟΧΙ

   Επιφάνεια (m^2) ……………………………………………………………………………………………………

Β2. ΧΑΡΑΚΤΗΡΙΣΤΙΚΑ ΚΟΥΦΩΜΑΤΩΝ

1. Υπάρχουν πατζούρια/ ρολά ΝΑΙ/ ΟΧΙ
2. Υλικό πλαισίου κουφωμάτων

Αλουμίνιο ☐
Ξύλο ☐
PVC ☐

3. Τύπος υαλοστασίου

Μονός ☐
Διπλός, μικρό διάκενο ☐
Διπλός, μεγάλο διάκενο ☐
Διπλό παράθυρο ☐
Άλλο ……

4. Επίπεδο αεροστεγανότητας

Καλό ☐
Μέτριο ☐
Κακό ☐

Γ. ΣΥΣΤΗΜΑ ΘΕΡΜΑΝΣΗΣ

1. Ποιος είναι ο τύπος του κύριου συστήματος θέρμανσης (Σε περιπτώσεις συστημάτων κεντρικής θέρμανσης, χρησιμοποιούμε και το Ερωτηματολόγιο 2. Ζητούμε, εάν υπάρχει, πρόσφατο έντυπο ελέγχου καυστήρα/ συστήματος κεντρικής θέρμανσης)

Κεντρική θέρμανση, πετρέλαιο ☐
Κεντρική θέρμανση, lpg ☐
Κεντρική θέρμανση, καυσόξυλο ☐
Τοπικές μονάδες, σόμπες πετρελαίου ☐
Τοπικές μονάδες, σόμπες υγραερίου ☐
Τοπικές μονάδες, σόμπες καυσοξύλων ☐
Ανοικτό τζάκι ☐
Κλειστό, ενεργειακό τζάκι ☐
Τοπικές αντλίες θερμότητας ☐
Κεντρική αντλία θερμότητας ☐
Θερμοσυσσωρευτές ☐

2. Χαρακτηριστικά κύριου συστήματος θέρμανσης, εκτός των κεντρικών (συμπλήρωση στο Ερωτηματολόγιο 2)

   Ισχύς ……….

   Απόδοση (εάν αναφέρεται στη συσκευή) ………………………………………………………………..

   Αριθμός συσκευών ……………………………………………………………………………………………….

3. Συστήματα αυτοματισμού (σύμφωνα με ΚΕΝΑΚ)

Α	
Β	
Γ	
Δ	

Ψηφιακός θερμοστάτης ΝΑΙ/ ΟΧΙ

4. Υπάρχει δευτερεύον σύστημα θέρμανσης στο σπίτι;

   Προσδιορίστε………

5. Εάν είναι δυνατόν, να ζητηθούν τιμολόγια δαπανών όσον αφορά στην ενέργεια για θέρμανση

Δ. ΣΥΣΤΗΜΑ ΨΥΞΗΣ

- Τέτοια συστήματα, πρακτικά, δε χρησιμοποιούνται στο Μέτσοβο. Παρ' όλα αυτά, εάν υπάρχει σύστημα ψύξης, να σημειωθούν: (α) ο αριθμός των συσκευών, (β) η ισχύς τους, (γ) η απορροφόμενη ηλεκτρική ισχύς από το ταμπελάκι της συσκευής.

Ε. ΣΥΣΤΗΜΑ ΠΑΡΑΓΩΓΗΣ ΖΕΣΤΟΥ ΝΕΡΟΥ ΧΡΗΣΗΣ

1. Τύπος συστήματος

Boiler, πετρέλαιο	
Boiler, lpg	
Boiler, ξύλο	
Ηλεκτρικός θερμαντήρας	

2. Υπάρχει ηλιακός θερμοσίφωνας; ΝΑΙ/ ΟΧΙ

   Τύπος/ μέγεθος boiler (κατ' εκτίμηση) ……………………………………………………………………………………

   Επιφάνεια (κατ' εκτίμηση) (m2) ………………………………………………………………………………………..

ΣΤ. ΗΛΕΚΤΡΙΚΕΣ ΣΥΣΚΕΥΕΣ ΚΑΙ ΕΓΚΑΤΑΣΤΑΣΗ

1. Τύπος ηλεκτρολογικής εγκατάστασης

1Φ	
3Φ	

2. Χρησιμοποιείται στο νοικοκυριό κάποια ειδική χρέωση;

Νυχτερινό Τιμολόγιο	
Κοινωνικό Οικιακό Τιμολόγιο	
ΟΧΙ	

3. Ηλεκτρικές συσκευές με μεγάλα φορτία

Ηλεκτρική κουζίνα	
Πλυντήρια	
Ηλεκτρικός Θερμοσίφωνας	
Άλλο	

4. Φωτισμός

   Τύπος κυρίως χρησιμοποιούμενων λαμπτήρων ……………………………………………………………………

   Εκτίμηση αριθμού λαμπτήρων …………………..……………………………………………………………………..

5. Αν είναι δυνατόν, ζητούμε το λογαριασμό ηλεκτρικής ενέργειας για ένα έτος
6. Εάν δε χρησιμοποιείται ηλεκτρική ενέργεια για μαγείρεμα, να καταγραφεί το είδος των συσκευών που χρησιμοποιούνται για τη χρήση αυτή

   ……

   ……

   ……

Ζ. ΣΥΜΠΕΡΙΦΟΡΙΚΕΣ ΠΑΡΑΜΕΤΡΟΙ – ΠΡΟΒΛΗΜΑΤΑ ΜΕ ΤΗΝ ΕΝΕΡΓΕΙΑΚΗ ΤΡΟΦΟΔΟΣΙΑ

1. Σε ποια θερμοκρασία ρυθμίζετε το θερμοστάτη; (σε περιπτώσεις κεντρικής θέρμανσης)

$<18^oC$	
$18\text{-}20^oC$	
$>20^oC$	

2. Ποια είναι, κατά μέσο όρο, η θερμοκρασία του σπιτιού σας το χειμώνα;

……

3. Για πόσες ώρες, κατά μέσο όρο, λειτουργείτε το σύστημα θέρμανσης το χειμώνα, ανά ημέρα;

< 2h	
2-4h	
4-6h	
6-8h	
>8 h	

4. Ανοίγετε τα παράθυρα για αερισμό του σπιτιού; ΝΑΙ/ ΟΧΙ

5. Ποια περίοδο της ημέρας ανοίγετε τα παράθυρα;

Νωρίς το πρωί	
Πριν το μεσημέρι	
Το μεσημέρι	
Το απόγευμα	
Το βράδυ	

6. Αισθάνεστε άνετα στο σπίτι το χειμώνα; ΝΑΙ/ ΟΧΙ

7. Αισθάνεστε άνετα στο σπίτι το καλοκαίρι; ΝΑΙ/ ΟΧΙ

8. Έχετε προβλήματα υγρασίας/ μούχλας/ συμπύκνωσης υδρατμών στο σπίτι; ΝΑΙ/ ΟΧΙ

9. Έχετε εντοπίσει προβλήματα υγείας σε μέλη του νοικοκυριού σας λόγω ανεπαρκούς θέρμανσης; ΝΑΙ/ ΟΧΙ

10. Έχετε καθυστερήσεις στην αποπληρωμή λογαριασμών ενέργειας; ΝΑΙ/ ΟΧΙ

ΕΡΩΤΗΜΑΤΟΛΟΓΙΟ ΕΝΕΡΓΕΙΑΚΩΝ ΣΥΜΒΟΥΛΩΝ ΓΙΑ ΣΥΣΤΗΜΑΤΑ ΚΕΝΤΡΙΚΗΣ ΘΕΡΜΑΝΣΗΣ

Α. ΒΑΣΙΚΑ ΧΑΡΑΚΤΗΡΙΣΤΙΚΑ

1. Καύσιμο

Πετρέλαιο	
LPG	
Καυσόξυλα	
Pellets	

Μάρκα/ Τύπος ……….

2. Ονομαστική Ισχύς Λέβητα ……………………………………………………………………………………………..
3. Κυκλοφορητής

   Τύπος …….....

   Παροχή …….

   Ύψος ……….

   Ισχύς……. …….
4. Υπάρχει boiler για παρασκευή ζεστού νερού χρήσης ΝΑΙ/ΟΧΙ

   Όγκος boiler (lit) ……………………………………………………………………………………………………….
5. Σημειώστε τα σχόλιά σας για τη γενική κατάσταση του συστήματος κεντρικής θέρμανσης μετά από τον οπτικό έλεγχο της εγκατάστασης

   ……

   ……

   ……

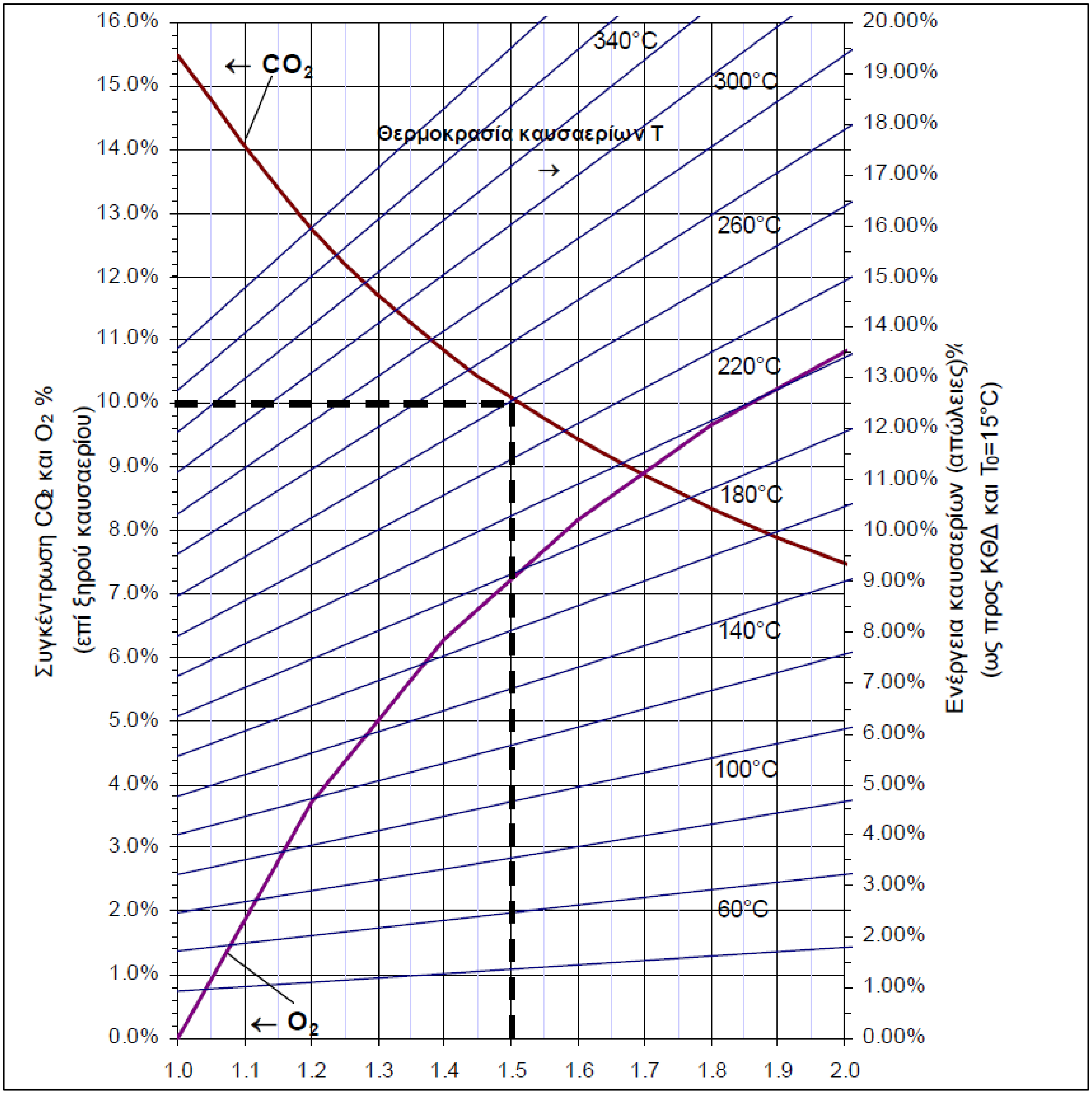
   ……
6. Υπάρχει ξεχωριστός πίνακας λεβητοστασίου ΝΑΙ/ΟΧΙ

Β. ΜΕΤΡΗΣΙΜΕΣ ΠΑΡΑΜΕΤΡΟΙ

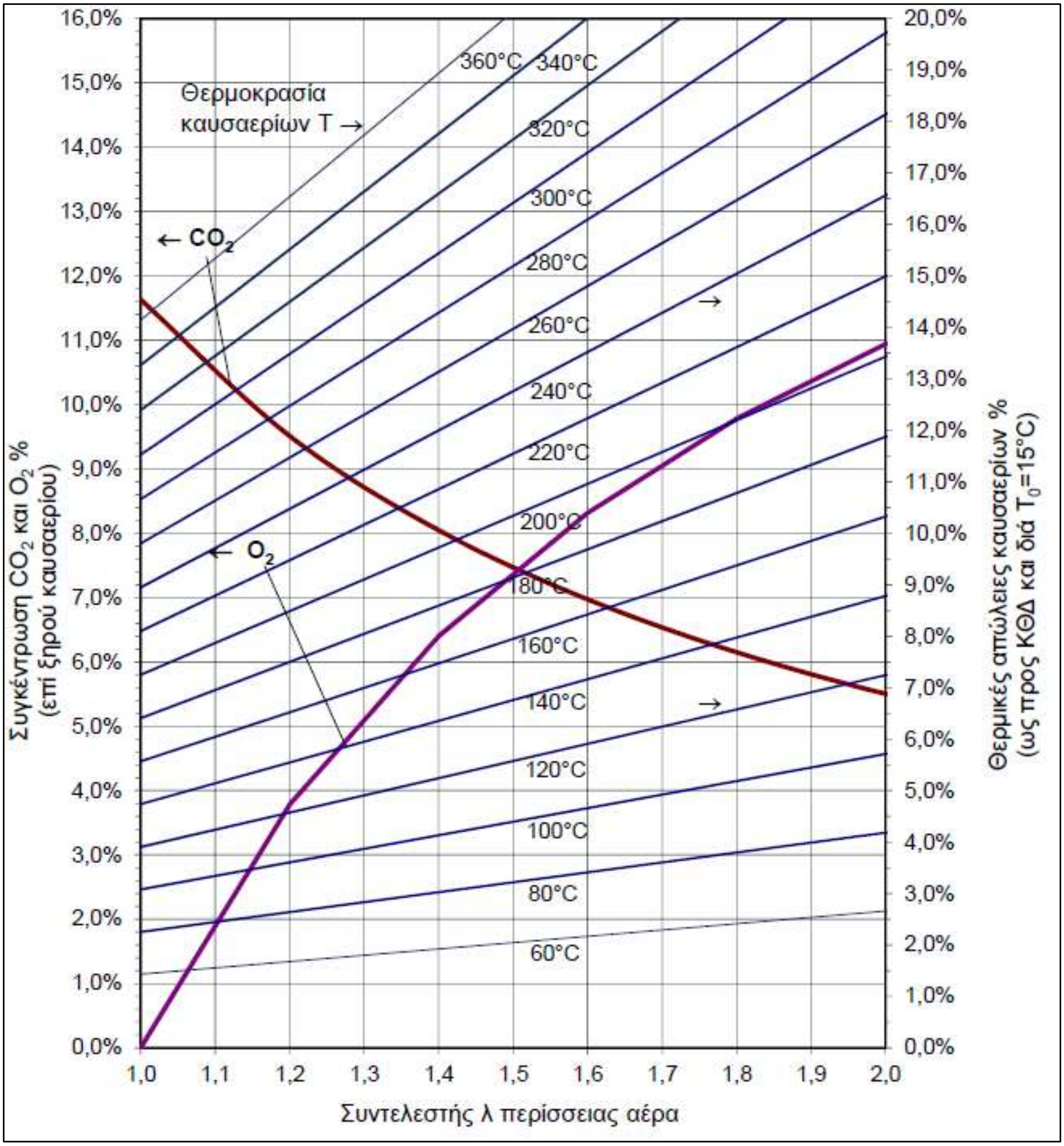
1. Θερμοκρασία καυσαερίων (^oC)…………………………………………………………………………………….
2. Πίεση καυσαερίων (mbar) ……………………………………………………………………………………………
3. CO (ppm) ……..
4. CO_2 (%) ……….

Γ. ΥΠΟΛΟΓΙΣΜΟΣ ΑΛΛΩΝ ΠΑΡΑΜΕΤΡΩΝ

- Εσωτερικός βαθμός απόδοσης λέβητα - καυστήρα: Βάσει Νομογραφημάτων 1 και 2.
- Συγκέντρωση οξυγόνου στα καυσαέρια: Βάσει Νομογραφημάτων 1 και 2.



Nomograph 1. For diesel oil



Nomograph 2. For LPG

ΕΡΩΤΗΜΑΤΟΛΟΓΙΟ ΕΝΕΡΓΕΙΑΚΗΣ ΕΠΙΘΕΩΡΗΣΗΣ ΚΑΤΑ ΤΗ ΛΗΞΗ ΤΟΥ 1ου ΚΥΚΛΟΥ ΤΟΥ LIVING LAB ΤΟΥ ΜΕΤΣΟΒΟΥ

Α. ΠΑΡΑΚΟΛΟΥΘΗΣΗ ΜΕΤΡΗΤΩΝ – ΣΥΜΒΟΛΗ ΤΟΥ STEP-IN ΣΤΗΝ ΕΞΟΙΚΟΝΟΜΗΣΗ ΕΝΕΡΓΕΙΑΣ ΚΑΙ ΤΗ ΒΕΛΤΙΩΣΗ ΣΥΝΘΗΚΩΝ ΖΩΗΣ ΣΤΑ ΝΟΙΚΟΚΥΡΙΑ

1. Παρακολουθούσατε τον μετρητή ηλεκτρικής κατανάλωσης μέσω της εφαρμογής στο κινητό/ υπολογιστή;

Ναι ☐ Όχι ☐

2. Αν ναι, πόσο τακτικά;

Πολλές Φορές/ ημέρα	☐
1 Φορά/ ημέρα	☐
Πολλές Φορές/ εβδομάδα	☐
2 Φορές/ εβδομάδα	☐
1 φορά/ μήνα	☐

3. Παρακολουθούσατε τον μετρητή θερμοκρασίας/υγρασίας;

Ναι ☐ Όχι ☐

4. Αν ναι, πόσο τακτικά;

Πολλές Φορές/ ημέρα	☐
1 Φορά/ ημέρα	☐
Πολλές Φορές/ εβδομάδα	☐
2 Φορές/ εβδομάδα	☐
1 φορά/ μήνα	☐

5. Αν δεν παρακολουθούσατε συστηματικά τις μετρήσεις κατανάλωσης ρεύματος ή θερμοκρασίας και υγρασίας, για ποιους λόγους δεν το κάνετε;

____

____

____

6. Σας βοήθησαν οι μετρητές να πάρετε κάποια απόφαση σχετικά με την ενεργειακή εξοικονόμηση στην οικία σας;

Ναι ☐ Όχι ☐

6Α. Αν ναι, με ποιο τρόπο;

Αγορά νέας ενεργειακά αποδοτικής/ων συσκευής/ων	
Αντικατάσταση λαμπτήρων	
Επιδιόρθωση ενεργοβόρας συσκευής	
Αναπροσαρμογή ωρών λειτουργίας ηλεκτρικών συσκευών	
Αλλαγή συνηθειών/ μείωση κατανάλωσης;	
Επεμβάσεις στο κτιριακό κέλυφος και αντικατάσταση κουφωμάτων	
Αντικατάσταση – Συντήρηση συστήματος λέβητα καυστήρα	
Προσθήκη θερμοστάτη ή αντικατάσταση του αναλογικού με ψηφιακό	
Αναπροσαρμογή ωρών λειτουργίας συστήματος θέρμανσης	
Μείωση θερμοκρασίας θερμοστάτη	
Καλύτερος αερισμός	
Αγορά συσκευής αφύγρανσης	

6Β. Αν όχι, γιατί;

____

____

____

7. Σχεδιάζετε να πραγματοποιήσετε το επόμενο διάστημα κάποιες δράσεις εξοικονόμησης ενέργειας στην κατοικίας σας;

Ναι	
Όχι	

8. Αν ναι, τι σκέφτεστε να κάνετε;

____

____

9. Έχετε υποβάλει αίτηση στο παρελθόν ή την τρέχουσα περίοδο στο πρόγραμμα «Εξοικονόμηση κατ’ οίκον»;

Ναι	
Όχι	

10. Εάν υπάρξει νέο πρόγραμμα από την Πολιτεία για την επιδότηση επεμβάσεων εξοικονόμησης ενέργειας, θα θέλατε να συμμετάσχετε;

Ναι	
Όχι	

11. Τι πιστεύετε ότι μπορεί να βοηθήσει περισσότερο τα νοικοκυριά για την εξοικονόμηση ενέργειας

Επιδότηση επεμβάσεων εξοικονόμησης ενέργειας	
Έκπτωση από το φόρο εισοδήματος της δαπάνης για επεμβάσεις εξοικονόμησης	

Άλλο____

12. Με βάση τα στοιχεία και τις μετρήσεις που λάβαμε, θα θέλαμε να σας προτείνουμε κάποια πιθανά μέτρα για τη μείωση του ενεργειακού σας κόστους. Ποια από τα μέτρα αυτά θα ήσασταν διατεθειμένη/ος να πραγματοποιήσετε και με ποια σειρά προτεραιότητας:

____

____

____

____

____

13. Αν δεν σκέφτεστε να πραγματοποιήσετε κάποια ή όλες από τις παραπάνω προτάσεις, ποιοι είναι οι σημαντικότεροι λόγοι της απόφασής σας;

____

____

____

____

____

____

14. Σας βοήθησε η συμμετοχή στο έργο STEP-IN (Energy Café, επισκέψεις των ενεργειακών συμβούλων, κλπ.);

Ναι	
Όχι	

15. Αν ναι, με ποιο τρόπο;

Καλύτερη κατανόηση λογαριασμών ηλεκτρικής ενέργειας	
Αλλαγή συνηθειών καθημερινότητας	
Αλλαγή παρόχου ηλεκτρικής ενέργειας	
Χρήση νυχτερινού τιμολογίου ηλεκτρικής ενέργειας	
Επεμβάσεις στο κτιριακό κέλυφος και αντικατάσταση κουφωμάτων	
Αντικατάσταση – Συντήρηση συστήματος λέβητα καυστήρα	
Αποδοτικότερη χρήση συστήματος θέρμανσης	

Άλλο____

16. Αν όχι, γιατί;

____
____
____

17. Γενικά, οι συνθήκες διαβίωσης στην κατοικία σας, έχουν βελτιωθεί κατά τη διάρκεια του τελευταίου εξαμήνου;

Ναι	
Όχι	

18. Αν ναι, με ποιο τρόπο;

Καλύτερες συνθήκες θερμοκρασίας/υγρασίας στο σπίτι	
Μείωση ενεργειακού κόστους	
Μείωση υγρασίας/ μούχλας	
Έγκαιρη πληρωμή ενεργειακών λογαριασμών	

Άλλο____

Αν μειώθηκε το ενεργειακό σας κόστος, πόσο περίπου είναι η μείωση αυτή (ποσό ή ποσοστό)____

B. ΔΗΜΟΓΡΑΦΙΚΑ

D1.	Από πόσα άτομα αποτελείται το νοικοκυριό σας;	______	Προτιμώ να μην απαντήσω	☐
D2.	Πόσα από αυτά είναι παιδιά κάτω των 5 ετών;	______	Προτιμώ να μην απαντήσω	☐
D3.	Πόσα από αυτά είναι συνταξιούχοι;	______	Προτιμώ να μην απαντήσω	☐
D4.	Πόσα από αυτά είναι άνεργοι;	______	Προτιμώ να μην απαντήσω	☐
D5.	Πόσα από αυτά είναι άτομα με αναπηρία ή κάποια μακροχρόνια ασθένεια;	______	Προτιμώ να μην απαντήσω	☐

D6. Ποιο είναι το ανώτερο επίπεδο εκπαίδευσής οποιουδήποτε μέλους του νοικοκυριού σας;

Δεν έχει ολοκληρωθεί το δημοτικό	☐	ΤΕΙ	☐
Δημοτικό σχολείο	☐	ΑΕΙ	☐
Γυμνάσιο/ Λύκειο	☐	Μεταπτυχιακό	☐
Δευτεροβάθμια επαγγελματική	☐	Διδακτορικό	☐
Προτιμώ να μην απαντήσω	☐		

D7. Ποιο είναι το σύνολο των εξόδων του νοικοκυριού σας κάθε μήνα για όλες του τις ανάγκες;

<u>Παρακαλώ προσδιορίστε</u> €............................

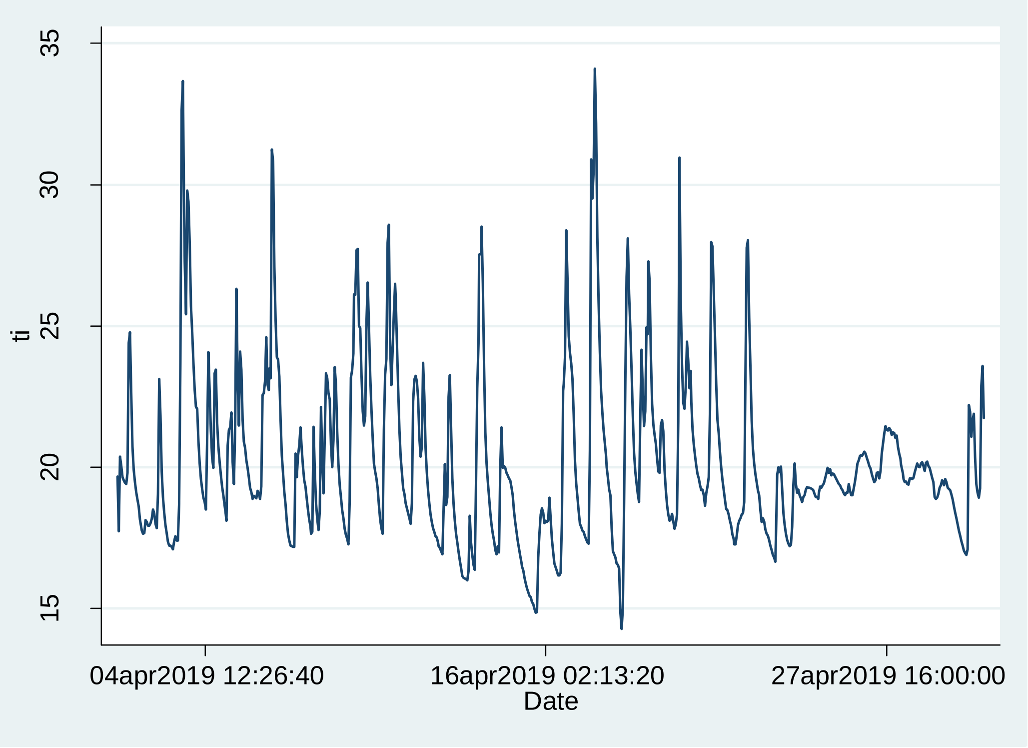
D8. Ποιο ήταν το καθαρό μηνιαίο εισόδημα ολόκληρου του νοικοκυριού σας (συμπεριλαμβανομένων επιδομάτων, εισοδημάτων από ενοίκια κλπ.);

< 300 EUR	☐	1201-1500 EUR	☐
301-600 EUR	☐	1501 – 2000 EUR	☐
601-900 EUR	☐	2001 - 2500 EUR	☐
901-1200 EUR	☐	> 2500 EUR	☐
Προτιμώ να μην απαντήσω	☐		

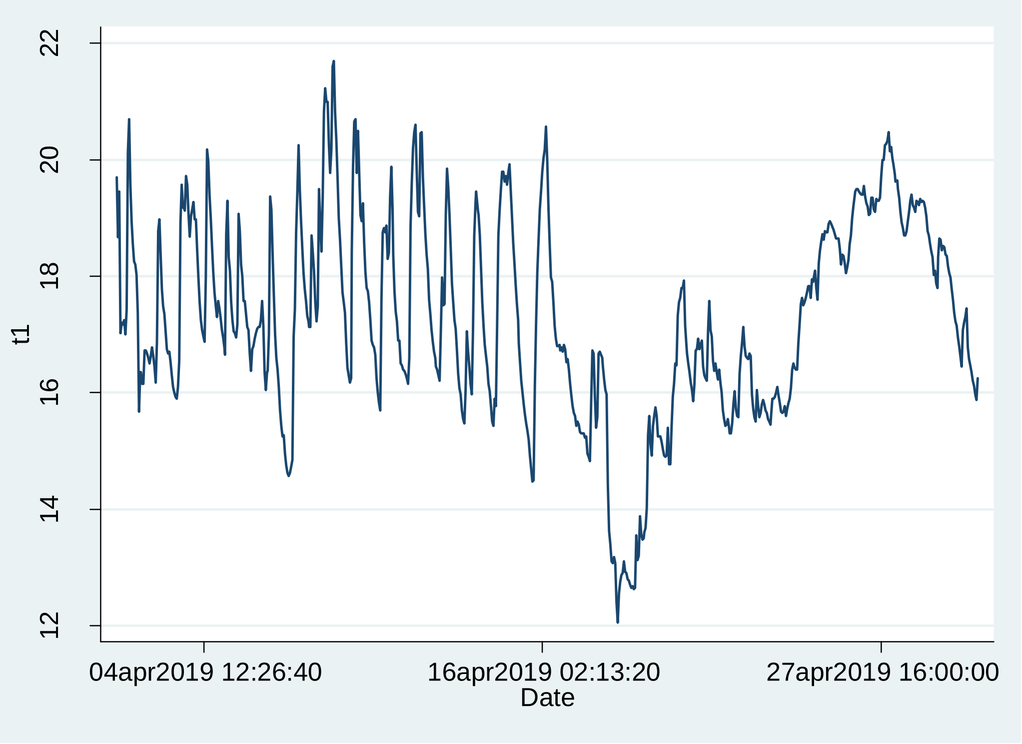
<u>Παρακαλώ προσδιορίστε</u> €............................

Annex IV: Illustrative examples of household-specific reports and energy advice leaflets (in Greek)

STEP-IN PROJECT

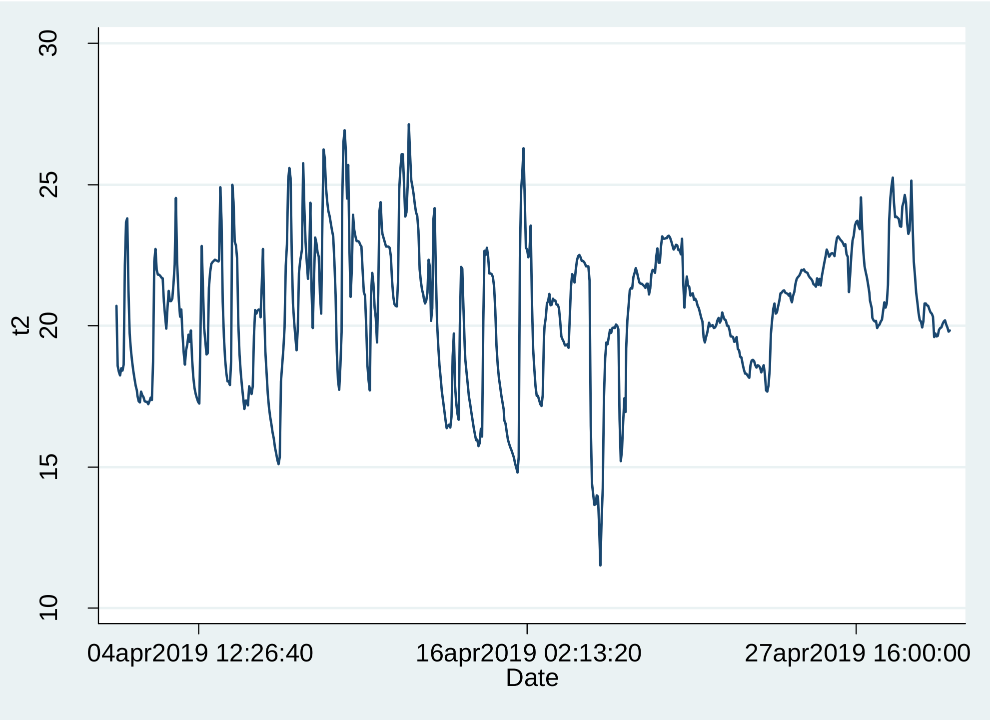


Εικόνα 1: Μέση θερμοκρασία Κεντρικού μετρητή (σαλόνι)

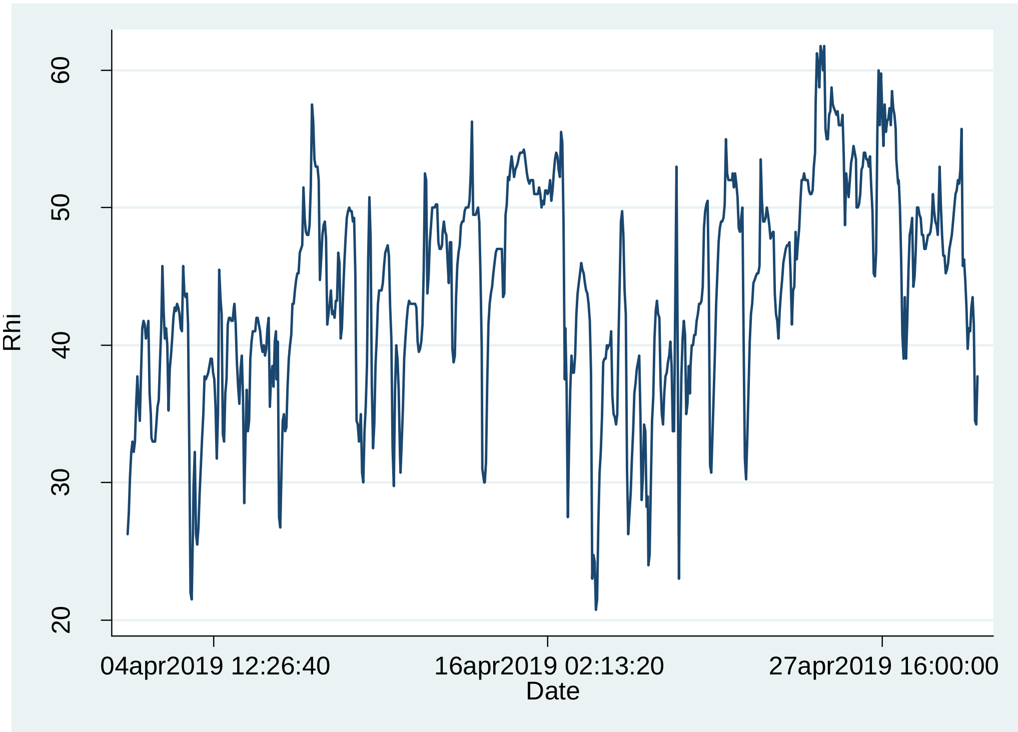


Εικόνα 2: Μέση θερμοκρασία μετρητή 1 (υπνοδωμάτιο)

STEP-IN PROJECT

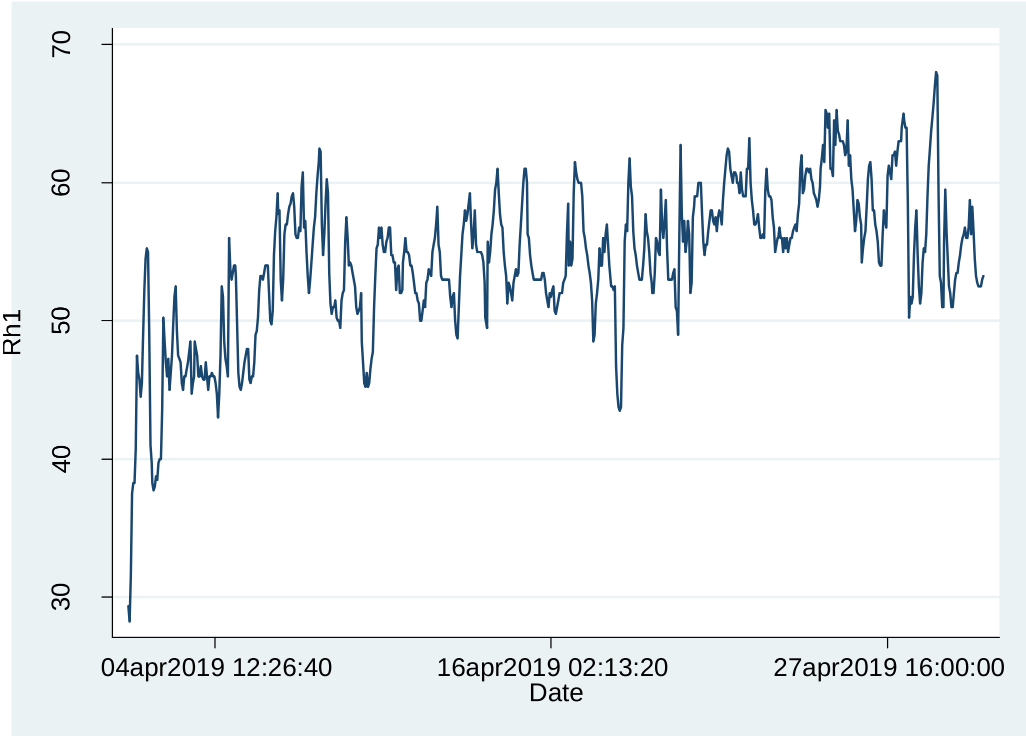


Εικόνα 3: Μέση θερμοκρασία μετρητή 2 (κουζίνα)

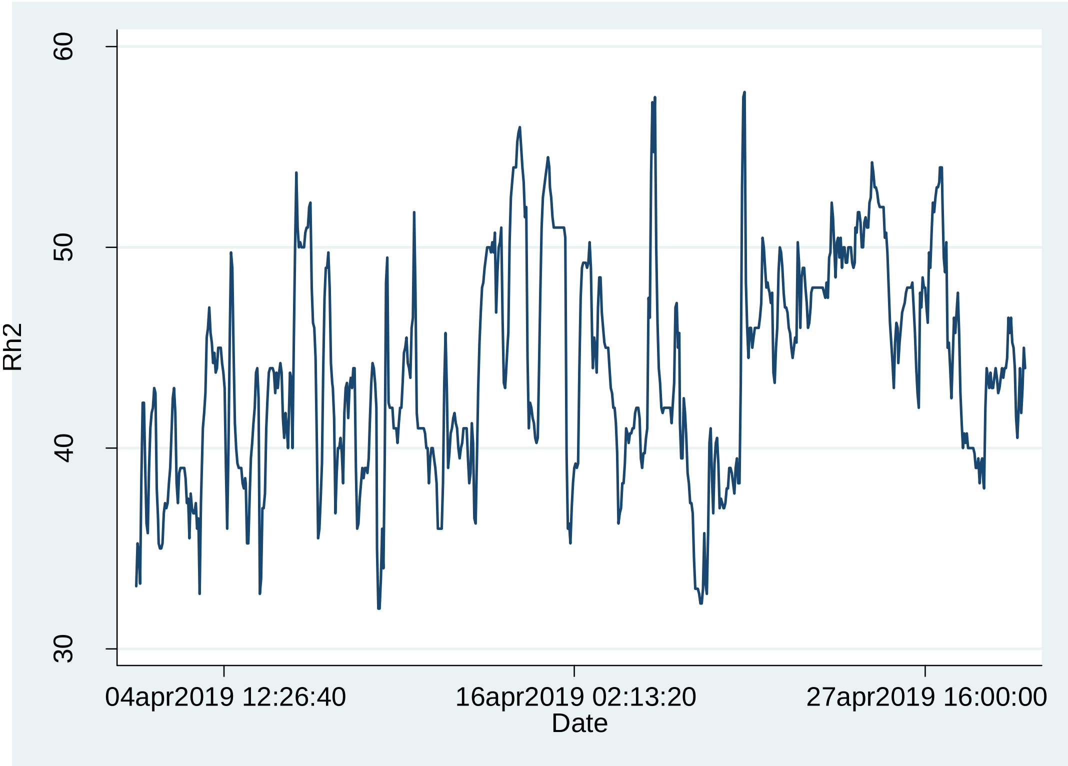


Εικόνα 4: Μέση υγρασία Κεντρικού μετρητή

STEP-IN PROJECT



Εικόνα 5: Μέση υγρασία μετρητή 1

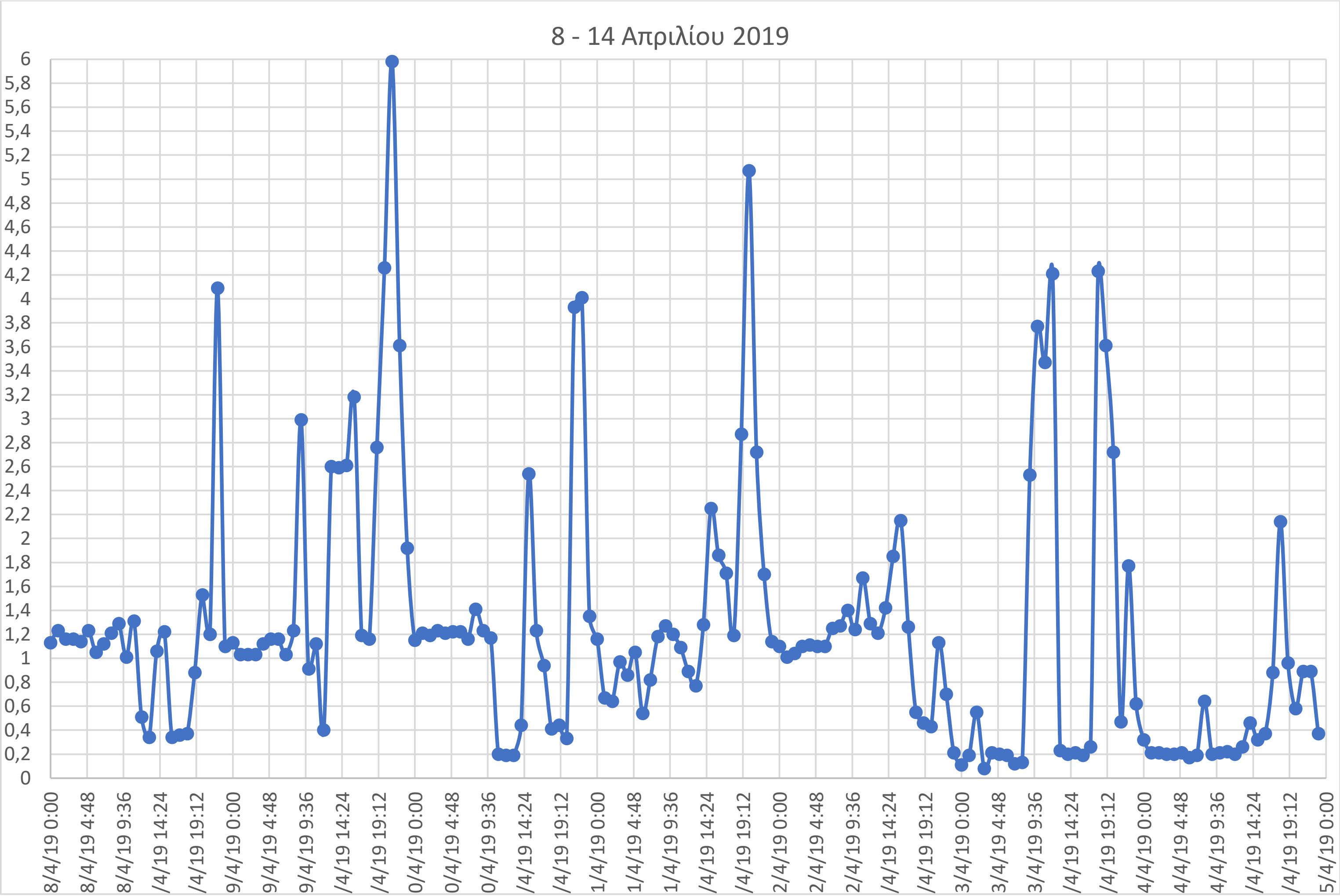


Εικόνα 6: Μέση υγρασία μετρητή 2

STEP-IN PROJECT

Μεταβλητή	*Μέση Τιμή*	*Ελάχιστη Τιμή*	*Μέγιστη Τιμή*
Θερμοκρασία (t_i)	20.88	14.27	34.1
Σχετική υγρασία (rh_i)	50.32	20.75	74.75
Θερμοκρασία (t_1)	18.97	12.05	25.975
Σχετική υγρασία (rh_1)	59.19	28.25	80.25
Θερμοκρασία (t^2)	21.66	11.5	27.15
Σχετική υγρασία (rh_2)	49.7	32	73

STEP-IN PROJECT

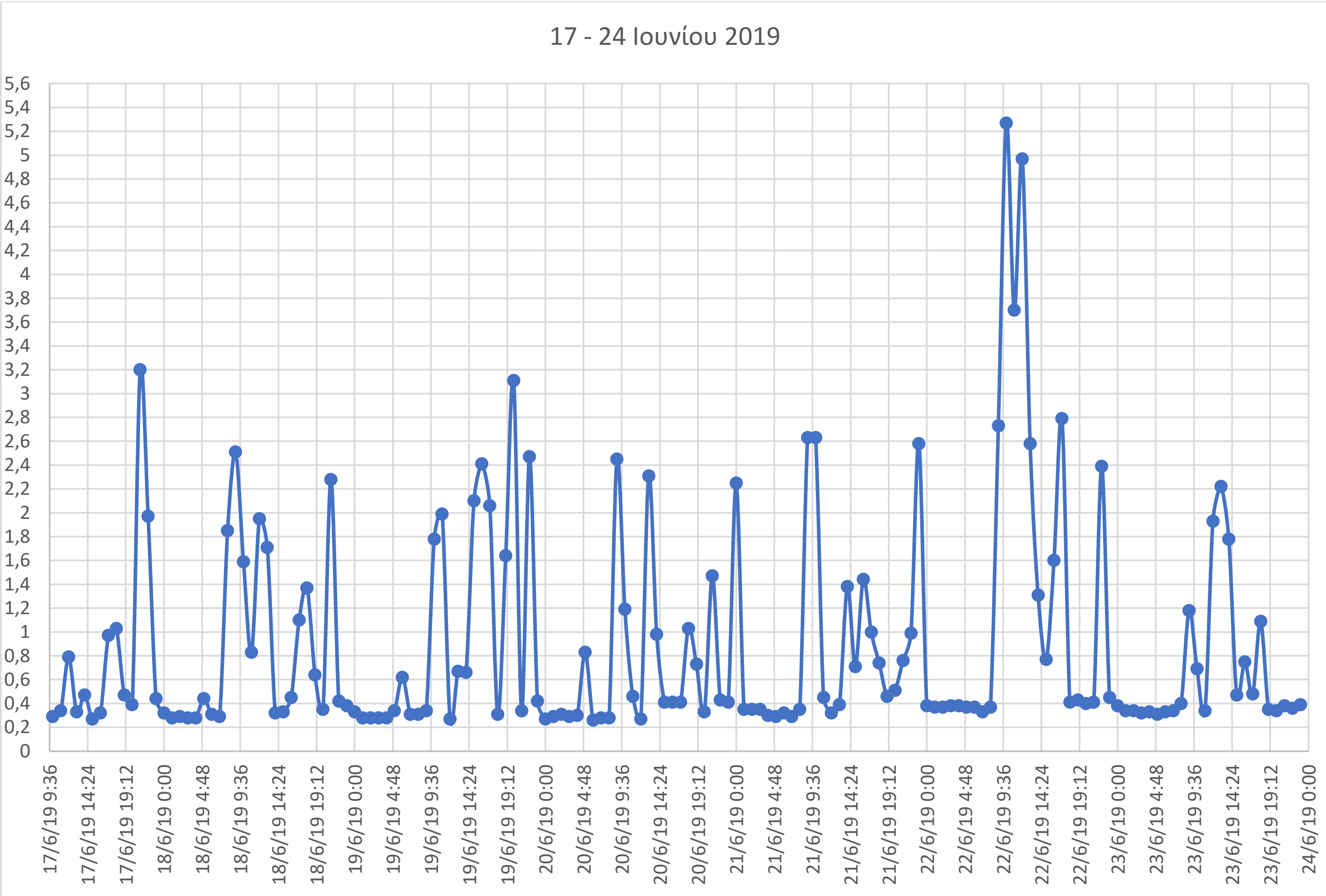


ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ

ΜΕΤΣΟΒΙΟ ΚΕΝΤΡΟ ΔΙΕΠΙΣΤΗΜΟΝΙΚΗΣ ΕΡΕΥΝΑΣ

Μετρητικά Δεδομένα

STEP-IN PROJECT



ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ

ΜΕΤΣΟΒΙΟ ΚΕΝΤΡΟ ΔΙΕΠΙΣΤΗΜΟΝΙΚΗΣ ΕΡΕΥΝΑΣ

Περίπου το 40% των ορεινών νοικοκυριών στην Ελλάδα αναφέρουν ότι αδυνατούν να κρατήσουν το σπίτι τους επαρκώς ζεστό. Η κατάσταση αυτή πρέπει να αναστραφεί και το έργο STEP-IN φιλοδοξεί να συμβάλει θετικά στη βελτίωση της ποιότητας ζωής των κατοίκων των ορεινών περιοχών

Γενικές συμβουλές

- Τουλάχιστον μια φορά ανά δύο χρόνια να κάνετε συντήρηση του καυστήρα. Έτσι αποφεύγονται βλάβες και μειώνεται το κόστος θέρμανσης.
- Ενημερωθείτε από τον πάροχο ηλεκτρικής ενέργειας για το νυχτερινό τιμολόγιο ή άλλα ειδικά τιμολόγια, μπορείτε να αποφύγετε σημαντικά κόστη
- Να μην ξεχνάτε να αερίζετε το σπίτι σας επαρκώς. Όσο μπορείτε, το χειμώνα, να ανοίγετε τα παράθυρα τις μεσημεριανές ώρες, ειδικά όταν έχει ηλιόλουστο καιρό.

STEP-IN PROJECT

ΕΡΕΥΝΗΤΙΚΟ ΕΡΓΟ STEP - IN

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ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ

ΜΕΤΣΟΒΙΟ ΚΕΝΤΡΟ ΔΙΕΠΙΣΤΗΜΟΝΙΚΗΣ ΕΡΕΥΝΑΣ

—

+30 26560 29040

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https://www.step-in-project.eu/el/

Προτάσεις για τη βελτίωση των συνθηκών και τη μείωση του κόστους ενέργειας στο σπίτι σας

στο πλαίσιο του έργου STEP-IN (LL-01-11)

Υφιστάμενη κατάσταση κατοικίας/ θέρμανση

Με βάση τους υπολογισμούς και τις μετρήσεις που έγιναν από την ερευνητική ομάδα του ΕΜΠ και του ΜΕΚΔΕ, ειδικά για την κατοικία σας, προέκυψαν τα ακόλουθα:

ΣΥΝΘΗΚΕΣ ΘΕΡΜΟΚΡΑΣΙΑΣ / ΥΓΡΑΣΙΑΣ

- Κοντά στις συνθήκες άνεσης για την περίοδο θέρμανσης η θερμοκρασία. Παρατηρήθηκαν κάποιες ιδιαίτερα υψηλές τιμές (ενδεχομένως ταυτόχρονη χρήση λέβητα και ενεργειακού τζακιού). Το καλοκαίρι, η επιπλέον μόνωση συμβάλει στη διατήρηση της θερμοκρασίας κοντά στις συνθήκες άνεσης
- Κοντά στα φυσιολογικά επίπεδο, κατά μέσο όρο, η υγρασία αλλά με σημαντικές διακυμάνσεις. Παρατηρήθηκαν πολύ χαμηλές τιμές στο χώρο που λειτουργεί το τζάκι και κάποιες περιπτώσεις υψηλών τιμών στους άλλους χώρους, στην αρχή του καλοκαιριού.

ΚΑΤΑΝΑΛΩΣΗ ΕΝΕΡΓΕΙΑΣ ΓΙΑ ΘΕΡΜΑΝΣΗ ΚΑΙ ΖΕΣΤΟ ΝΕΡΟ: 34.822 kWh/ έτος ή 409,7 kWh/m^2/έτος

ΣΥΝΟΛΙΚΟ ΚΟΣΤΟΣ ΘΕΡΜΑΝΣΗΣ: **2.500 €**

Υφιστάμενη κατάσταση κατοικίας/ ηλεκτρισμός

Η εκτιμώμενη ετήσια κατανάλωση ηλεκτρικής ενέργειας στην κατοικία σας κρίνεται υψηλή, πολύ μεγαλύτερη από το μέσο όρο της χώρας. Ανέρχεται, συγκεκριμένα σε περίπου **10.380** kWh/έτος και το εκτιμώμενο κόστος της είναι **2.600** €/έτος.

Η ηλεκτρική κατανάλωση επιβαρύνεται από τη χρήση ηλεκτρικού θερμοσίφωνα για την παραγωγή ζεστού νερού και στεγνωτηρίου.

Μεγαλύτερη είναι η κατανάλωση ηλεκτρικής ενέργειας κατά τις απογευματινές ώρες, συνήθως.

Η εξοικονόμηση ενέργειας και η «έξυπνη» χρήση ενέργειας ωφελεί τον προϋπολογισμό των νοικοκυριών και μειώνει τη ρύπανση του περιβάλλοντος

ΜΕΤΡΑ ΕΞΟΙΚΟΝΟΜΗΣΗΣ ΕΝΕΡΓΕΙΑΣ ΓΙΑ ΘΕΡΜΑΝΣΗ

Λόγω της επιπλέον θερμομόνωσης που έχει τοποθετηθεί και του προγραμματισμού για θερμομόνωση οροφής, δεν προτείνονται μείζονα μέτρα παρέμβασης, εκτός από την τοποθέτηση ψηφιακού θερμοστάτη.

ΤΟΠΟΘΕΤΗΣΗ ΨΗΦΙΑΚΟΥ ΘΕΡΜΟΣΤΑΤΗ

- Όφελος: 80 €/έτος
- Εκτίμηση κόστους εφαρμογής: 120 €

ΜΕΤΡΑ ΓΙΑ ΗΛΕΚΤΡΙΣΜΟ

Κρίνεται σημαντική η μείωση των ηλεκτρικών φορτίων. Επειδή υπάρχει σημαντική κατανάλωση για ζεστό νερό και ήδη χρησιμοποιείται λέβητας πετρελαίου, θα ήταν καλό να τοποθετηθεί boiler για παραγωγή θερμού νερού στο λεβητοστάσιο.

ΤΟΠΟΘΕΤΗΣΗ BOILER ΓΙΑ ΠΑΡΑΓΩΓΗ ΖΕΣΤΟΥ ΝΕΡΟΥ

- Όφελος: 200 €/έτος
- Εκτίμηση κόστους εφαρμογής: 400 €

Με προγραμματισμό της χρήσης των ενεργοβόρων συσκευών τις κατάλληλες ώρες, εκτιμάται ότι το νυχτερινό τιμολόγιο μπορεί να συμβάλει στη μείωση του κόστους ρεύματος.

ΧΡΗΣΗ ΝΥΧΤΕΡΙΝΟΥ ΤΙΜΟΛΟΓΙΟΥ

- Όφελος (κατ' εκτίμηση): έως και 700 €/έτος

ΜΕΤΡΑ ΓΙΑ ΤΗ ΓΕΝΙΚΟΤΕΡΗ ΒΕΛΤΙΩΣΗ ΤΩΝ ΣΥΝΘΗΚΩΝ ΣΤΗΝ ΚΑΤΟΙΚΙΑ

Επειδή εμφανίζονται ενίοτε υψηλές τιμές υγρασίας, θα ήταν σκόπιμο να προμηθευτείτε έναν αφυγραντήρα (ισχύος τουλάχιστον 200 W), ο οποίος θα βελτιώσει αισθητά τις συνθήκες στο σπίτι. Ακόμη, τα δωμάτια εκτός του σαλονιού πρέπει να αερίζονται περισσότερο.

Annex V: Samples of information sheet and consent forms used in the mountainous LL (in Greek)

Φύλλο Πληροφοριών Συμμετέχοντα στις δραστηριότητες του Βιωματικού Εργαστηρίου του Μετσόβου

Επισκέψεις Ενεργειακού Συμβούλου και εγκατάσταση καταγραφικού εξοπλισμού

1. Τίτλος Ερευνητικού Προγράμματος

Using Living Labs to Improve Energy Efficiency and Comfort Levels - STEP-IN

2. Πρόσκληση

Έχετε προσκληθεί να συμμετάσχετε σε αυτό το ερευνητικό πρόγραμμα επειδή δηλώσατε εθελοντικά το ενδιαφέρον σας για τον σκοπό αυτό. Πριν αποφασίσετε σχετικά με τη συμμετοχή σας, είναι σημαντικό να καταλάβετε γιατί πραγματοποιείται η έρευνα και τι θα περιλαμβάνει. Παρακαλούμε αφιερώστε λίγο χρόνο να διαβάσετε προσεκτικά τις παρακάτω πληροφορίες και να τις συζητήσετε με άλλους, εάν το επιθυμείτε. Σας προτρέπουμε να μας ρωτήσετε για οτιδήποτε δεν είναι σαφές καθώς και για περισσότερες πληροφορίες. Χρησιμοποιείστε όσο χρόνο κρίνετε απαραίτητο για να αποφασίσετε εάν θέλετε ή όχι να συμμετάσχετε. Σας ευχαριστούμε που διαβάσατε το συγκεκριμένο φύλλο πληροφοριών.

3. Ποιος είναι ο σκοπός του ερευνητικού προγράμματος;

Το ερευνητικό πρόγραμμα, το οποίο χρηματοδοτείται από την Ευρωπαϊκή Ένωση, στοχεύει στη βελτίωση της ποιότητας ζωής, της ενεργειακής απόδοσης των νοικοκυριών και των επιπέδων άνεσης των ευάλωτων καταναλωτών, καθώς και στην παροχή συμβουλών σχετικά με τις βέλτιστες πρακτικές σε οργανισμούς που δραστηριοποιούνται στον τομέα της ενεργειακής πενίας. Το έργο βασίζεται στα αποτελέσματα παλαιότερων ερευνών, οι οποίες πραγματοποιήθηκαν τόσο από την υφιστάμενη ερευνητική ομάδα όσο και από τρίτους, και έχει σχεδιαστεί με τέτοιο τρόπο ώστε να επιτρέπονται συγκρίσεις με τα προηγούμενα ευρήματα.

4. Γιατί επιλέχθηκα;

Επιλεχθήκατε, διότι εθελοντικά δηλώσατε τη διάθεση σας να συμμετάσχετε στο παρόν πρόγραμμα και διότι ως κάτοικος του οικισμού του Μετσόβου πληροίτε τα απαραίτητα κριτήρια του Βιωματικού Εργαστηρίου.

5. Η συμμετοχή μου είναι υποχρεωτική;

Παρόλο που δηλώσατε εθελοντικά ότι επιθυμείτε να συμμετάσχετε στο παρόν πρόγραμμα, εξαρτάται από εσάς να αποφασίσετε εάν τελικά θα συμμετάσχετε ή όχι. Η συμμετοχή σας είναι εντελώς εθελοντική. Εάν αποφασίσετε να λάβετε μέρος, θα διατηρήσετε ένα αντίγραφο του συγκεκριμένου πληροφοριακού φύλλου και θα πρέπει να δηλώσετε τη συγκατάθεσή σας στη φόρμα συγκατάθεσης. Μπορείτε να αποσυρθείτε από την εν λόγω έρευνα ανά πάσα στιγμή χωρίς να απαιτείται δικαιολογήσετε την απόφασή σας. Επιπλέον, έχετε το δικαίωμα:

- πρόσβασης στα δεδομένα που συγκεντρώνει ο Ενεργειακός Σύμβουλος μέσω του ερωτηματολογίου και αφορούν στο νοικοκυριό σας,
- διαγραφής των δεδομένων που συγκεντρώνει ο Ενεργειακός Σύμβουλος μέσω του ερωτηματολογίου και αφορούν στο νοικοκυριό σας. Τα εν λόγω δεδομένα δύναται να διαγραφούν οποτεδήποτε, χωρίς να απαρνηθείτε το δικαίωμα της ψευδοανωνυμοποίησης,
- να αντιτίθεστε οποτεδήποτε στην επεξεργασία προσωπικών δεδομένων ή/ και να περιορίζετε την επεξεργασία δεδομένων,
- να διορθώσετε ανακριβή προσωπικά δεδομένα που παρέχονται στους Ενεργειακούς Συμβούλους χωρίς αδικαιολόγητη καθυστέρηση, καθώς και να συμπληρώσετε ατελή προσωπικά δεδομένα μέσω της παροχής συμπληρωματικής δήλωσης,
- μεταφοράς δεδομένων. Μπορείτε να ζητήσετε και να λάβετε όλα τα δεδομένα που σχετίζονται με το νοικοκυριό σας σε διαλειτουργική μορφή, χωρίς να μειώσετε την ασφάλεια του περιεχομένου των δεδομένων.

6. Τι συνεπάγεται η συμμετοχή μου στην έρευνα;

Κατά τη διάρκεια της συμμετοχής σας στην έρευνα θα σας επισκεφτεί τρεις φορές ο Ενεργειακός Σύμβουλος. Στο πλαίσιο αυτών των επισκέψεων θα σας ζητηθεί να συμπληρώσετε ένα σύντομο ερωτηματολόγιο σχετικά με τα χαρακτηριστικά του σπιτιού σας, τα χαρακτηριστικά του συστήματος θέρμανσης, τα στοιχεία των λογαριασμών ηλεκτρικής ενέργειας κλπ. Αυτά τα δεδομένα θα υποβληθούν σε επεξεργασία έτσι ώστε να σας παρασχεθούν εξατομικευμένες συμβουλές, οι οποίες θα σας βοηθήσουν να εξοικονομήσετε ενέργεια και χρήματα στο πλαίσιο των καθημερινών σας δραστηριοτήτων.

7. Ποιες είναι οι υποχρεώσεις μου;

Θα σας ζητηθεί μόνο να απαντήσετε στις ερωτήσεις του ερωτηματολογίου.

8. Ποια είναι τα πιθανά μειονεκτήματα και οι κίνδυνοι εξαιτίας της συμμετοχής μου;

Η συμμετοχή σας στην έρευνα δεν πρόκειται να επιφέρει κανενός είδους κίνδυνο ή ενόχληση. Η πιθανή δυσφορία θα είναι ίδια με μια καθημερινή εμπειρία.

9. Ποια είναι τα πιθανά οφέλη από τη συμμετοχή μου;

Ελπίζουμε ότι αυτή η έρευνα θα έχει ευεργετική επίδραση στο ενεργειακό κόστος του νοικοκυριού σας. Επιπλέον, εκτιμάται ότι η ανάλυση των συλλεγόμενων δεδομένων θα μπορούσε να σας βοηθήσει να βελτιώσετε την καθημερινή σας ζωή, μειώνοντας ταυτόχρονα το ενεργειακό σας κόστος.

10. Τι θα συμβεί σε περίπτωση που το ερευνητικό πρόγραμμα σταματήσει νωρίτερα από το αναμενόμενο;

Το έργο έχει διάρκεια 30 μηνών. Κάθε κύκλος Βιωματικού Εργαστηρίου έχει διάρκεια 6 μηνών. Εάν η έρευνα σταματήσει νωρίτερα από ότι είχε προγραμματιστεί και επηρεαστείτε με οποιονδήποτε τρόπο, θα σας ενημερώσουμε και θα σας παρέχουμε τις απαραίτητες εξηγήσεις.

11. Και αν κάτι πάει στραβά;

Αν έχετε οποιοδήποτε παράπονο ή/και καταγγελία σχετικά με τη διαδικασία που ακολουθήθηκε, μπορείτε να επικοινωνήσετε με τον Ενεργειακό Σύμβουλο ή οποιοδήποτε άλλο μέλος της ερευνητικής ομάδας. Αν νομίζετε ότι η καταγγελία σας δεν αντιμετωπίζεται ικανοποιητικά, μπορείτε να επικοινωνήσετε με τον Κοσμήτορα της Σχολής Μηχανικών Μεταλλείων Μεταλλουργών του Εθνικού Μετσόβιου Πολυτεχνείου για να υποβάλετε περαιτέρω την καταγγελία σας (βλ. παρακάτω).

12. Η συμμετοχή μου στην παρούσα έρευνα θα είναι εμπιστευτική;

Όλες οι πληροφορίες που συλλέγουμε σχετικά με εσάς κατά τη διάρκεια της έρευνας θα διατηρηθούν αυστηρά εμπιστευτικές. Δεν θα μπορείτε να αναγνωριστείτε σε καμία έκθεση ή δημοσίευση. Οποιαδήποτε δεδομένα συλλέγονται για εσάς στο ερωτηματολόγιο θα αποθηκεύονται ηλεκτρονικά σε μορφή που προστατεύεται από κωδικούς πρόσβασης και άλλες σχετικές διαδικασίες και τεχνολογίες ασφάλειας.

Τα δεδομένα που συλλέγονται μπορούν να μοιραστούν με ανώνυμη μορφή για να επιτρέψουν την επαναχρησιμοποίησή τους μόνο από τα μέλη της ερευνητικής ομάδας. Αυτά τα ανώνυμα δεδομένα δεν επιτρέπουν την εξακρίβωση ή αναγνώριση ατόμων ή νοικοκυριών.

13. Θα καταγραφεί η συμμετοχή μου και πώς θα χρησιμοποιηθούν τα καταγεγραμμένα δεδομένα;

Οι συναντήσεις με τον Ενεργειακό Σύμβουλο δεν καταγράφονται με κανέναν άλλο τρόπο (π.χ. ηχογράφηση ή βιντεοσκόπηση), χωρίς ξεχωριστή άδεια από εσάς, πέραν των απαντήσεων που σημειώνονται στο ερωτηματολόγιο.

14. Τί είδους πληροφορίες θα ζητηθούν από εμένα και γιατί η συλλογή αυτών των πληροφοριών σχετίζεται με την επιτυχία των σκοπών του ερευνητικού προγράμματος;

Το ερωτηματολόγιο θα σας θέσει ερωτήσεις σχετικά με τις απόψεις και τις τρέχουσες πρακτικές σας αναφορικά με τα χαρακτηριστικά και τις εγκαταστάσεις της κατοικίας σας, συμπεριλαμβανομένων ενεργειακών αναγκών, χρήσης, κατανάλωσης, κόστους και πρακτικών, προβλημάτων υγείας ή άλλων, που σχετίζονται με τα ενεργειακά συστήματα και τις εγκαταστάσεις σας. Οι απόψεις και η εμπειρία σας είναι ακριβώς αυτό που το πρόγραμμα ενδιαφέρεται να εξερευνήσει. Οι πληροφορίες που συλλέγονται θα χρησιμοποιηθούν για την παροχή εξατομικευμένων συμβουλών που θα σας βοηθήσουν να εξοικονομήσετε ενέργεια και χρήματα στις καθημερινές σας δραστηριότητες και να βελτιώσετε την καθημερινή σας ζωή. Αυτός είναι ακριβώς ο στόχος του STEP-IN.

15. Πώς θα χρησιμοποιηθούν τα αποτελέσματα του ερευνητικού προγράμματος;

Τα αποτελέσματα της έρευνας θα δημοσιευθούν. Δεν θα αναγνωριστείτε σε καμία αναφορά ή δημοσίευση εσείς ή το νοικοκυριό σας. Εάν επιθυμείτε να σας δοθεί αντίγραφο των εκθέσεων που προκύπτουν από την έρευνα, παρακαλούμε να μας ζητήσετε να σας βάλουμε στον ενημερωτικό μας κατάλογο.

16. Ποιος οργανώνει και χρηματοδοτεί την έρευνα;

Η έρευνα χρηματοδοτείται από το Ευρωπαϊκό Πρόγραμμα Horizon 2020 και εκτελείται από μια κοινοπραξία με επικεφαλής το Luxembourg Institute of Science and TECHNOLOGY - LIST (Λουξεμβούργο), το University of Manchester - UMAN (Ηνωμένο Βασίλειο), το Εθνικό Μετσόβιο Πολυτεχνείο, την VAASAETT LTD (Φινλανδία), την ARTTIC (Γαλλία), την Ariosz Szolgaltato Informatikai Estanacsado Korlatolt Felelossegu Tarsasag - ARIOSZ (Ουγγαρία), την Greater Manchester Combined Authority - GMCA (Ηνωμένο Βασίλειο), τη Magyar Maltai Szeretetszolgalat Egyesulet - MALTAI (Ουγγαρία), τη Ρυθμιστική Αρχή Ενέργειας - ΡΑΕ, το Δήμο Μετσόβου, την E.ON Eszak-Dunantuli Aramhalozati Zartkoruen Mukodo RT - E.ON (Ουγγαρία), την Associazione Italiana Difesa Consumatori Ed Ambiente Adiconsum (Ιταλία), και το University of Surrey - SURREY (Ηνωμένο Βασίλειο).

17. . Ποιος επιλαμβάνεται των ηθικών ζητημάτων του έργου;

Το έργο ελέγχεται ως προς την ηθική του από τον Καθηγητή Peter Wahlgren του Stockholm University, που έχει μακρά εμπειρία με τα ζητήματα ηθικής. Η Επιτροπή Ηθικής και Δεοντολογίας του ΕΛΚΕ του ΕΜΠ, με τη σύστασή της θα παρακολουθεί την εφαρμογή και ικανοποίηση αυτών των ζητημάτων επίσης. Τα έγγραφα που τυχόν απαιτούνται από τις τοπικές αρχές προστασίας των δεδομένων και τους κανόνες συμμόρφωσης με το Γενικό Κανονισμό για την Προστασία Δεδομένων (GDPR) θα συμπληρωθούν από το ΕΜΠ.

18. Επαφές για περισσότερες πληροφορίες

Καθηγητής Δημήτρης Δαμίγος, Σχολή Μηχ. Μεταλλείων - Μεταλλουργών, ΕΜΠ, Ελλάδα. Τηλ: +30 2107722214, email: ddamigos@central.ntua.gr

Dr. Rod McCall, Συντονιστής STEP-IN, Ινστιτούτο Επιστήμης και Τεχνολογίας του Λουξεμβούργου, Λουξεμβούργο. Τηλ: +352 275 888, email: roderick.mccall@list.lu

Ο Κοσμήτορας της Σχολής Μηχανικών Μεταλλείων-Μεταλλουργών του Εθνικού Μετσόβιου Πολυτεχνείου είναι ο Καθηγητής Δημήτρης Καλιαμπάκος. Μπορείτε να έρθετε σε επαφή μαζί του στην ακόλουθη διεύθυνση: Καθηγητής Δημήτρης Καλιαμπάκος, Σχολή Μηχ. Μεταλλείων – Μεταλλουργών, ΕΜΠ, Ηρώων Πολυτεχνείου 9, 15780, Ζωγράφου, Τηλ.: +30 2107722211, email: dkal@central.ntua.gr.

Ευχαριστούμε που συμμετέχετε στην έρευνα..

Ερευνητικό κέντρο: ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ – ΕΡΓ. ΜΕΤΑΛΛΕΥΤΙΚΗΣ ΤΕΧΝΟΛΟΓΙΑΣ & ΠΕΡΙΒΑΛΛΟΝΤΙΚΗΣ ΜΕΤΑΛΛΕΥΤΙΚΗΣ

Βιωματικό Εργαστήρι Διερεύνησης: Μέτσοβο

ΕΝΗΜΕΡΩΜΕΝΗ ΦΟΡΜΑ ΣΥΓΚΑΤΑΘΕΣΗΣ

Τίτλος Προγράμματος: **STEP-IN**

Όνομα Ερευνητή:

Παρακαλώ επιλέξτε όλα τα κουτιά

1. Επιβεβαιώνω ότι έχω διαβάσει και έχω κατανοήσει πλήρως το ενημερωτικό δελτίο με ημερομηνία ……………………………… για το πρόγραμμα STEP-IN. Είχα την ευκαιρία να εξετάσω τις πληροφορίες, να θέσω ερωτήσεις και να λάβω ικανοποιητικές απαντήσεις. Έχω ενημερωθεί σχετικά με τις διαδικασίες προστασίας των προσωπικών μου δεδομένων σύμφωνα με το Γενικό Κανονισμό για την Προστασία Δεδομένων (GDPR). ☐

2. Κατανοώ τα οφέλη που θα μπορούσε να μου προσφέρει το Βιωματικό Εργαστήριο του STEP-IN. Συμφωνώ να συμμετάσχω οικειοθελώς σε αυτή την έρευνα και κατανοώ ότι μπορώ να αποσυρθώ από την έρευνα του Βιωματικού Εργαστηρίου οποιαδήποτε στιγμή, χωρίς να χρειάζεται να δώσω κάποιο λόγο. ☐

3. Κατανοώ ότι οι απαντήσεις μου και τα δεδομένα που συλλέγονται μέσω των ερωτηματολογίων θα διατηρηθούν αυστηρά εμπιστευτικά. Κατανοώ ότι το όνομά μου δεν θα συνδεθεί με το ερευνητικό υλικό και δεν θα αναγνωριστεί, ούτε θα είναι αναγνωρίσιμο στην αναφορά ή στις αναφορές που προκύπτουν από την έρευνα. Έχω ενημερωθεί ότι η διαχείριση των δεδομένων προστατεύεται από τους αντίστοιχους εθνικούς νόμους για την προστασία των δεδομένων. ☐

4. Κατανοώ ότι τα δεδομένα που συλλέγονται κατά τη διάρκεια της έρευνας μπορεί να εξεταστούν από τους ερευνητές του προγράμματος STEP-IN**.** Κατανοώ ότι οι πληροφορίες που συλλέγονται από την έρευνα θα χρησιμοποιηθούν μόνο για ανάλυση και ότι τμηματικά δεδομένα, από τα οποία δεν θα μπορούσα να αναγνωριστώ προσωπικά, μπορούν να χρησιμοποιηθούν σε οποιαδήποτε παρουσίαση συνεδρίου, έκθεση ή άρθρο περιοδικού, που προκύπτει ως αποτέλεσμα της έρευνας. Κατανοώ ότι καμία άλλη χρήση των δεδομένων δεν θα γίνει χωρίς τη γραπτή μου άδεια και ότι κανείς, εκτός της ερευνητικής ομάδας του STEP-IN, δεν θα έχει πρόσβαση στην πρωτογενή έρευνα. ☐

5. Συμφωνώ να συμμετάσχω στην παραπάνω μελέτη. ☐

Δίνω την άδεια να χρησιμοποιηθούν τα ανώνυμα δεδομένα μου για μελλοντικούς ερευνητικούς σκοπούς, όπως δημοσιεύσεις σχετικές με αυτή ή μελλοντική έρευνα για 10 χρόνια μετά τη λήξη του προγράμματος STEP-IN. Μετά από 10 χρόνια, τα δεδομένα θα διαγραφούν.

______________________	______________________	______________________
Όνομα Συμμετέχοντα	Ημερομηνία	Υπογραφή

______________________	______________________	______________________
Όνομα προσώπου που λαμβάνει τη συγκατάθεση	Ημερομηνία	Υπογραφή